Spreading Success

How London is Changing

Transport for London

LONDON DEVELOPMENT AGENCY

MAYOR OF LONDON

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GLA Economics
The Mayor of London established GLA Economics in May 2002 to provide a firm statistical, factual and forecasting basis for policy decision-making by the GLA and its functional bodies.

London is well known as one of the three great world cities, and as an international centre for finance and business. But it is more than that – the city includes an extraordinary diversity of places and people, which it is easy to overlook in the midst of discussions about globalisation and London's international role. Most Londoners work outside the three most central boroughs of Westminster, the City and Tower Hamlets. There are many employment sectors other than financial and business services that are growing in London, and there are places outside the centre where new jobs are being created.

As this report describes, this diversity is something we are determined to encourage. All of London's people and places need access to a range of opportunities and services if they are to thrive, and if our vision for a truly sustainable city is to be realised against the background of the population and job growth we expect to see over the next fifteen years. That is why finding ways of encouraging local economic development and job creation in all parts of London is vitally important.

This can only be achieved if all London-wide and local policy and decision-makers work together. This report is intended to start a process of discussion between all the organisations involved to this end. It sets out a good deal of detailed information about what is happening to local economies in all parts of London and which areas of the economy are showing jobs growth.

It ends by drawing on the work done by the GLA Group in drawing up the draft London Plan, my Transport and Economic Development Strategies, and on experience of five boroughs in very different parts of our city to suggest policy approaches to respond to these forces in ways that will help create the kind of opportunities we are committed to secure for everyone in London, no matter where they live.

We have a huge amount to learn from each other, and I hope this will mark the start of a new process of dialogue and exchange of information to help achieve the best for all Londoners.

Mayor of London

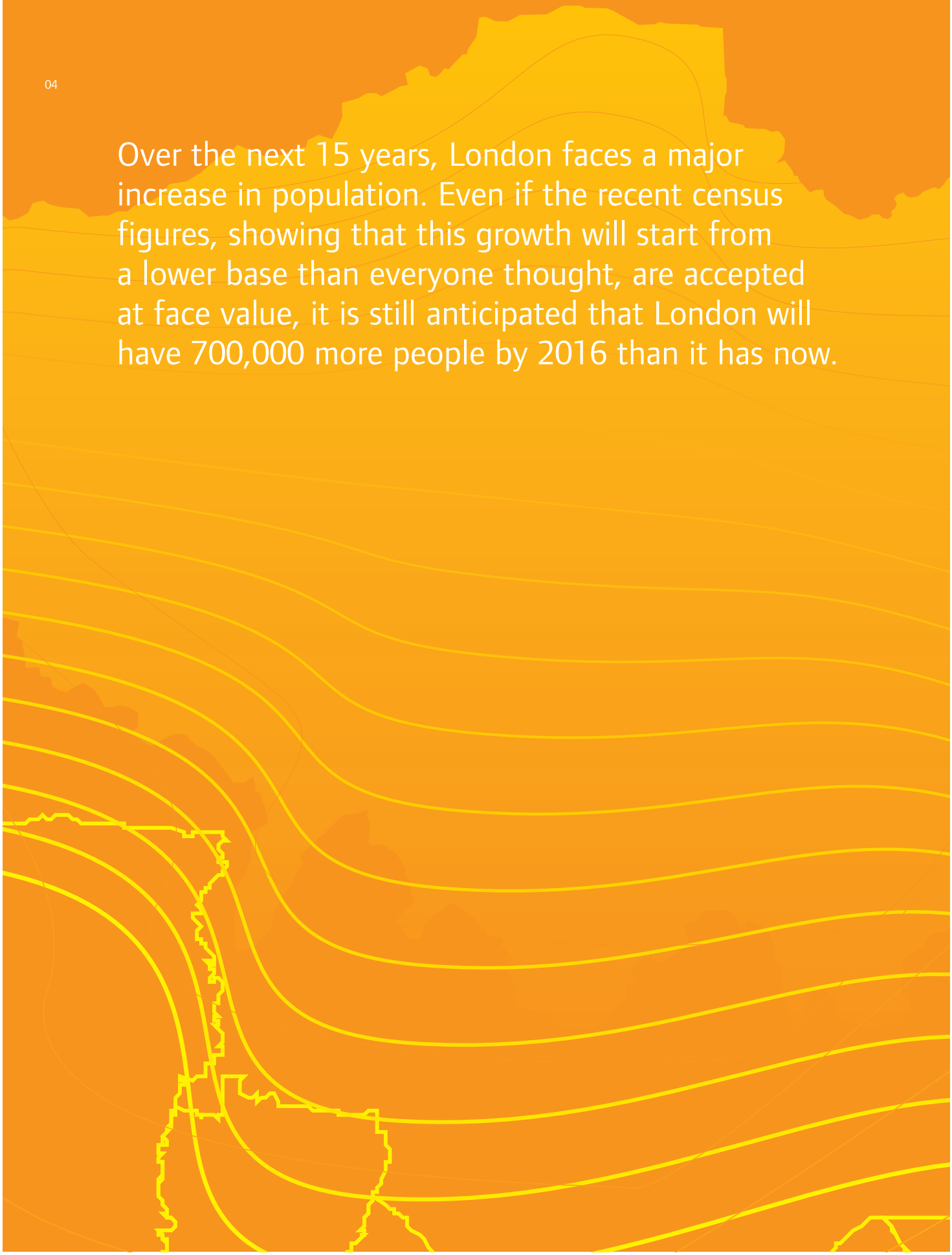
Much has been written about London's role as one of the world's three major centres of financial activity. The financial nerve centre is undoubtedly focused on central London and many business services and headquarters functions are located there. What is much less well described, however, is what has been happening in other parts of London and other job sectors.

The purpose of this report is to help address this information gap and is part of a longer-term research strategy that intends to further develop our understanding of the London economy and the dynamics of its operation. This report looks specifically at the spatial changes in employment patterns, past, present and future, across the capital and at the challenges and opportunities represented by these changes for spatial planning and development. The report does not attempt to look at the myriad issues concerning access to these employment opportunities or the associated issues of skills shortages and deficiencies; these will be subject to future analysis.

This report also seeks to build upon recent work across the GLA Group including the detailed analysis contained in the Mayor's report 'London Divided: income inequality and poverty in the capital' and the forthcoming work on London's Sub-Regional Economies prepared by the London Development Agency ('Understanding London's Sub-Regional Economies'), as well as the GLA's recent report on the creative industries ('Creativity: London's Core Business').

This report draws on all of these sources as well as additional research to investigate how employment patterns in different parts of London have been changing and the types of policies that are most likely to be effective in fostering future growth and economic development.

Over the next 15 years, London faces a major increase in population. Even if the recent census figures, showing that this growth will start from a lower base than everyone thought, are accepted at face value, it is still anticipated that London will have 700,000 more people by 2016 than it has now.



The challenge

Over the next 15 years, London faces a major increase in population. Even if the recent census figures, showing that this growth will start from a lower base than everyone thought, are accepted at face value, it is still anticipated that London will have 700,000 more people by 2016 than it has now. This means that over the same period, there will be 515,000 more people of working age. These projections are based on well-understood demographic trends (largely the natural growth in population arising from having more births than deaths and more people moving into London than moving out); it is not a question of whether or not this level of growth is one that anyone would ideally 'like' to see, but of taking a responsible view of what is likely to happen and planning accordingly.

One of the most important things to plan for, given the projection of more than half a million additional workers – the same number as the current workforce of Birmingham, England's second biggest city – is the need for more jobs, and for a suitable range of jobs for what will be an increasingly diverse workforce. Joblessness exacerbates poverty and social exclusion. There are already patterns of disadvantage, with minority ethnic unemployment worse than that for white Londoners and children's poverty strongly related to their parents' worklessness. Failure to look at what is happening to London's job market and identify ways to ensure it works effectively in the future, will reinforce historical patterns of disadvantage and raise the spectre of new social problems, which will make living in London an increasingly unjust and unpleasant experience for everyone.

Ensuring that there are enough jobs, of the right type and in the right place, for the new Londoners, are key challenges for all policy-makers throughout the city. The draft London Plan started to identify the challenge and possible responses, but because of its strategic nature, cannot look at the smaller-scale of local trends and approaches. This is particularly true for places outside the opportunity zone and other areas pinpointed as being of London-wide strategic importance. This publication seeks to fill this gap, by:

- Identifying job creation trends across all parts of London.

- Determining growing sectors.

- Establishing where growth is taking place.

- Considering the experiences of some boroughs which have faced particularly significant change.

- Suggesting policy approaches that local decision-makers might consider.

The central question: fight the future, or embrace change?

In the past, London has remade its economy many times in response to changing patterns of local and international demand, and has been quick to adopt new technologies and methods of work. The last 40 years has seen one of these dramatic periods of upheaval. In 1966, 1.29 million Londoners worked in manufacturing; over the following 30 years nearly 80 per cent of these jobs disappeared. Areas like Park Royal and the Lee Valley, which developed as industrial areas over a period stretching back as long as two hundred years, saw the practical end of their primary industrial existence by 1985. Household names such as Bassetts Confectionery, Firestone Tyres and Norton Villiers, and major landmark public facilities such as Battersea Power Station and Beckton Gas Works, closed and shed industrial jobs. Every part of London has its own particular example of this phenomenon.

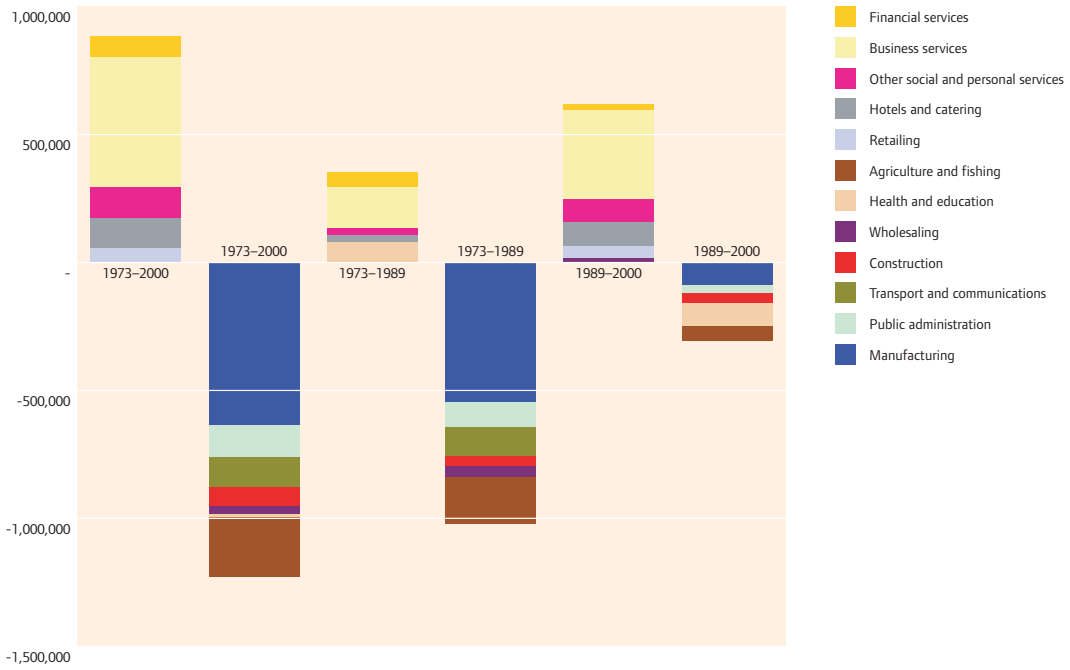
This is not to say that manufacturing is no longer important. It also has a new role. For example, many of the most dynamic parts of London's creative industries need close links with the production industries. However, since 1971, employment in manufacturing has declined by 621,000. This loss of manufacturing jobs was most concentrated in the period up to the late 1980s. The rise in London's employment since the recession of the early 1990s is due to that massive rate of decline in manufacturing employment ending and growth in the service sector continuing at a fairly constant rate. Financial and business services have contributed most to this, employing 390,000 more jobs since 1992, though sectors such as retailing and wholesaling, personal and leisure services and hotels and restaurants have also grown. While in 1971, 60.5 per cent of London's jobs were in these service sectors; by 2000 this had reached 83.1 per cent (figure 1.1).

Forecasts prepared for the London Plan show these strong trends continuing, with a projected increase of 190,000 jobs in leisure and other personally-oriented services, 150,000 in hotels and catering and 10,000 in retail. These trends may not be a reflection of what everyone would abstractly want to happen, but they are the best and most realistic view of probable developments, taking account of:

- *The likely increase in London's population:* an extra 700,000 Londoners are going to increase demand for leisure and personal services, and for places to shop.

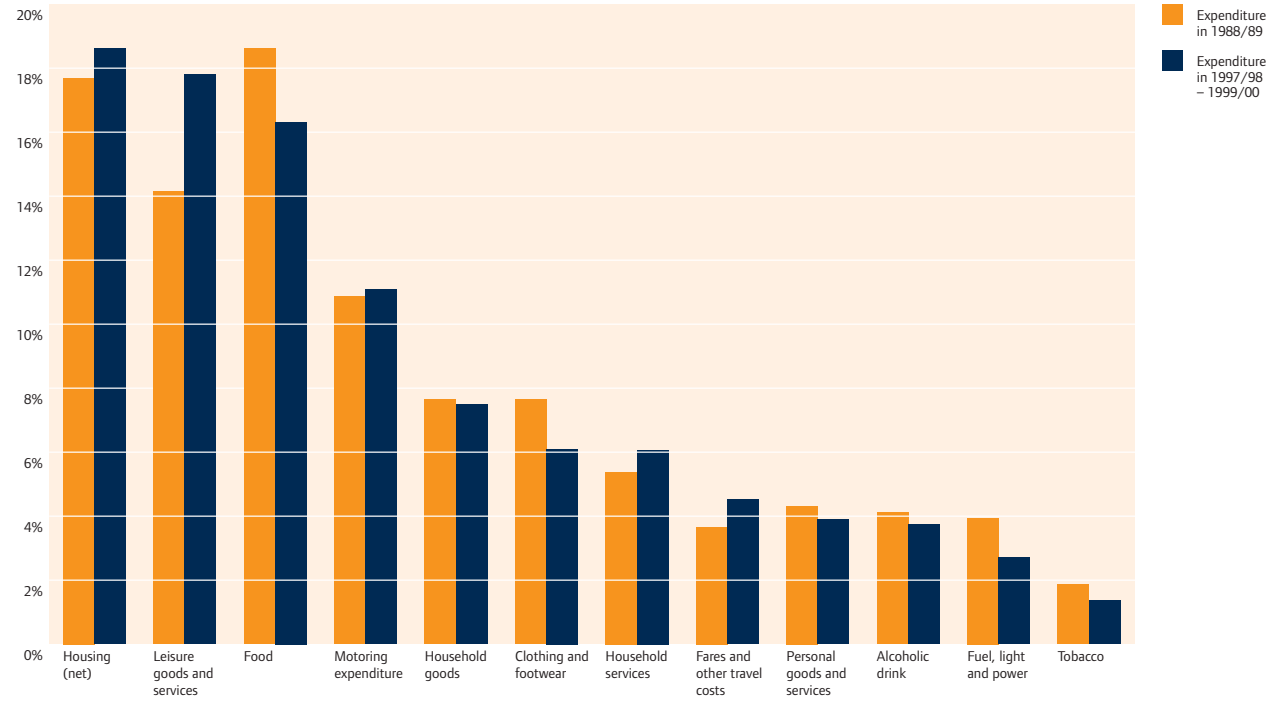
- *Growing demand for services:* the 2000/01 Family Expenditure Survey showed that for the first time, typical London households spend more on leisure goods and services than on food (figure 1.2). In a new generation of mixed-use urban areas across the capital, London's increasingly young population is also likely to look to leisure activities close to home.

Figure 1.1 Numerical change in employee jobs



Source: Experian Business Strategies (EBS), Annual Business Inquiry (ABI), GLA Economics

Figure 1.2 Composition of household expenditure in London



Source: Family Expenditure Survey, National Statistics

• *New ways in which services are consumed:* the changing ways people work, live and enjoy their leisure time are having major impacts on when and where they spend their money, as well as what they buy. For many Londoners, tight geographical divisions between workplace and residential areas are weakening. This is shown by the growth in night-time economies in several of London's suburban centres – Croydon Council points out that their area's night economy is now larger than central Manchester's.

• *London's competitive advantage for services:* This can be shown by looking at London's share of the UK's total service sector employment (see table 1.1). London has particular advantages in a wide range of high-value, high-skill and knowledge-intensive activities (ranging from broking to the music business). Some are closely linked to other sectors, such as air transport, tourism, fashion design and other cultural activities. These services, and those needed to support them, are increasingly locating in London. This is impacting on the structure of all parts of the city. For example, back office and support services are locating in less central, cheaper locations and new sectors are locating in places where there is a good supply of affordable and readily available property.

The challenge for policy makers, therefore, is to decide whether their approach to encouraging jobs and promoting employment should be based around trying to reverse these very powerful trends, or understanding and accepting them, taking active steps to make sure they work to the benefit of local people. Over the past twenty years, different approaches have been tried. These have included attempts to turn back the clock and attract back large scale manufacturing and other similar sectors. So far, with limited exceptions, this approach has proved largely unsuccessful. Alternatively, attempts to attract jobs of any kind to an area have, without a proper complementary policy framework, too often resulted in supporting jobs which have gone to more skilled people – often from outside the area concerned – with few lasting benefits for local people and places. In some areas, there has been major job growth and economic change almost regardless of any approach taken locally.

This document – which reflects the policy approach being taken by the Mayor, the London Development Agency and the GLA Group as a whole – takes the position that even if it were desirable to try to turn back the clock, the range of policies realistically available would be inadequate to produce the necessary change in deep-seated economic forces. Instead, these forces need to be understood and policies developed to maximise job

Table 1.1

Specialist strengths of the London Economy 2000	*London employment (000s)*	*% of GB total*
Financial services		
Financial markets, security broking and fund management	*39*	*68%*
Other specialised financial services (other than pensions and insurance)	*21*	*48%*
Banks and building societies	*153*	*34%*
Insurance brokers, agents and risk evaluators	*39*	*31%*
Property, professions, IT and other business services		
Employers, professional and union organisations	*18*	*42%*
Advertising and photography	*45*	*39%*
Law and accounting	*146*	*35%*
Market research and consultancy	*73*	*34%*
Real estate: development, management and dealing	*37*	*32%*
Data processing and data bases	*18*	*32%*
Other business activities (inc. interior/fashion design, entertainment agencies, exhibition organisers)	*81*	*31%*
Publishing, media and cultural services		
Sound publishing	*4*	*63%*
Film/video production, distribution	*11*	*59%*
Radio and TV	*34*	*53%*
Artistic and literary: creation and facilities	*28*	*45%*
Publishing: books and journals	*37*	*45%*
Newspapers: publishing, printing, news agencies	*22*	*41%*
Travel and distribution		
Wholesale of clothing and cosmetics	*19*	*36%*
Air transport and supporting services	*38*	*32%*
Rail and other scheduled surface passenger transport	*45*	*28%*

Source: 'London's place in the UK economy', Annual Report, London School of Economics and Political Science, September 2002

growth in all parts of London, so as to provide a choice of high-quality job opportunities within the reach of everyone, based on the most sustainably dynamic sectors of London's economy. Under this approach, policies will be developed and implemented to support and sustain growth sectors (which will include some production and manufacturing) where London has clear comparative and competitive advantage.

Is local job creation important?

One theoretical way forward could be to encourage job growth in central London, while promoting the rest of the city as somewhere essentially for people to live, with employment limited to serving the needs of local residents.

There are a number of reasons why this approach is not practical, even if it were desirable:

- It is unlikely that the kind of job growth that would be needed could be entirely accommodated in the three central boroughs (Westminster, City and Tower Hamlets) and the city fringe areas of Kensington and Chelsea, Camden, Islington, Hackney, Southwark and Lambeth.

- It is likely that a high proportion of the spending on leisure goods and services (such as buying or renting videos, visits to the cinema and booking holidays), which is expected to grow, will tend to take place close to home.

- Much of London's transport system is already at capacity, a situation that is likely to get worse before it gets better. Boosting local employment will help relieve London's transport problems.

- Londoners' circumstances differ, and not everyone will want or be able to travel long distances to full-time jobs in the centre. There is a need for a range of accessible opportunities to suit people with differing needs.

Promoting local employment will also boost local economies, provide for a range of employment opportunities for people wanting part-time and other atypical jobs and help tackle localised problems of social exclusion. One feature of London's employment pattern is that, as a proportion of its workforce, there are fewer part-time employees than elsewhere in the country. Since part-time jobs are largely taken by women, this reduces women's job opportunities (of course costs associated with transportation and childcare are also important factors needing to be addressed). At the same time, one of the major sources of deprivation identified by the Mayor's report on poverty is that of worklessness, particularly in single parent families.

Is this realistic?
London has shown in the past that it can be extremely flexible in adapting to change. The last major expansion in its economy and population, in the 1920s and 1930s, saw the development of new light industries and products. These had the effect of providing new suburban homes, affordable cars from Ford at Dagenham, Smiths crisps, Heinz baked beans, Guinness from Park Royal, safety razors from Gillette in Brentford and wireless sets from Marconi in Brent. The early growth of Croydon Airport and of centres of creativity such as Fleet Street, the BBC and Ealing Studios, also have parallels with today. This expansion was made possible or encouraged by major public and private sector investment in infrastructure, such as the great arterial road system, extension of the Tube and new, higher-quality housing. Today, examples of radical change can again be found across the city – in the once traditional manufacturing areas like the Wandle and Lee Valleys, for example, or in the new vitality of places such as Park Royal.

The analysis of sub regional performance prepared for the LDA shows that all parts of London began to improve their performance relative to that of the country as a whole in the early to mid 1990s. This was after a long period in which apparent structural advantages of the location of growth sectors had not been translated into growth at the same pace as elsewhere in the country. In short, London has proportionately more jobs in the sectors that have shown the most job growth nationally. Within London, those places with the largest number of these jobs have also shown the most growth.

No part of London has remained untouched by economic change. Although financial and world market-oriented business services are highly concentrated in central London and the City, other growth sectors are much more dispersed: boroughs including Barnet, Kingston upon Thames, Redbridge and Bromley have seen employment in growing service sectors increase. What has happened in the last ten years shows that substantial local job creation is possible, and it is to this evidence that we turn now.

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While most attention has been given to the huge increase in the financial and business services jobs that reflect London's world city status, other service activities including retail, leisure, hotels and catering, have been additional major sources of London's recent jobs growth, and GLA projections show they will go on expanding. More than half of all the 382,000 businesses in London – and more than half of all employees – are engaged in the retail and wholesale, business services or the hotel and catering trades. By 2016, the GLA expects there to be 190,000 new jobs in leisure and other personally-oriented services and 150,000 in hotels and catering. As the recent GLA report on London's creative industries makes clear, high-value services with high creative input are already showing strong growth; this is likely to continue.

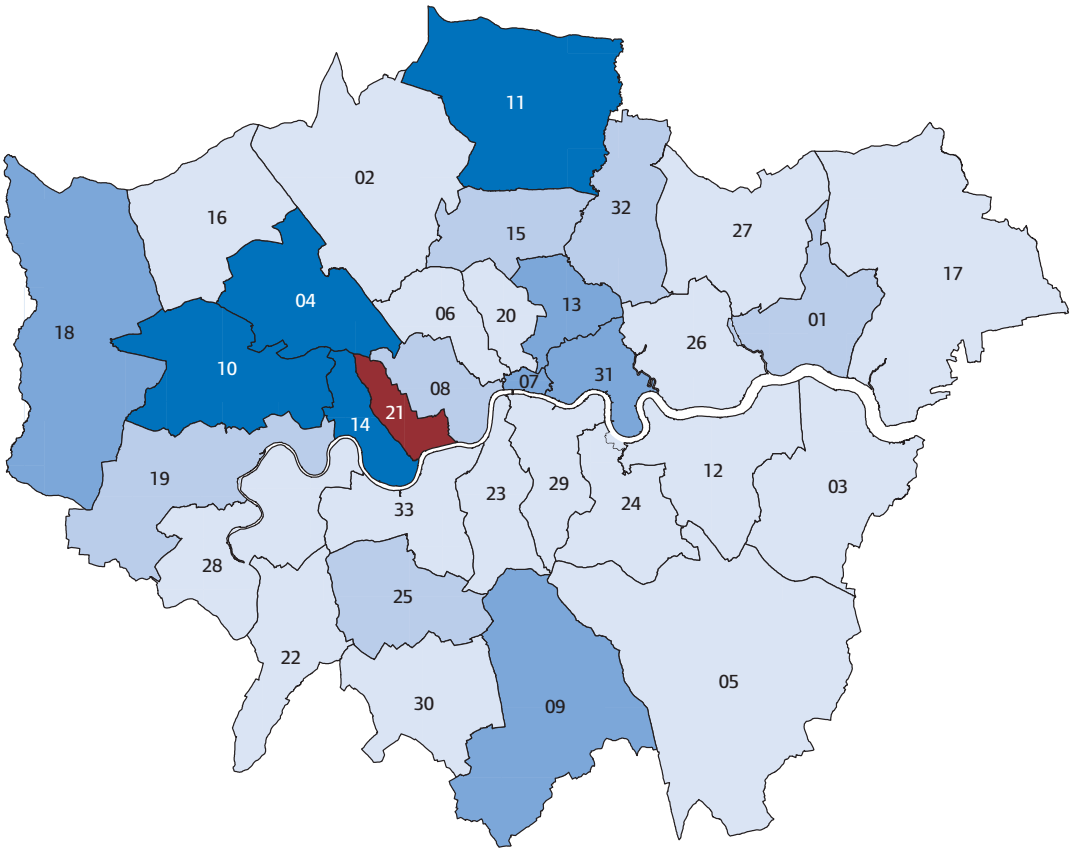
What jobs are being created – and where?

Large-scale job losses in manufacturing affected almost all boroughs – only one showed small increases over the period from 1973. Figure 2.1 shows the biggest losses were concentrated in the west and north of the city, though inner London also shows large falls.

At the same time, of course, new jobs were created. Figures 2.2 and 2.3 show the change in manufacturing employment and business services employment over the period 1989-2000 – from the high point of one business cycle to that of another. In almost all boroughs, manufacturing employment has continued to decline while that in business services has increased. The increases in business services are concentrated along the river, both north and south, while the losses in manufacturing continue, particularly in a number of outer boroughs like Barking and Dagenham, Croydon and Enfield.

Between 1996 and 2000, both total and full-time jobs increased in every London borough other than Kingston upon Thames. Total percentage job growth reached double figures in most boroughs, and exceeded 20 per cent in Tower Hamlets, Hounslow, Newham, Islington, Camden, Hackney, Waltham Forest and Hammersmith and Fulham. Full-time employment expanded by ten per cent or more in all of these boroughs, and also in Croydon, Lambeth, Redbridge, Bexley, Havering, Bromley and Kensington and Chelsea (figures 2.4 and 2.5). Looking over a

Figure 2.1 Change in Manufacturing employee jobs between 1973 and 2000
Total change: 730,419

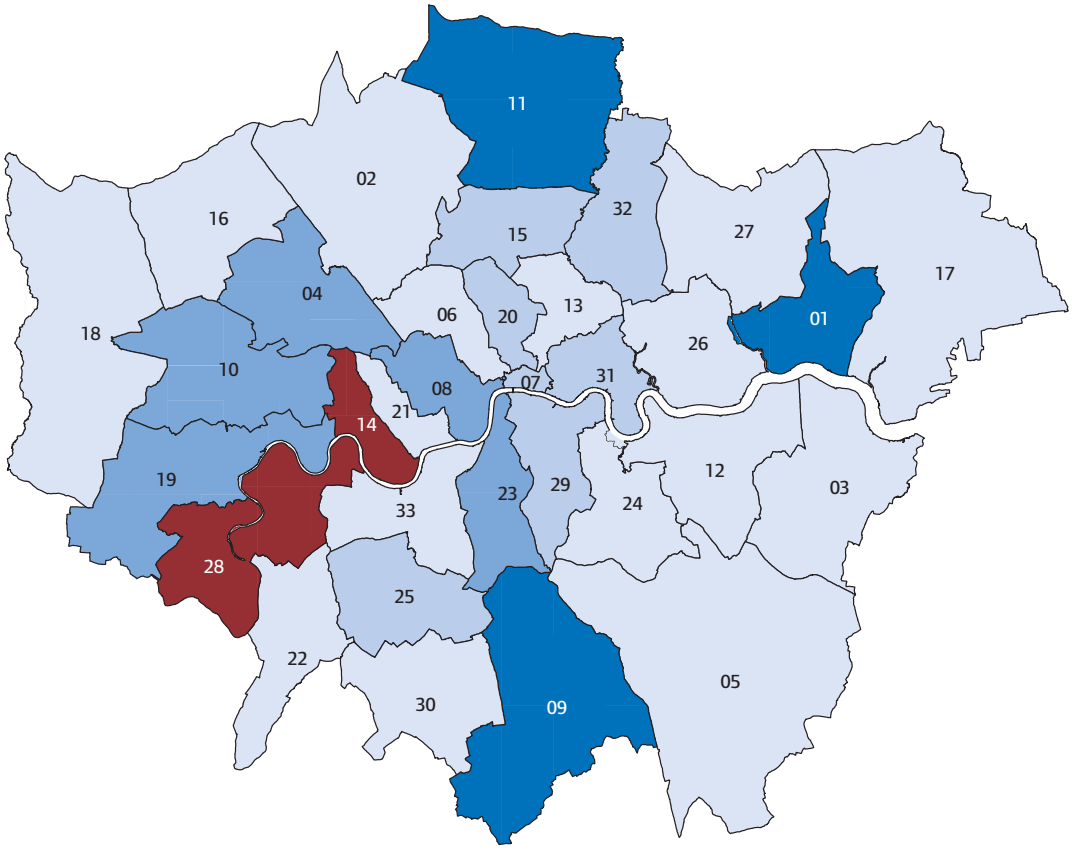


Source: "Making Sense of the ABI" EBS, GLA Economics

01 Barking and Dagenham
02 Barnet
03 Bexley
04 Brent
05 Bromley
06 Camden
07 City of London
08 City of Westminster
09 Croydon
10 Ealing
11 Enfield
12 Greenwich
13 Hackney
14 Hammersmith and Fulham
15 Haringey
16 Harrow
17 Havering
18 Hillingdon
19 Hounslow
20 Islington
21 Kensington and Chelsea
22 Kingston upon Thames
23 Lambeth
24 Lewisham
25 Merton
26 Newham
27 Redbridge
28 Richmond upon Thames
29 Southwark
30 Sutton
31 Tower Hamlets
32 Waltham Forest
33 Wandsworth

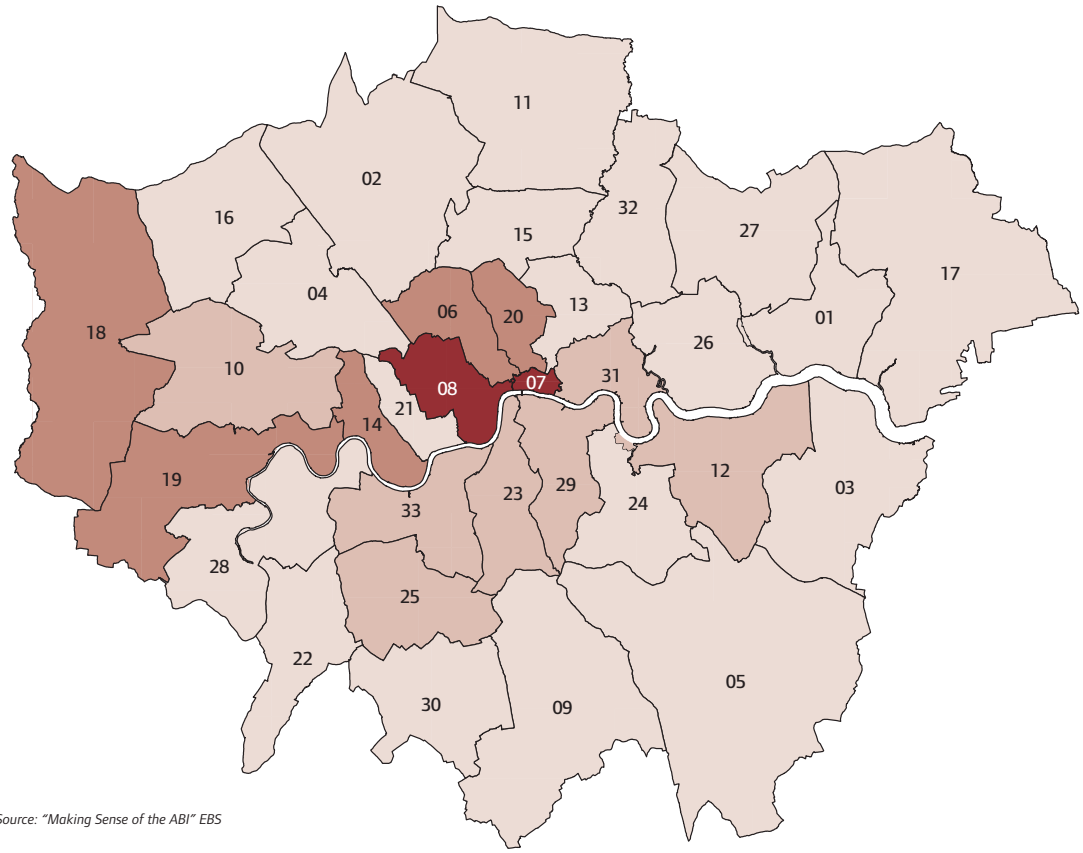
0 to 1,600 (1)
-21,000 to 0 (17)
-34,000 to -21,000 (6)
-40,000 to -34,000 (5)
-75,000 to -40,000 (4)

Figure 2.2 Change in Manufacturing employee jobs between 1989 and 2000
Total change: 123,900



Source: "Making Sense of the ABI" EBS, GLA Economics

Figure 2.3 Change in Business Services jobs between 1989 and 2000
Total change: 369,300



Source: "Making Sense of the ABI" EBS

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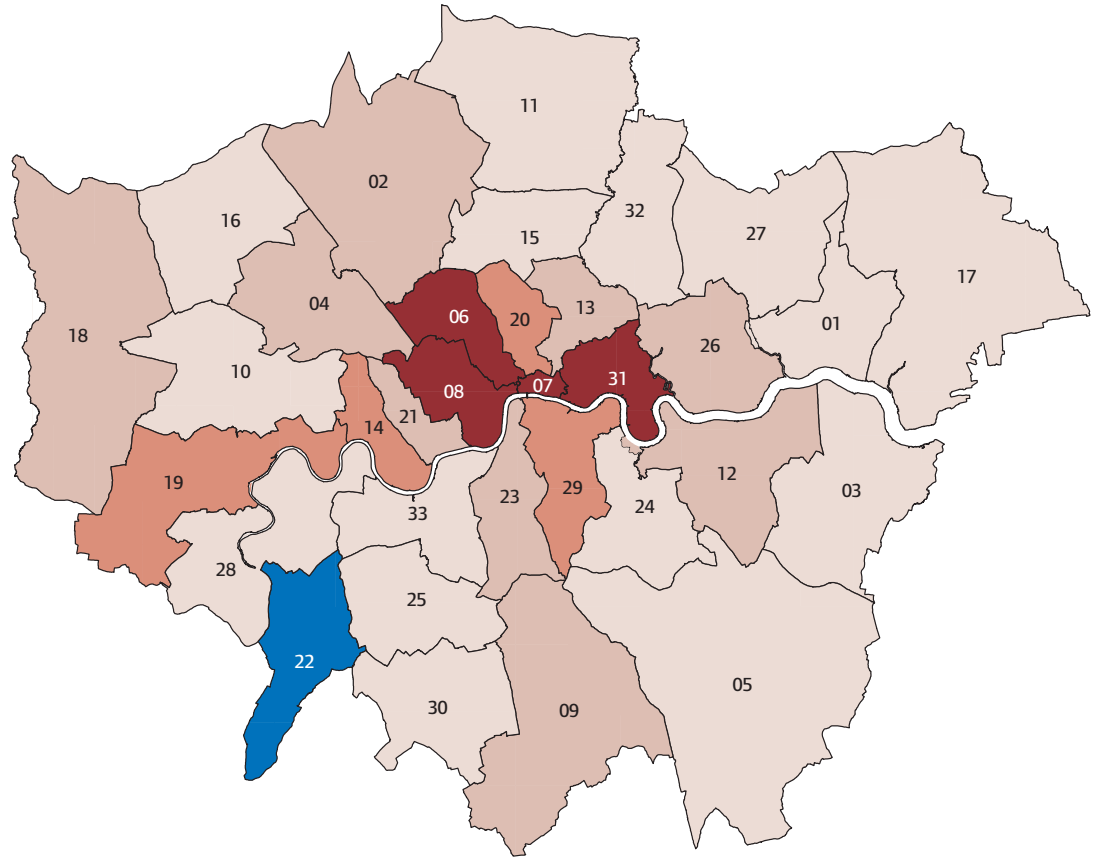
22 Kingston upon Thames
23 Lambeth
24 Lewisham
25 Merton
26 Newham
27 Redbridge
28 Richmond upon Thames
29 Southwark
30 Sutton
31 Tower Hamlets
32 Waltham Forest
33 Wandsworth

41,700 to 50,600 (2)
15,800 to 41,700 (5)
11,500 to 15,800 (7)
0 to 11,500 (19)

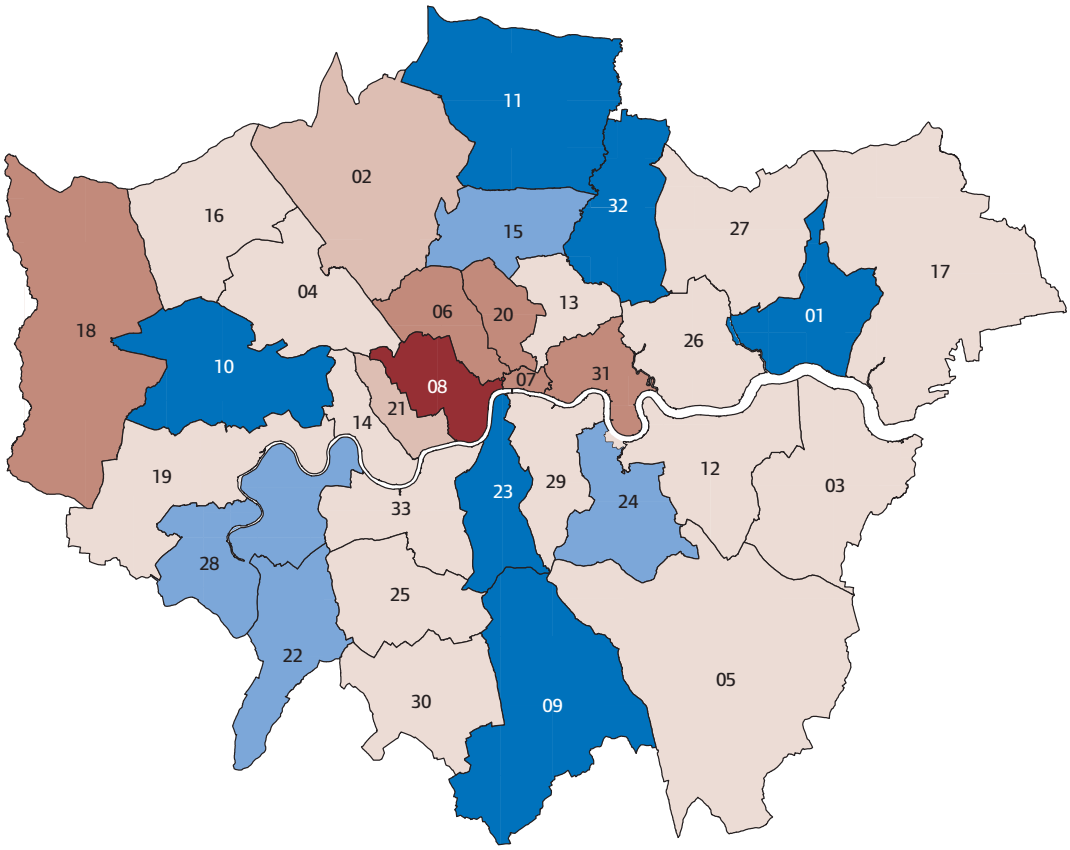
Figure 2.4 Change in Total employee jobs between 1996 and 2000
Total change: 551,200



Source: Office of National Statistics, ABI

- 30,000 to 55,000 (4)
- 21,100 to 30,000 (4)
- 12,000 to 21,000 (9)
- 0 to 12,000 (15)
- -2,400 to 0 (1)

Figure 2.5 Change in Total employee jobs between 1989 and 2000
Total change: 270,600



Source: "Making Sense of the ABI" EBS, GLA Economics

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26 Newham
27 Redbridge
28 Richmond upon Thames
29 Southwark
30 Sutton
31 Tower Hamlets
32 Waltham Forest
33 Wandsworth

40,000 to 55,000 (1)
25,000 to 40,000 (5)
22,000 to 25,000 (2)
0 to 22,000 (15)
-7,000 to 0 (4)
-15,000 to -7,000 (6)

longer period – across the last business cycle (1989-2000) – shows job losses in Barking and Dagenham, Ealing, Waltham Forest, Lambeth, Croydon, Enfield, Haringey, Lewisham, Richmond upon Thames and Kingston upon Thames. The more recent evidence, however, shows the restructuring of the jobs market reached a stage over the 1990s where the positive impact on job creation began spreading throughout London.

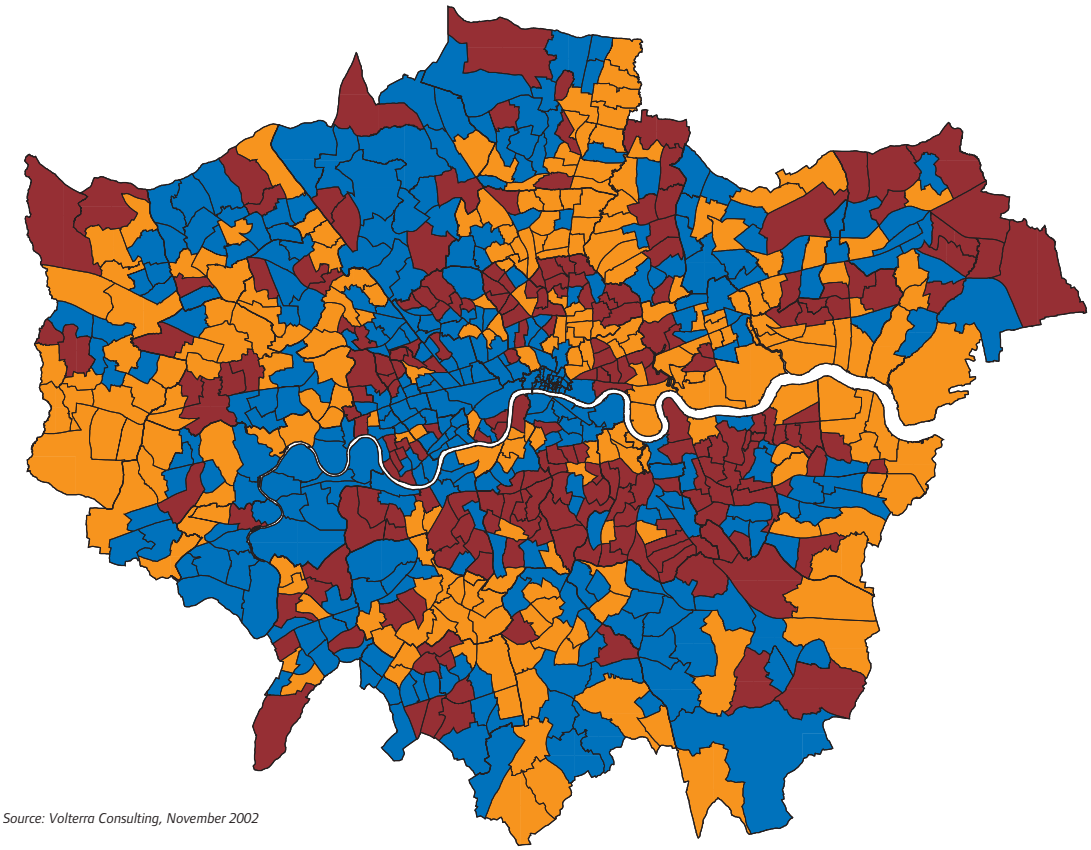
It is important to grasp the scale of the structural changes affecting local economies across London. Although by 1989 most of the large-scale loss of manufacturing jobs had already occurred, many places could still be described as having industrially-based employment. An analysis of employment structure at borough ward level has been undertaken using a technique known as 'fuzzy clustering' (which is described in detail in appendix 2). It identifies the key distinguishing characteristics of wards and finds three kinds of places where employment is dominated by Industrial, Commercial or Public Sector jobs respectively. In1989 about a third of wards (234 out of 782) could be classified as Industrial (covering manufacturing, transport and construction) (figures 2.6 and 2.7). By 2000, on the same basis, over half the wards could be classified as Commercial (covering activities like business services, computing and financial services). Wards classified as Commercial by 1989 showed an average employment growth of seven per cent between 1989 and 2000, while Industrial wards showed a fall of nearly seven per cent, and those dominated by the Public Sector a fall of 14 per cent. This shift to services is a revolution similar in scale and scope to the last remaking of London's economy and population in the 1920s and 1930s.

Which service sectors have grown?

The biggest increases have occurred in computer and related services, professional services and recruitment agencies (which includes temporary employees). Figures 2.8, 2.9 and 2.10 show how these increases are distributed across the boroughs (showing where people work, rather than where they live). The geographical distribution of the increases is varied: even increases in professional services, while concentrated on the central area, spread across a north-south axis. Computer-related jobs fan out towards western London, while recruitment and agency employment is more widespread.

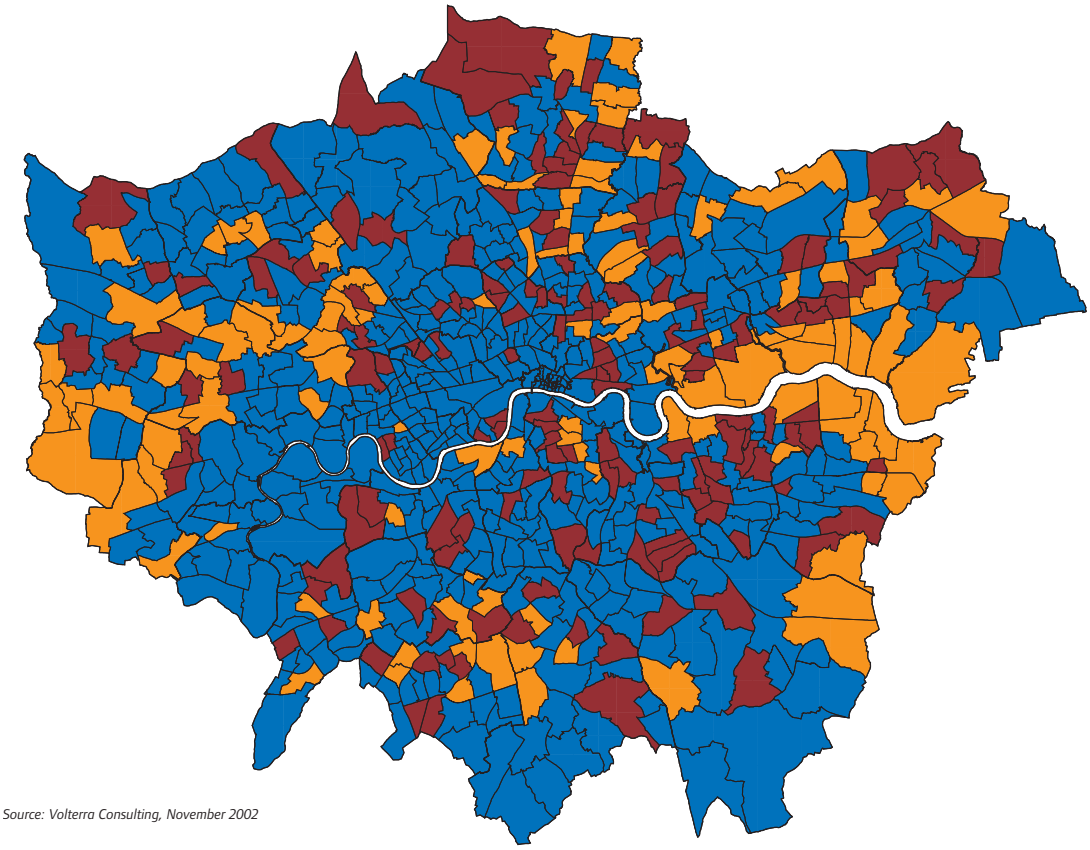
Growth in financial and business services employment between 1989 and 2000 took place predominantly in Westminster and the City of London. With the exception of Hounslow (which is affected by proximity to Heathrow airport), the other boroughs with the greatest increases – Islington, Tower Hamlets and Camden – surround Westminster and the City in the central business

Figure 2.6 Employee jobs clustering in 1989



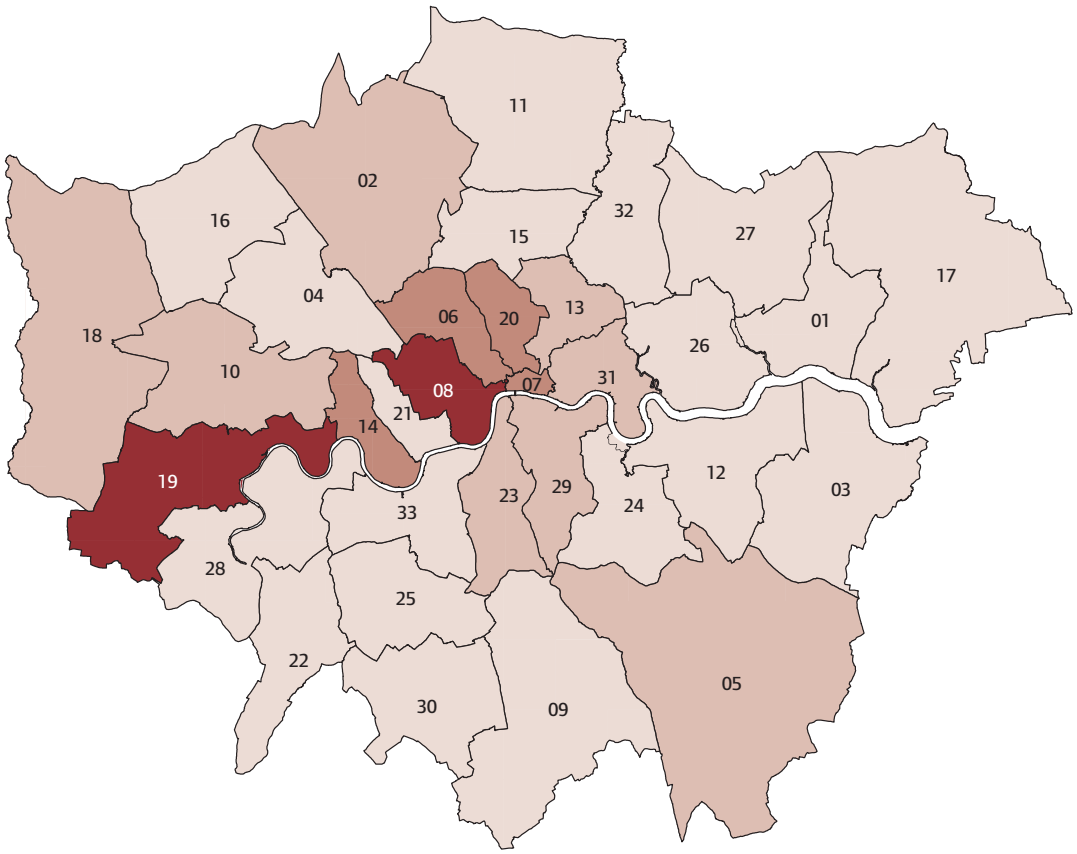
Source: Volterra Consulting, November 2002

Figure 2.7 Employee jobs in 2000 (with 1989 clusters)



Source: Volterra Consulting, November 2002

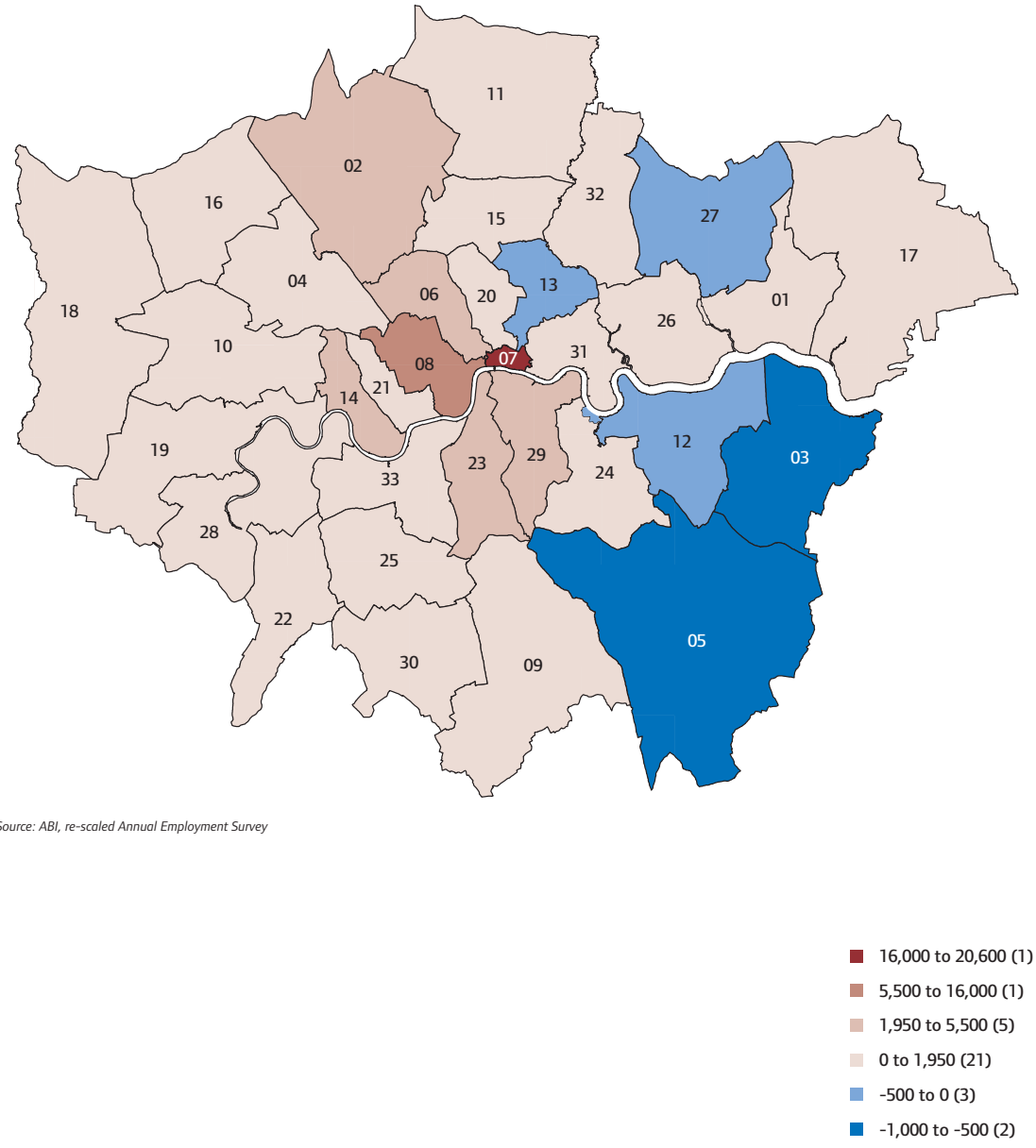
Figure 2.8 Change in Computer and Related employee jobs between 1995 and 2000



Source: ABI

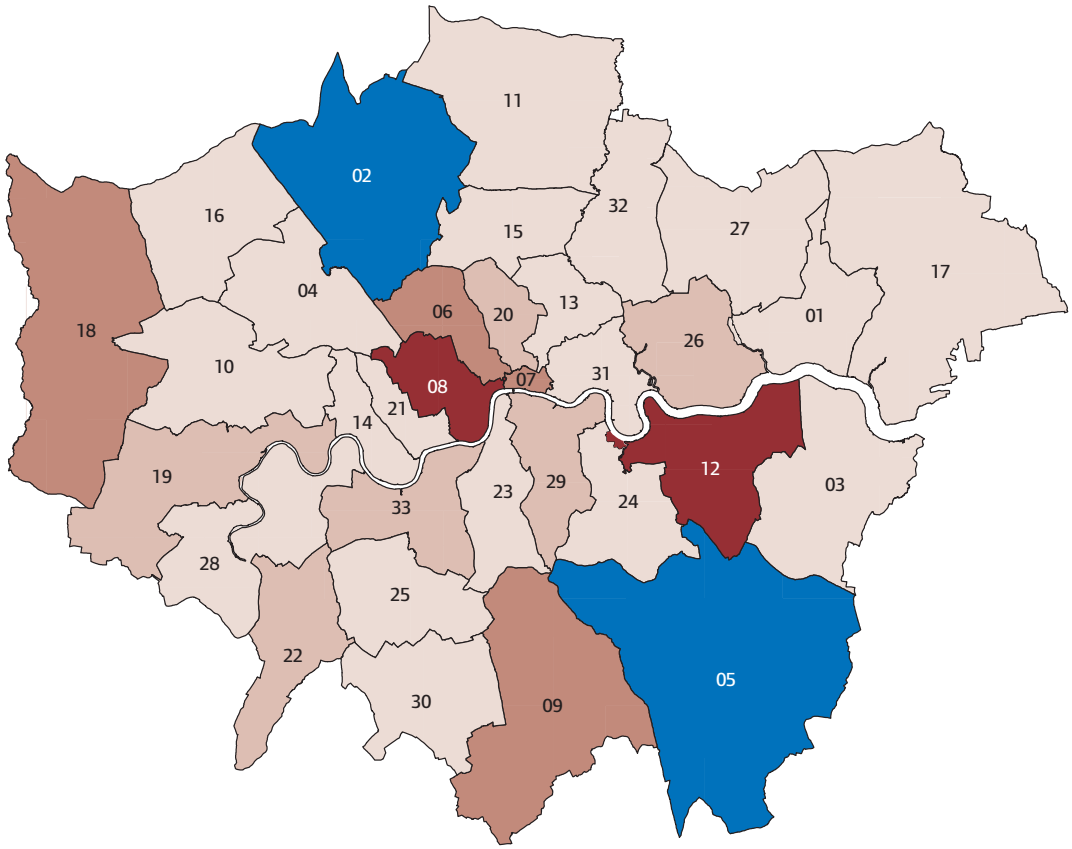
01 Barking and Dagenham	12 Greenwich	23 Lambeth	9,400 to 9,550 (2)
02 Barnet	13 Hackney	24 Lewisham	3,900 to 9,400 (4)
03 Bexley	14 Hammersmith and Fulham	25 Merton	1,600 to 3,900 (8)
04 Brent	15 Haringey	26 Newham	0 to 1,600 (19)
05 Bromley	16 Harrow	27 Redbridge	
06 Camden	17 Havering	28 Richmond upon Thames	
07 City of London	18 Hillingdon	29 Southwark	
08 City of Westminster	19 Hounslow	30 Sutton	
09 Croydon	20 Islington	31 Tower Hamlets	
10 Ealing	21 Kensington and Chelsea	32 Waltham Forest	
11 Enfield	22 Kingston upon Thames	33 Wandsworth	

Figure 2.9 Change in Professional Services employee jobs between 1995 and 2000
Total change: 67,600



Source: ABI, re-scaled Annual Employment Survey

Figure 2.10 Change in Recruitment and Agencies employee jobs between 1995 and 2000
Total change: 79,741



Source: ABI, re-scaled Annual Employment Survey

01 Barking and Dagenham
02 Barnet
03 Bexley
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07 City of London
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09 Croydon
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25 Merton
26 Newham
27 Redbridge
28 Richmond upon Thames
29 Southwark
30 Sutton
31 Tower Hamlets
32 Waltham Forest
33 Wandsworth

9,000 to 13,500 (2)
4,000 to 9,000 (4)
2,450 to 4,000 (6)
0 to 2,450 (19)
-900 to 0 (2)

district (which includes Canary Wharf and, perhaps, Stratford). It is likely that the bulk of mainstream financial and business services will remain clustered in this central district. Leading financial organisations elect to locate close to their competitors and peers, with specialist support services, such as legal, accountancy and management consultancy, growing up around these clusters.

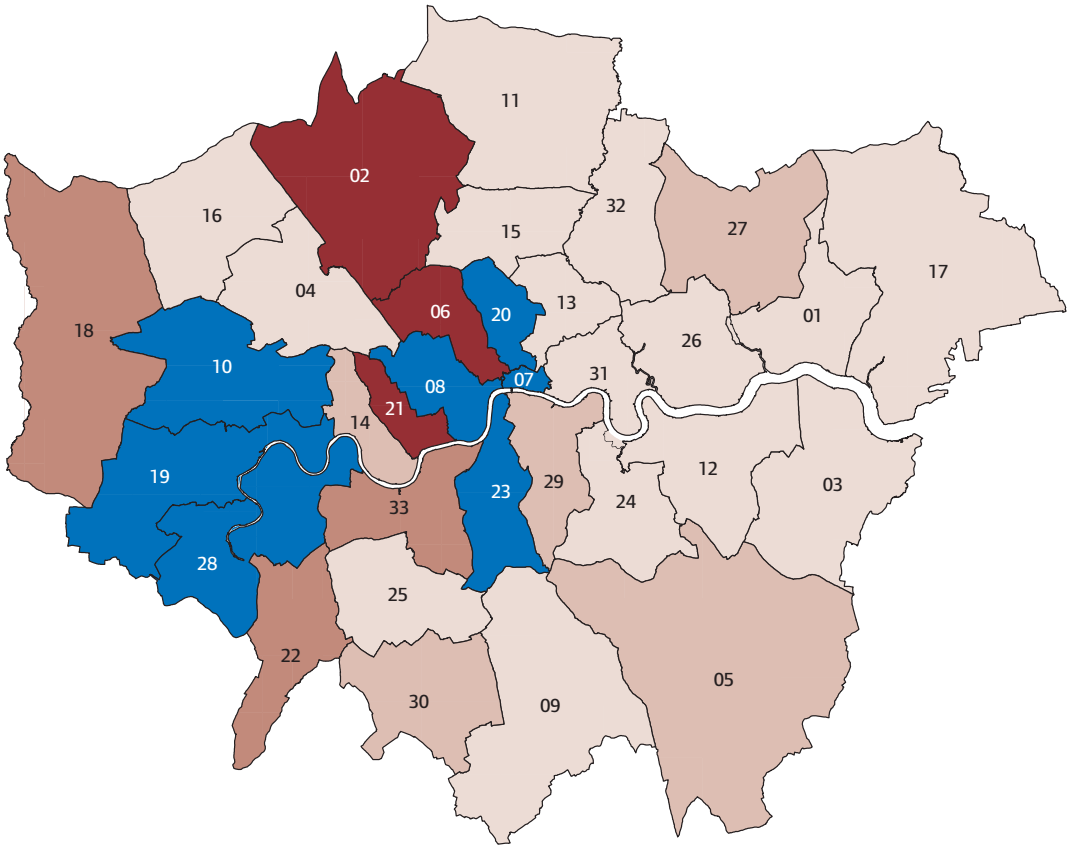
Not all future growth in these sectors will be restricted to the central area. An increase in an area's population or residentialisation will tend to increase the demand for services related, for example, to buying and selling houses. Merton, Ealing and Greenwich, for example, gained around 12,000 jobs in the 12 years to 2000. A London Office Policy review commissioned by the Mayor has shown that some outer London town centres can absorb a greater proportion of demand for office space; the review identifies Bromley, Croydon, Enfield and Stratford town centres as being suitable for office development because of their good public transport links and available labour. Use of information and communications technology also provides new opportunities for working from home and home-based self-employment in business services such as training and consultancy.

Other services tend to be much more dispersed across London. As the GLA's report on 'Creativity: London's Core Business' has shown, outside the dominant West End, creative industries – the most rapidly growing sector in London – showed strongest growth between 1995-2000 in Hounslow. Although growth rates were strongest in boroughs with existing high concentrations of creative activities, notable growth was also recorded in some outer boroughs where this has traditionally not been the case, such as Havering, Merton, Enfield, Barnet and Harrow.

In other sectors, growth in retail jobs has been led by Barnet, followed by Kensington and Chelsea, Camden, Kingston upon Thames, Wandsworth, Hillingdon, Redbridge and Bromley (figure 2.11). Hotel and catering jobs have increased in almost every borough, with growth increasingly in boroughs outside the central area, such as Brent, Islington, Lambeth and Barnet (figure 2.12). The personally-oriented services (including recreational and personal services) have also grown across the city, with particular growth in Westminster and Camden, Hammersmith and Fulham, Lambeth, Islington, Kensington and Chelsea, the City and Hounslow (figure 2.13). Growth in these sectors is likely to be driven by residentialisation and ready access. Other growth sectors, such as wholesaling, are driven by location – it is outer boroughs such as Barnet, Hillingdon, Sutton and Croydon, which have shown most jobs growth in wholesaling (figure 2.14).

Other growth sectors, such as wholesaling, are driven by location...

Figure 2.11 Change in Retail employee jobs between 1989 and 2000
Total change: 42,400



Source: "Making Sense of the ABI" EBS, GLA Economics

01 Barking and Dagenham
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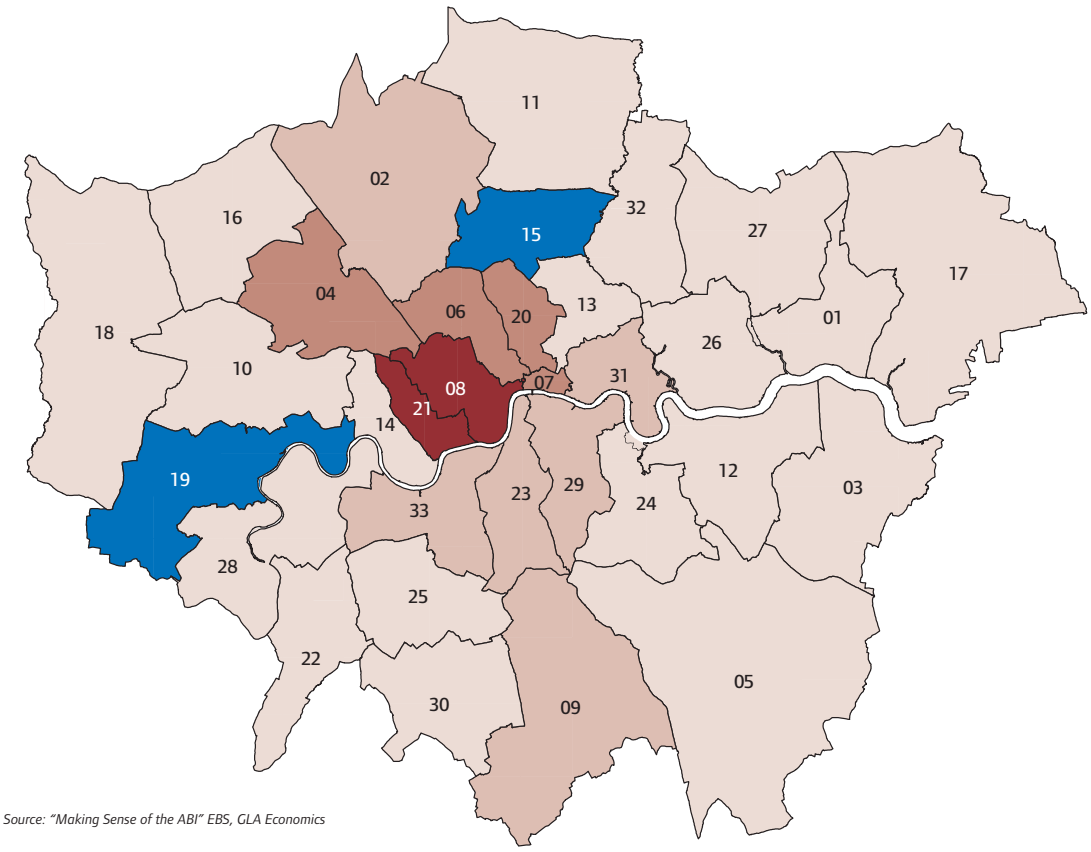
28 Richmond upon Thames
29 Southwark
30 Sutton
31 Tower Hamlets
32 Waltham Forest
33 Wandsworth

3,700 to 7,500 (3)
3,050 to 3,700 (3)
1,400 to 3,050 (5)
0 to 1,400 (15)
-4,400 to 0 (7)

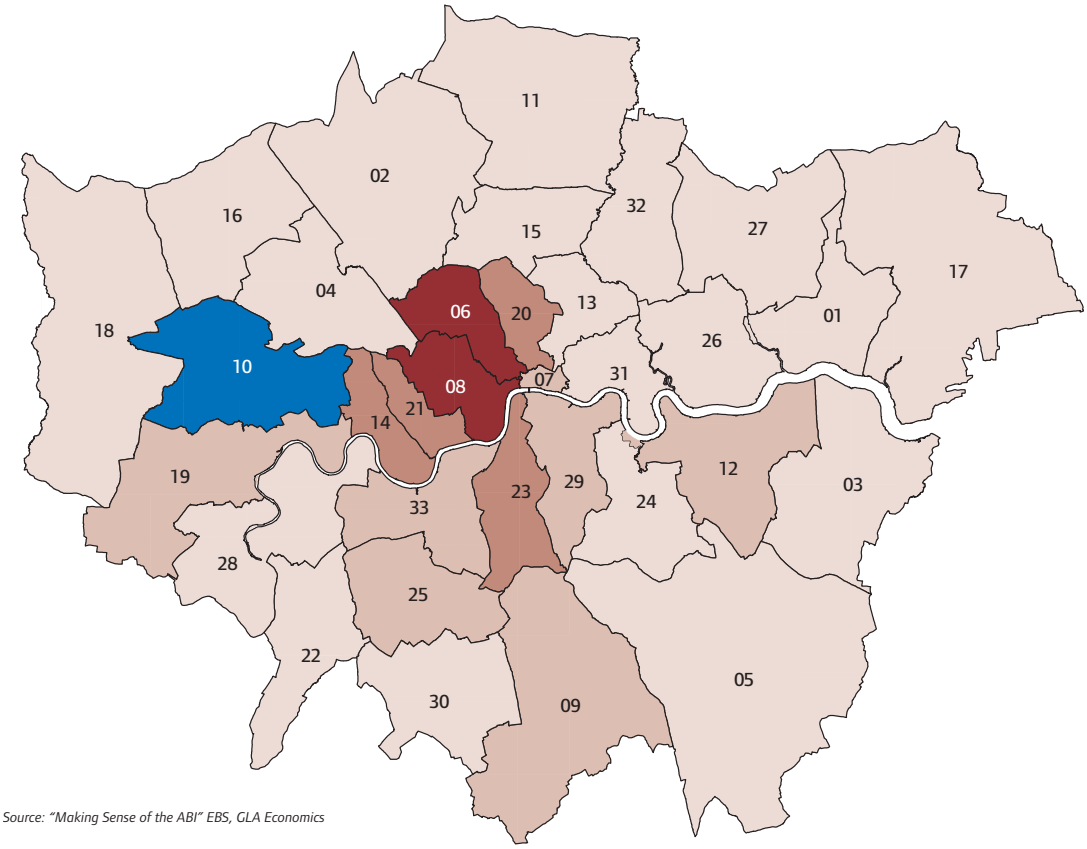
Figure 2.12 Change in Hotels and Catering employee jobs between 1989 and 2000
Total change: 76,100



Source: "Making Sense of the ABI" EBS, GLA Economics

- 6,250 to 17,900 (2)
- 3,450 to 6,250 (4)
- 2,100 to 3,450 (6)
- 0 to 2,100 (19)
- -2,200 to 0 (2)

Figure 2.13 Change in Other Services employee jobs between 1989 and 2000
Total change: 95,200



Source: "Making Sense of the ABI" EBS, GLA Economics

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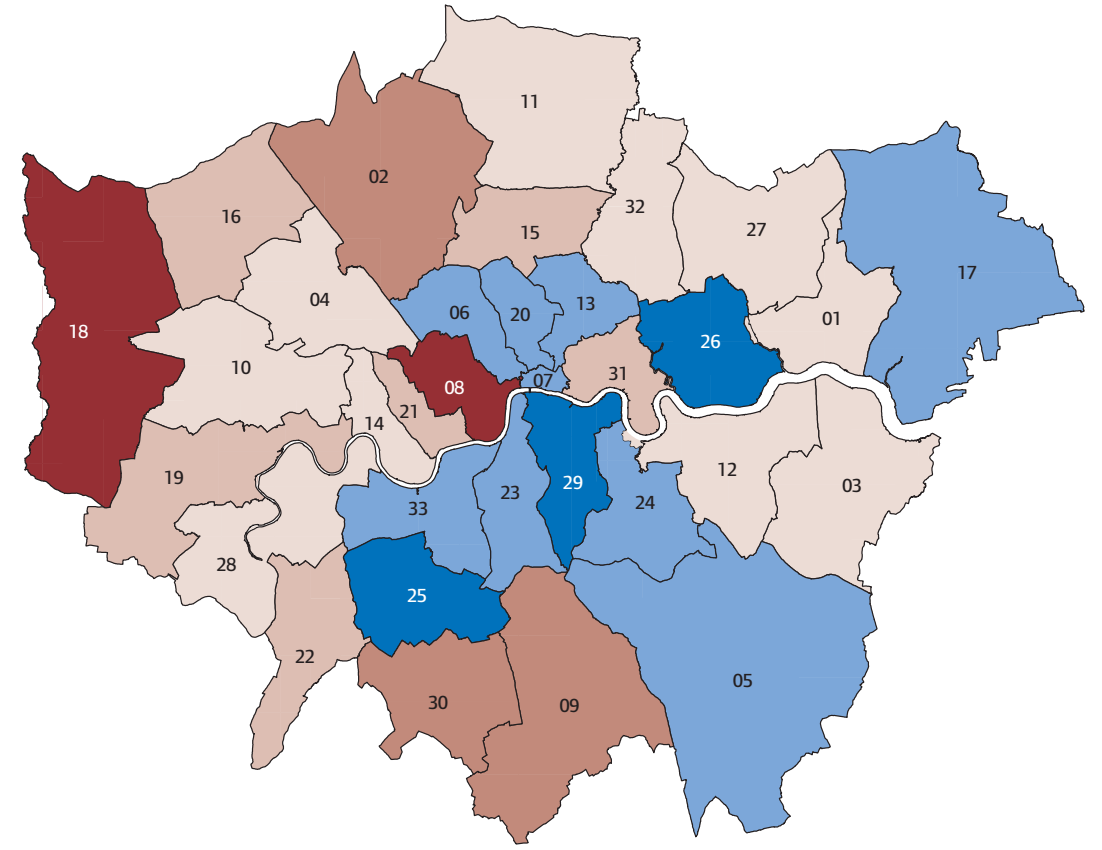
25 Merton
26 Newham
27 Redbridge
28 Richmond upon Thames
29 Southwark
30 Sutton
31 Tower Hamlets
32 Waltham Forest
33 Wandsworth

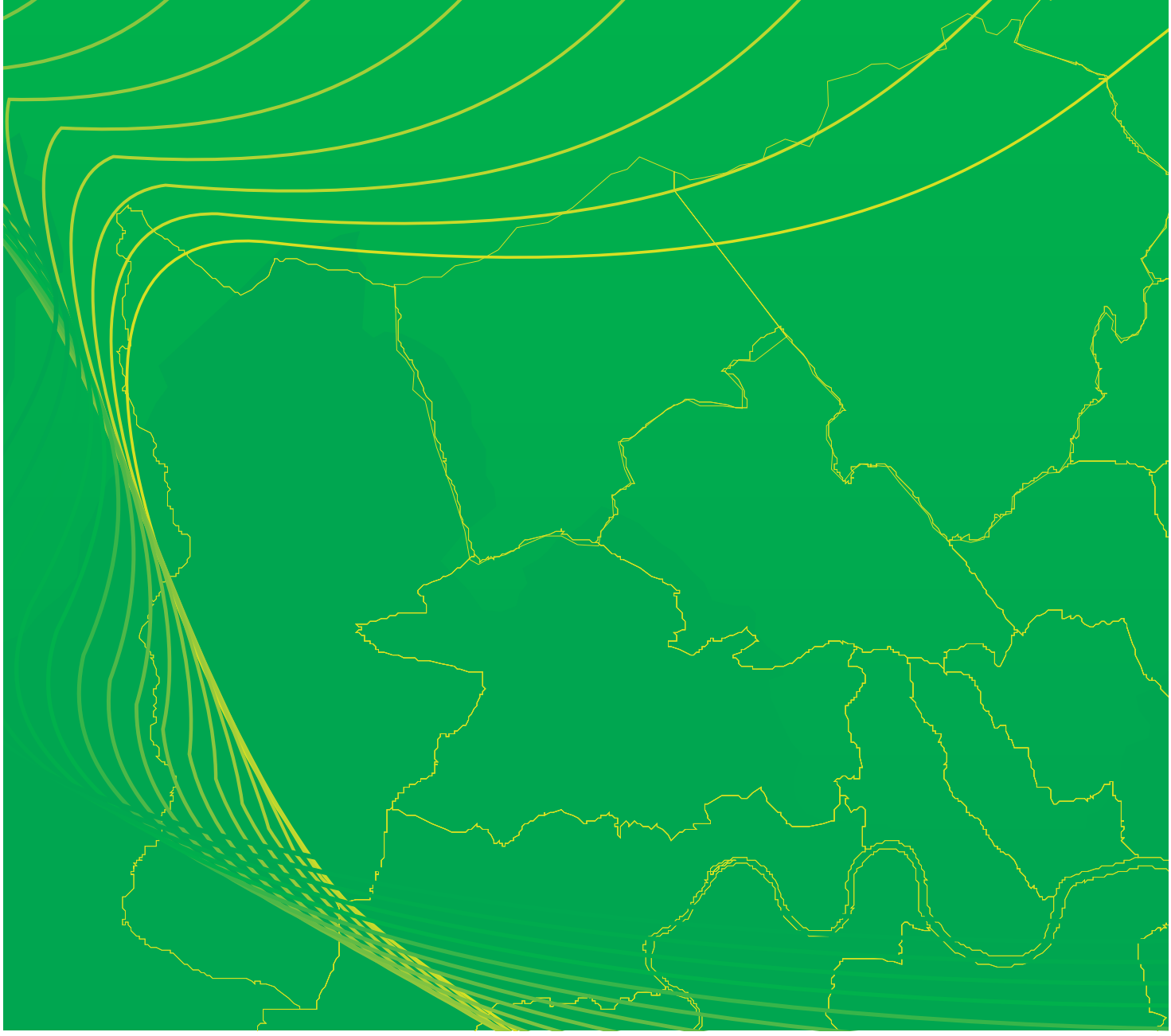
9,200 to 17,200 (2)
4,400 to 9,200 (4)
2,350 to 4,400 (7)
0 to 2,350 (19)
-700 to 0 (1)

Figure 2.14 Change in Wholesale employee jobs between 1989 and 2000
Total change: 15,700



Source: "Making Sense of the ABI" EBS, GLA Economics

In the majority of London boroughs, planning completions for retail, finance and professional, and other office based industries since the peak of the current business cycle in 2001, have outweighed those for the traditional UK industries combined with the remaining major planning uses.



Types of places

The demands on space arising from the changes described here are revealed when looking at development patterns for some of these growth sectors. In the majority of London boroughs, planning completions for retail, finance and professional, and other office based industries since the peak of the current business cycle in 2001, have outweighed those for the traditional UK industries combined with the remaining major planning uses (figure 3.1).

We have also classified wards by their density of jobs and population using the methods discussed earlier. The results are shown in figures 3.2 and 3.3, and give six different types of ward. As might be expected, a largely concentric picture emerges; the innermost wards have high employment and population densities; these tend to fall together as distance from the centre increases (table 3.1).

When the densities for 2000 are compared with those in 1989 (table 3.2), a moderate yet distinct pattern of change emerges. While both population and employment densities in inner London have increased, in outer boroughs employment densities have decreased in most places. Between 1989 and 2000 the general pattern of the

Table 3.1 Cluster analysis – wards by areas and density of employment/population

Cluster	*Area (sq. km)*	*Employment density (people per sq. km)*	*Population density (people per sq. km)*	*Cluster size*
1	*1.3*	*46189*	*6903*	*13*
2	*0.6*	*4887*	*14257*	*107*
3	*1.0*	*3502*	*9169*	*174*
4	*1.7*	*1658*	*5572*	*268*
5	*3.2*	*1413*	*3282*	*156*
6	*8.9*	*570*	*1446*	*39*

Source: Volterra Consulting, November 2002

Table 3.2 Percentage change from 1989 cluster centres to 2000 cluster centres with 1989 area clustering

Cluster	*Area (% change)*	*Employment density (% change)*	*Population density (% change)*	*Cluster size*
1	*-4.5*	*6.5*	*13*	*-7.7*
2	*4.4*	*0.6*	*3.1*	*22.4*
3	*7.5*	*-5.8*	*2.5*	*-2.3*
4	*1.6*	*-9.9*	*1.8*	*-4.9*
5	*1.1*	*-5.7*	*2.4*	*-3.8*
6	*0.3*	*1.4*	*4.1*	*0.0*

Source: Volterra Consulting, November 2002

clusters does not change much, but there are signs over this period of intensification of employment growth in the central area. Table 3.2 also shows how employment density and population density have both increased in the central clusters 1 and 2, which together now also include more wards.

More jobs in fewer places – the importance of centres

As the map showing employment growth by ward (figure 3.4) demonstrates, while most boroughs have seen an increase in the number of jobs in recent years, these have been more and more focussed on defined centres in outer London areas. These maps also show that increases in population, and the housing needed to accommodate it, are not necessarily enemies of job creation. Although there is not an exact relationship, jobs and population tend to grow together. In broad terms, boroughs to the north and west of London experienced above average population and jobs growth between 1989 and 2000, while the opposite has happened to the south and east.

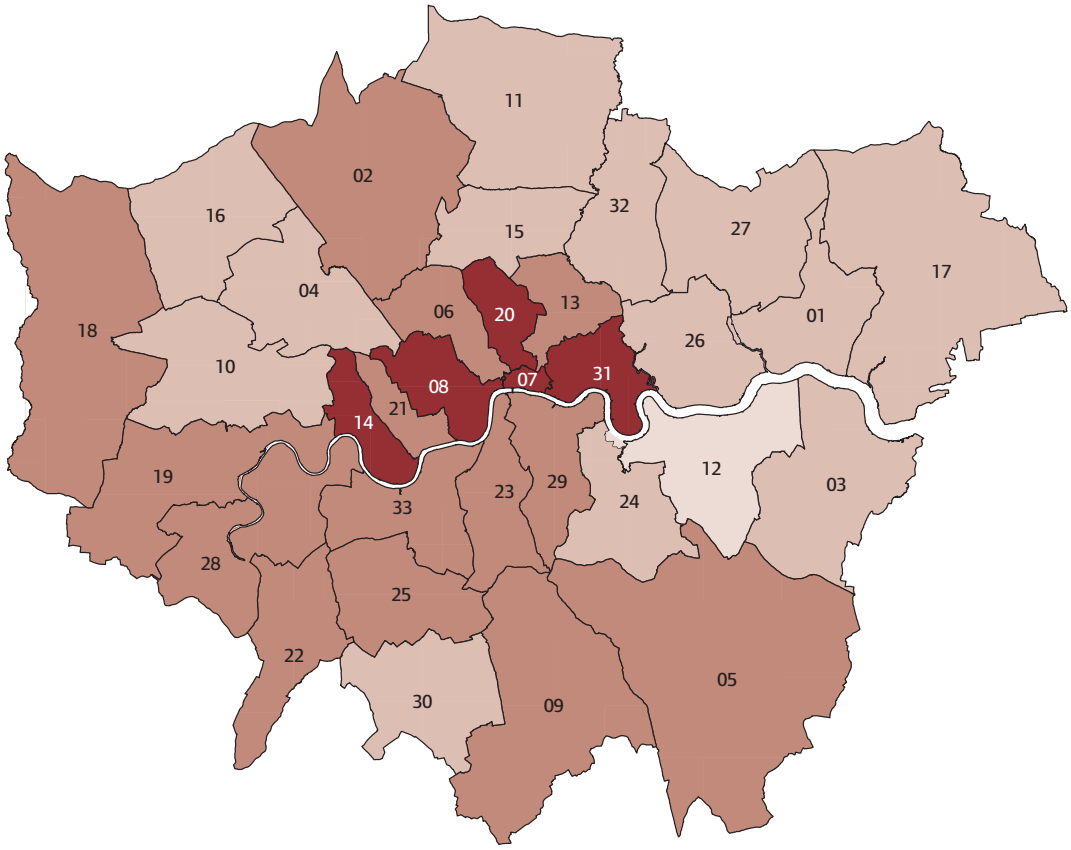
The importance of centres is highlighted by the provisional results of an exercise developed by the Centre for Advanced Spatial Analysis at University College London for the Office of the Deputy Prime Minister, which uses London as a pilot study for a new approach to producing town centre statistics. The exercise mapped the type and intensity of economic activity, diversity of town centre activities and intensity of property development in 147 town centre areas in London. Inevitably, the map (figure 3.5) of London centres is dominated by the central area, but the provisional results drive home the significance of the link between town centres and jobs for London as a whole – 61 per cent of comparison (non-food and drink) retail employment and 59 per cent of jobs in bars and restaurants are located in town centres. London's centres provide 70 per cent of commercial office employment and 62 per cent of public service jobs. Particularly in outer London, town centres provide opportunities in a wide range of sectors and occupations (in south London, for example, finance and business services in Bromley and Croydon, retail and publishing in Sutton and a university and county council headquarters in Kingston).

Working in services

There are often concerns about the value of service sector jobs – all too often they are caricatured as being low skill, low pay jobs with few opportunities for advancement. Conditions of employment are obviously important to both the health of local economies and to promoting social inclusion across London. In all sectors, the 1990s showed growth in demand for managers and administrators, professionals and associate professional and technical occupations, while jobs in other categories declined. In almost every borough, there were proportionately more employees in skilled professional occupations by the end of the 1990s than at their start; this was accompanied by a corresponding London-wide decline in less-skilled activities. Demand for employees with higher-level skills is growing. As the LDA analysis of sub-regional economies shows, there is a close relationship between the proportion of employment in highly skilled jobs and employment growth. In one third of London boroughs – the City of London, Westminster, Kensington and Chelsea, Camden, Hammersmith and Fulham, Ealing, Islington, Tower Hamlets, Southwark and Richmond upon Thames – the proportion of the workforce in skilled professional occupations now equals or exceeds those in less skilled jobs.

In short, London has more knowledge-intensive sectors to its economy than any other UK region. It is these sectors that are growing strongly and creating skilled jobs for the future.

Figure 3.1 Retail, Finance and Professional, Restaurants and Pubs, Office and Light Industry Planning Completions as a percentage of the accumulative total completions 1989 to present



Source: London Development Monitoring System

01 Barking and Dagenham
02 Barnet
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06 Camden
07 City of London
08 City of Westminster
09 Croydon
10 Ealing
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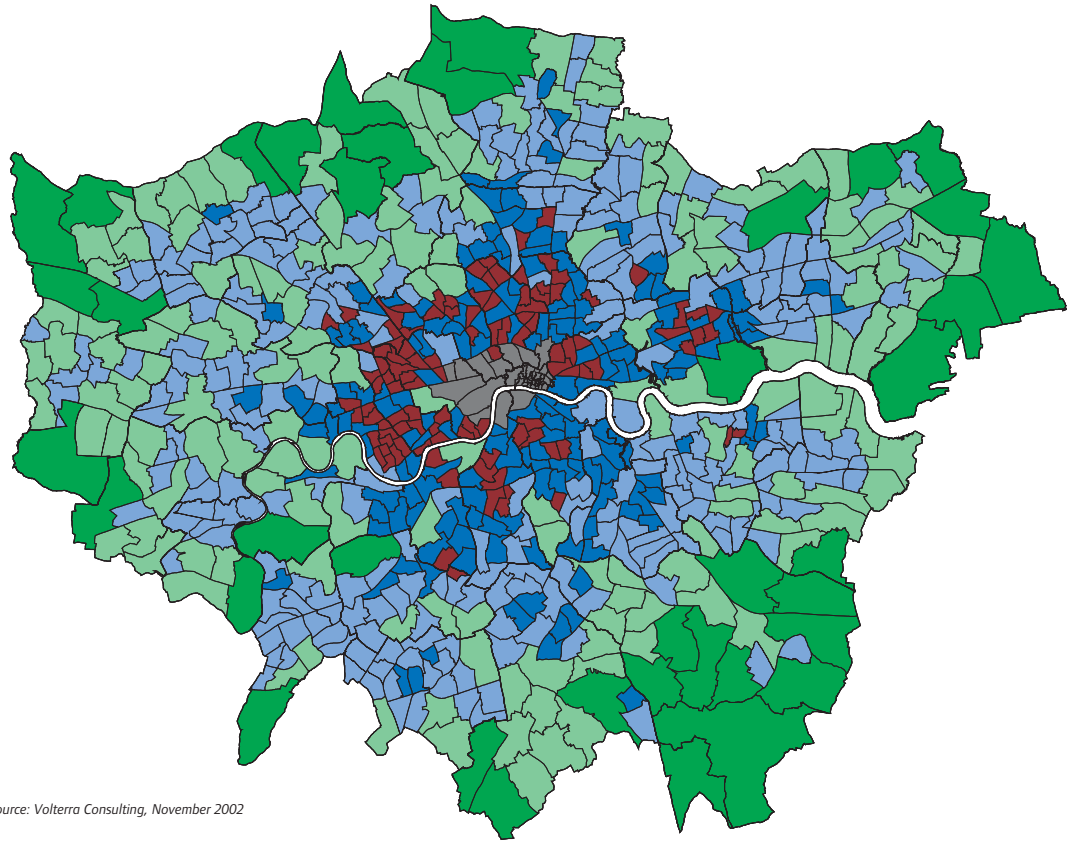
23 Lambeth
24 Lewisham
25 Merton
26 Newham
27 Redbridge
28 Richmond upon Thames
29 Southwark
30 Sutton
31 Tower Hamlets
32 Waltham Forest
33 Wandsworth

75% to 100% (5)
50% to 75% (14)
25% to 50% (13)
0 to 25% (1)

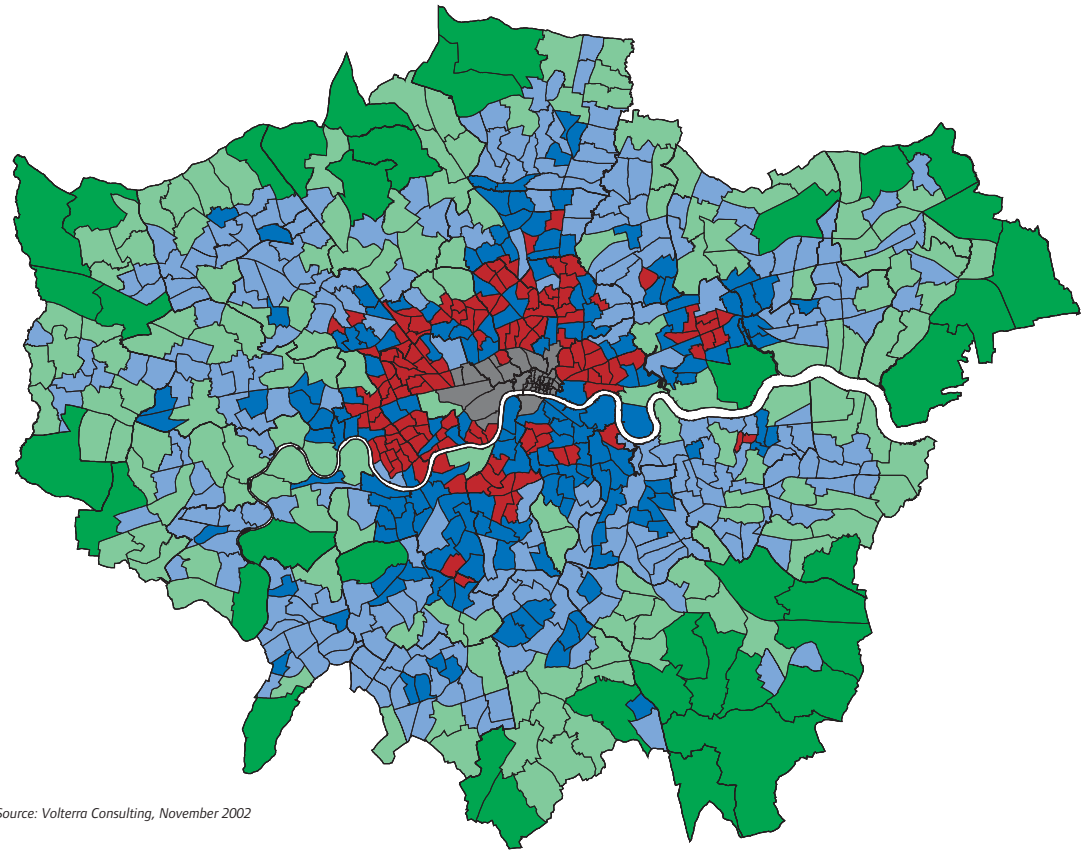
Figure 3.2 Area clustering 1989/91



Source: Volterra Consulting, November 2002

Cluster 1 (38)
Cluster 2 (107)
Cluster 3 (174)
Cluster 4 (268)
Cluster 5 (156)
Cluster 6 (39)

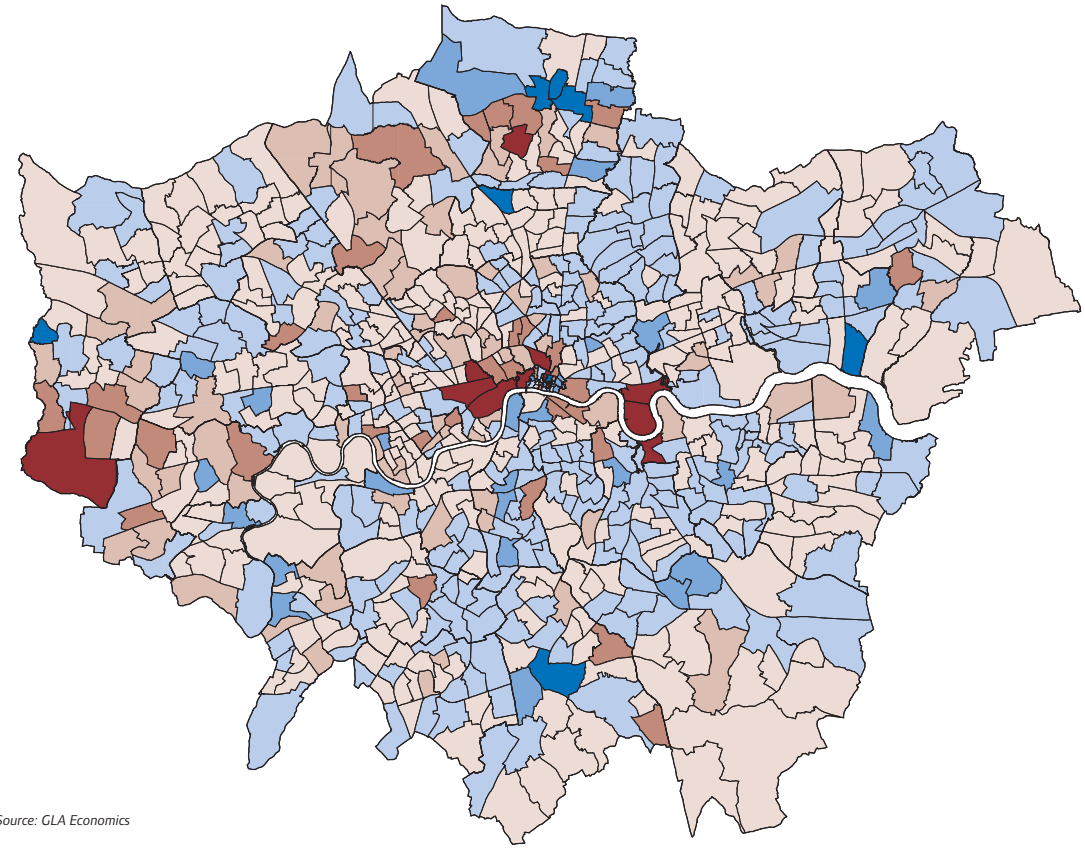
Figure 3.3 Area data 2000/01 with 1989/91 clustering



Source: Volterra Consulting, November 2002

- Cluster 1 (37)
- Cluster 2 (131)
- Cluster 3 (170)
- Cluster 4 (255)
- Cluster 5 (150)
- Cluster 6 (39)

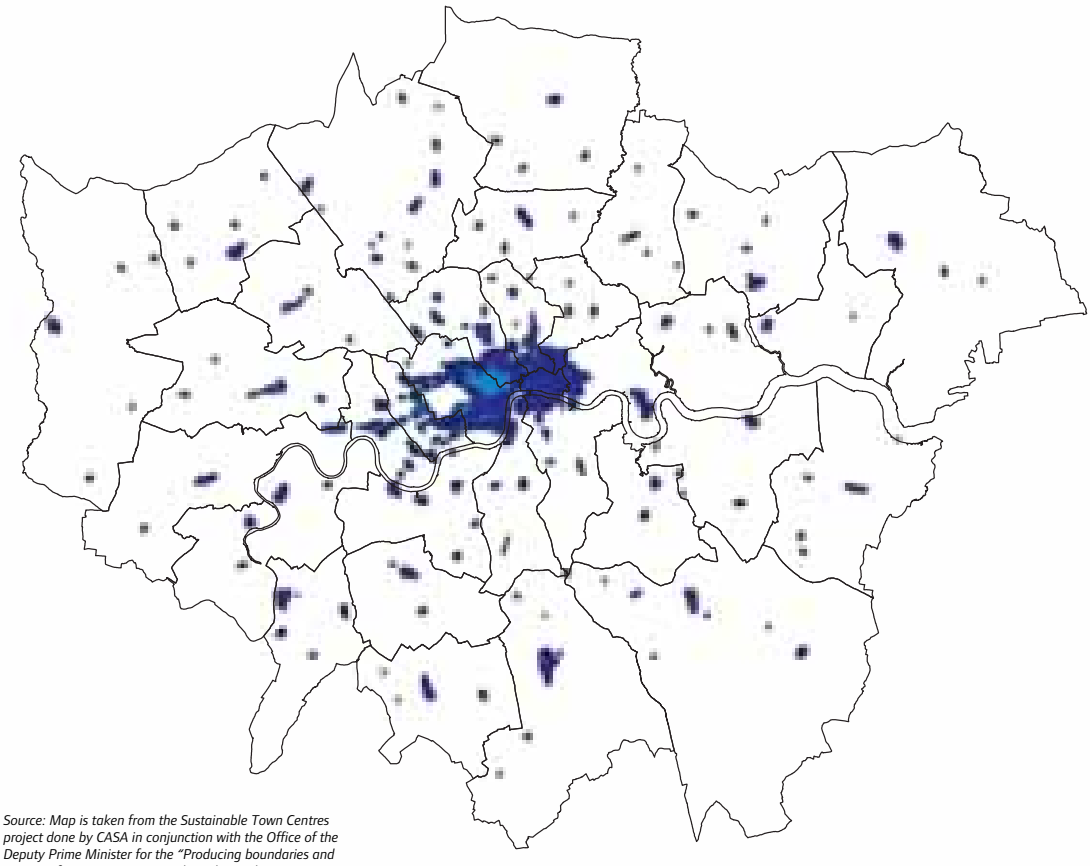
Figure 3.4 Change in Total employees by ward between 1989 and 2000
Total change: 270,600



Source: GLA Economics

9,000 to 31,000 (11)
3,000 to 9,000 (36)
1,400 to 3,000 (77)
0 to 1,400 (335)
-2,200 to 0 (284)
-7,000 to -2,200 (31)
-18,700 to -7,000 (8)

Figure 3.5 Map of London town centers



Source: Map is taken from the Sustainable Town Centres project done by CASA in conjunction with the Office of the Deputy Prime Minister for the "Producing boundaries and statistics for town centres: London pilot study summary" report. The map has been reproduced with the permission of Her Majesties Stationary Office and Ordnance Survey.

The patterns of job creation in the various areas of London reflect the city's diversity. While overall trends are clear, the detailed picture at borough level is much more complex.

Having reviewed the employment market across London, attention will now be given to policy approaches that local decision-makers might consider in order to help maximise local benefit from the changing trends. This section draws on the experience of five London boroughs which have faced particularly significant economic changes in recent years: Croydon, Enfield, Hammersmith and Fulham, Redbridge and Wandsworth.

This report has focussed on the service sectors, and it is important to bear in mind that these fall into different broad categories:

• Some have to be delivered 'face-to-face' (such as beauty treatments and restaurants). These must be located close to the markets they serve, and location will be determined by the compactness or spread of their customer base.

• Others have a strong tendency to 'cluster', either because easy transfer of information and ideas is important to them, or because they need complex or scarce support services. Growth in these sectors will tend to be from an existing location that already has critical mass.

• A third group consists of services less tied to particular locations. Where these are of routine or low value, they will tend to be located in areas where expenses such as land and operating costs are lower.

Of course, some services may fall into more than one of these categories, while others may move from one to another as patterns of demand, working and delivery methods change. These factors need to be taken into account in considering how policies can best be oriented to encourage location of growth sectors in particular places.

The patterns of job creation in the various areas of London reflect the city's diversity. While overall trends are clear, the detailed picture at borough level is much more complex. All decision-makers responsible for policy on regeneration, education, training or promoting economic, environmental or social well-being, will need to understand what is happening in London and in their local areas if their objectives are to be attained. The need for a sound evidence base for strategy development and service delivery led the GLA Group to establish GLA Economics to provide data and analysis; boroughs and London's Learning and Skills Councils should also continue to review the information resources available to them and consider ways of addressing gaps. While not all boroughs have dedicated research resources (as in Hammersmith and Fulham), there may be scope for joint working – between boroughs and Learning and Skills Councils at sub-regional level, for example – to provide a capacity of this kind. GLA Economics is looking at how it can develop its work to provide data at sub-regional and local levels, to help support work of this kind.

While overall trends are clear, the detailed picture at borough level is much more complex.

Decision-makers need to pay attention to the broader changes being experienced in the sub-regional and regional economy, and not just to what is happening locally. They need to have an awareness of the implications of their spatial location, and its relationship with what is happening in other parts of London – and outside. Redbridge, for example, in making plans for Ilford town centre, has explicitly identified and built upon its location in relation to forthcoming developments in the Thames Gateway. This report has touched on reasons why service sector businesses locate in particular places. A good spatial awareness will help identify the relevant factors applying in a particular place.

As the draft London Plan makes clear, every part of London has potential for jobs growth. In addition to the very large-scale opportunity areas identified in the Plan, there are also many places with established infrastructure where additional employment can be created and sustained, building on existing and emerging sectoral strengths. Much of this activity will be in town centres, like Croydon, where there are sites available for development now and others that could become available in the future.

The evidence highlights the importance of town centres as employment bases, particularly in outer boroughs. This underscores the emphasis on supporting and developing centres in the draft London Plan, which envisages a wide role for centres as locations for leisure and cultural activities, business, housing, public and community services, as well as retail services. All of the boroughs that were visited in preparing this report, were concerned with maximising the benefits of their town centres while recognising that not every town centre can provide a universal range of services and opportunities:

- Wandsworth has targeted policies for each of its principal town centres, seeking to identify a niche for all of them and helping them to fill this role. These policies include attention to environmental issues, traffic and parking, and are implemented by five town centre managers. The centres are at the heart of the Borough's economic development strategy, as locations for growth sectors such as IT consultancies, financial advisers, property specialists and other local business services alongside retail and leisure activities.

- Redbridge and Croydon, with metropolitan shopping centres in their main towns, are both engaged in ambitious schemes to place town centres at the heart of regeneration. 'Progressive Ilford' is the title of Redbridge Council's plans to expand and diversify Ilford through mixed-use development at a higher residential density than at present. These plans emphasise the importance of rebuilding

town centres as places to live, as well as to work and shop.

Accessibility is central to improving the potential for job creation – firms will locate only in places employees can get to and where the goods and services they provide can easily reach customers. The Mayor's Transport Strategy identifies a range of major transport and infrastructure projects to improve accessibility to key centres. Boroughs can also develop local schemes to improve transport, both to enhance accessibility of people to jobs, and firms to markets (Transport for London provides guidance on the most appropriate schemes to meet the Mayor's transport strategy objectives.)

Economic and spatial trends, and the importance of centres, need to be taken into account by boroughs in making decisions about land use in their strategic planning and landholding policies. The draft London Plan encourages boroughs to manage the protection, release or enhancement of former employment sites. In drawing these policies up, there is a need for realism about the likelihood of sites formerly used for manufacturing being reused in their entirety for employment uses alone. As has been shown, given the link between population and employment, new housing is not necessarily the enemy of jobs. Redbridge, for example, having lost a once-substantial base in engineering and electronics, acknowledges its current status as a suburban economy. The enhancement of Ilford town centre and protection of other local centres demonstrates the importance the council attaches to developing and sustaining a service-dominated economy. If former industrial land is required for housing, it is often released. Wandsworth has attached a great deal of importance to promoting small business development and, through adjusting its strategic planning policies to meet what it perceives as market needs, it promotes mixed-use developments combining housing and employment in ways intended to promote a more entrepreneurial climate in the borough.

Of course, there are key parts of London where manufacturing is still of key importance. In such places, it is worth taking steps to promote and encourage the types of high-value added manufacturing that are increasingly necessary for the sector's survival (see the GLA report on cultural industries). Even in these areas, however, the secular trend of declining employment in manufacturing is likely to continue, if at a slower rate, and policy approaches aimed at managing and slowing this decline will remain appropriate. This will mean nurturing new high value-added, design-linked production industries. Enfield Council, for example, has taken steps to enhance its industrial estates in partnership with the private

Accessibility is central to improving the potential for job creation.

sector. It has attracted and retained cutting edge sectors, building on its location in relation to the cluster of scientific and technical activity between London and Cambridge. The London Development Agency is coordinating a Production Industries Commission to help develop a more strategic London-wide approach to development of this sector.

New firms, particularly perhaps in the new growth sectors, find it hard to locate accommodation that is affordable and meets their needs. The importance of incubator and other low-cost, supported workspace for emerging and growing business of all kinds is recognised in several boroughs. The significance of this issue can be gauged by considering that less than one per cent of employers in London have 200 or more employees; 85 per cent of businesses employ ten or fewer. In some places successful business start-ups often leave an area when they grow for this reason. Boroughs can make provision for accommodation of this kind in their approach to major development proposals (through use of planning obligations, for example) – Hammersmith and Fulham is promoting subsidised space for small media companies for inclusion in the BBC's current White City redevelopment. These needs can also be taken into account when local authorities and others draw up strategies for the management and use of their own landholdings.

Good environmental quality is also important. Businesses will look for good quality work space in surroundings which provide an attractive, safe and secure environment for staff and customers, and which help sustain a positive image for them. Enfield, for example, has sought to improve the environment on their industrial estates; environmental improvements are also important elements of many boroughs' town centre strategies for these reasons. Experience also shows that a good environment and high quality housing and local services are important in recruiting and retaining staff. Enfield has made a particular feature of these issues in their work to attract inward investment.

The move towards more skilled jobs is another of the human pressures facing the London employment market. Skills shortages cause problems for employers, while lack of sometimes even basic skills can make it difficult for some Londoners to find work.

Lack of skilled employees is not confined to specialised high-tech occupations; the hotel and catering sector – one of those with a high level of projected growth – is already facing acute problems of staff and specific skill shortages that are hampering its expansion.

The London Skills Commission has published a Framework for Employment and Skills Action (FRESA) to shape support for skills and employment across the capital. Its priority theme is to develop a strong, healthy labour market, reflecting the critical issues of equality and diversity. The FRESA's strategic objectives include: ensuring access to employment and training for those needing them, enabling the excluded to access learning and sustainable employment, enabling London's employers to recruit and retain the skilled workers they need, and encouraging provision of training and services which are market sensitive and matching the needs of London's workforce. Flagship initiatives to help kick start the implementation of the framework include:

- London Higher Level Skills, aimed at embedding science, technology, engineering and maths skills demands.
- A programme to address information and communications technology skills shortages in small and medium-sized businesses.
- A media sector skills development programme.

Again, these themes are already being addressed by boroughs committed to ensuring that emerging job opportunities are widely available to local people. Hammersmith and Fulham, for example, emphasises the need for more coordinated employment support services with specialist provision for ethnic minority groups, and for more intensive support for individuals lacking the basic skills needed to successfully seek work. Croydon has adopted a 'person-centred, rather than property based' approach to supporting business start-ups, seeking to identify and support individuals with potential to become successful entrepreneurs. In disadvantaged communities, specific obstacles are addressed, such as basic skills, language, initial finance and premises. A council-funded project helps the long-term unemployed, women and ethnic minorities, turn creative skills and hobbies into income generating businesses.

Finally, discussions with boroughs show how important it is to build good relationships between the public and private sectors. Effective policy-making and implementation is possible only where both sides of the partnership understand each other and the challenges and issues each faces.

Taken in isolation, none of the ideas presented here may appear particularly original or unexpected. Many of them have been adopted in different places, with varying degrees of success. But they do show what is possible against the background of the changes to London's economic structure. They are approaches the Mayor, the London Development Agency and the rest of the GLA Group will be supporting and underlay the policies in the draft London Plan and other strategies.

This report has shown how all parts of London can make – and already are making – a contribution to the balanced and sustainable development of the city, and to tackling problems of joblessness and social exclusion. If London is to thrive, there must be opportunities suitable for all across the city as a whole. As has been shown, there are a range of measures that sub-regional and local decision-makers can take to understand the forces shaping the economy of our city, making them work for the benefit of its people.

This document is only the start, marking the beginning of debate and discussion with boroughs and others involved in local economic development in the public, private and voluntary sectors, about what can be done to promote the creation of jobs – and the spreading of success.

Appendix 1:
Case study: boroughs

The five London boroughs considered in compiling this report – Croydon, Enfield, Hammersmith and Fulham, Redbridge and Wandsworth – all underwent notable changes in their economies and employment markets during the 1990s.

Taken over the period from 1989 to 2000 as a whole, the impact of these changes on jobs varied distinctly between the five boroughs. While Enfield lost eight per cent of its jobs and Croydon six per cent, total jobs increased by 27 per cent in Hammersmith and Fulham – the highest percentage rise in all London, outstripping even a 26 per cent increase in Tower Hamlets where the development of Canary Wharf fuelled job creation. Total jobs rose by 19 per cent in Redbridge, while there was no significant change in Wandsworth.

However, in the more recent years of the period – between 1996-2000 – all five boroughs experienced double-figure growth in both total and full-time employment. Total employment growth can be seen in table 1.1.

Growth in the proportion of skilled professional employees in local workforces was a common pattern across the five boroughs during the 1990s, allied to reductions in numbers in other occupations.

Hammersmith and Fulham, both in 1996 and 2000, had the highest average wage of the five boroughs. In 2000, gross weekly earnings in Hammersmith and Fulham were (rounded to nearest £1) £485, compared with £414 in Wandsworth, £374 in Enfield, £379 in Croydon and £338 in Redbridge.

In London as a whole, manufacturing employment declined by 30 per cent between 1989 and 2000. Three of the five boroughs, reflecting long traditions of industrial employment, shed manufacturing jobs in excess of this rate: these were Croydon (-53 per cent), Enfield (-50 per cent) and Wandsworth (-40 per cent), while Redbridge was close to the London average (-28 per cent). Hammersmith and Fulham was, with Richmond-upon-Thames, one of only two boroughs to record any rise in manufacturing employment whatsoever during the 1990s. Although the Hammersmith and Fulham percentage increase was an impressive-looking 59 per cent, it nonetheless represented only 2,500 new jobs.

Employment in computer and related activities throughout London rose by 133 per cent during the 1990s, to more than 120,000 jobs by 2000. Three of the boroughs, Hammersmith and Fulham, Enfield and Wandsworth, saw their share of this expanding area of employment rise by well in excess of the London average. Hammersmith and Fulham se another London-wide record with the highest growth rate in the capital – 844 per cent – although, as with manufacturing, the number of new jobs was more modest

Table 1.1 Total employment growth in 1996-2000

	1996	*2000*
Croydon	*121,800*	*141,500*
Enfield	*83,800*	*93,900*
Hammersmith and Fulham	*83,100*	*105,100*
Redbridge	*61,700*	*70,500*
Wandsworth	*95,400*	*106,700*

than the percentage figure might suggest, at 4,600.

In numerical terms, large-scale service activities led the expansion of employment in all five boroughs: services became increasingly central to their economies during the 1990s. Financial and business services, which throughout London increased by 41 per cent between 1989 and 2000, rose by 138 per cent in Hammersmith and Fulham – taking the borough's total number of jobs in those sectors to 29,000 – and by 66 per cent to 27,000 jobs in Wandsworth. While the overall number of jobs (excluding financial and business services) fell by eight per cent across London, Hammersmith and Fulham and Redbridge delivered increases of eight per cent and 12 per cent respectively.

In Croydon, the capital's largest retail area outside central London, retailing employed more than 16,000 people by 2000; by the same year there were over 18,000 jobs in other social and personal services in Hammersmith and Fulham. During the 1990s, however, some of the fastest growth rates were not in these established locations. Retail employment grew by 36 per cent in Wandsworth and 30 per cent in Redbridge – against a London average of 14 per cent. Croydon's jobs in other social and personal services grew by 88 per cent, compared with 56 per cent in London as a whole.

All five boroughs gained population between 1989 and 2000 although, in the cases of Redbridge, Wandsworth and Enfield, this was at substantially lower rates than the overall London increase of eight per cent.

Croydon

Croydon expanded as a commercial centre under post-war policies encouraging migration of jobs and population from central London. The results were remarkable – its 8.5 million square feet of commercial floor space make it one of the largest office centres in the country. Its retail area, currently undergoing enlargement, is already the largest in the south east of England outside central London. Having a large-scale economy in London borough terms, Croydon has an outward looking approach, and in 1995 founded the Edge Cities Network – a grouping of councils across Europe located on the edge of their capital cities – which shares best practice on economic development.

Despite the size of the local economy, Croydon and the other boroughs surrounding the industrial Wandle Valley were affected by the 1980s industrial downturn. Manufacturing now accounts for only eight per cent of Croydon's economy. As part of its efforts to secure a balanced economy, the council has retained support for the sector, and has world-famous companies such as Centronic, Smith Industries, Sigma Aerospace Ltd. and Phillips; a Single Regeneration Budget project is aimed at attracting

further manufacturing investment. In addition, Croydon Council is actively encouraging the development of a Business Innovation Centre and a Science and Business Park, which will provide the infrastructure to encourage the growth of new innovative, high-tech companies that will help to replace some of the jobs lost in the traditional manufacturing sector. Financial and business services are Croydon's biggest sector, contributing 31 per cent of the local economy. Office rents have been stagnant for some years. However, since the introduction of the tram (light rail system) in 2000, and the arrival of such companies as Merrill Lynch, Utell, and the Mourant Group, rents have risen and Croydon expects to see new office development commence shortly. There is currently a shortage of new office space to meet the demands of relocating companies wishing to be in Croydon.

Central to the council's regeneration efforts is a wide-ranging town centre renewal programme, Vision 20/20. Vision 20/20 is a holistic plan that encourages more diversified uses and activities, compatible functions, an integrated transport system, contemporary architectural designs and open spaces to provide the built environment and physical infrastructure to meet businesses' and residents' needs. When complete, Croydon will have more than two million square feet of retail floor space. Many of the 1960s and 1970s buildings dominating the skyline will be redeveloped, adding new leisure, cultural, hotel and residential development. The local 24-hour economy is developing strongly. Allied to physical improvements, the council is working to ensure that the borough is greener, cleaner and has improved air quality and is a place that can be used by all age and social groups, throughout the day and evening.

Enfield

Enfield's approach to regeneration rests on the area's manufacturing heritage. Between 1987 – 1995 the borough lost 18,000 or 60 per cent of its manufacturing jobs; the council is seeking to maintain and develop the manufacturing base that remains, attracting and sustaining new, high value-added production sectors.

This has shown itself in proactive and sophisticated inward investment initiatives, building on its London and local advantages – such as being 'London's greenest borough', having affordable housing and high education standards, and being part of 'the world's most vibrant, culturally-rich city'. The council has a dedicated Business Initiatives Team, strong relationships with the private sector and a record of success – last year it received 1,200 inquiries about available sites and landed 81 inward investors. Over the past decade, the number of

businesses has increased by almost ten per cent. The council has also invested in its industrial estates, developing a public-private partnership model that on one estate has in effect become an industrial version of the business improvement district concept.

A key development is the Innova London Science Park in the Lee Valley, which will offer more than 1.5 million square feet of affordable, state-of-the art business accommodation. It is also home to the London Business Innovation Centre, which works with individuals, businesses, universities and research organisations to encourage the commercial exploitation of innovation.

Hammersmith and Fulham

West London has the capital's most concentrated presence of media-related businesses outside the West End.
In addition to the BBC at White City and Shepherds Bush, there are international media organisations including BskyB, Disney, AOL-Time Warner, Haymarket, HarperCollins, EMI and Chrysalis. Working with Action Acton and the Park Royal Partnership, Hammersmith and Fulham Council has gained commitment from a number of partners to a media strategy intended to 'deliver real and meaningful change in the area'. The ultimate objective is to create a media 'cluster'; steps to achieve this include improving training and recruitment opportunities for local people and increasing the supply of small-business workspace. Key locational advantages identified by the research for the strategy include availability of large-scale business premises that are cheaper than in central London, and quick access to the central area and to national and international transport networks.

The strategy research also shows that a strong local demand for jobs is coupled with 'unrealistic expectations about the types of jobs available to people without high-level skills'. A central objective of the strategy is to enhance coordination and delivery of training to meet employers' specific needs (including customer care, telephone and IT skills) and to offer excluded groups enhanced support.

Workspace is another of the strategy's priorities. Rising demand, with consequent cost increases, is becoming a barrier to growth. Targeting the particular needs of micro-businesses, encouraging planning agreements with developers to provide affordable workspace and investigating ways of subsidising rents, are all under consideration. There are plans to promote a network of different types of workspace under a West London media brand.

Redbridge

Redbridge Council's ambitious plans for Ilford, its main town centre, are an example of the way boroughs are redefining the role of central areas to support new lifestyles and

In numerical terms, large-scale service activities led the expansion of employment in all five boroughs.

economic activities. They envisage diversification to distinguish Ilford from competitor areas, not only in its facilities, but through enhancing environmental quality, the built environment and streetscape. In turn, improvements to Ilford's environment, transport connections and image will boost the currently stagnant office market. The plans seek to reflect the ethnic diversity of the area and, with public transport improvements, turn Ilford into a different experience from more 'suburban, car dominated and retail focused centres'. Once the renewal of the centre has taken place, Ilford 's location should become a major advantage as development of the Thames Gateway proceeds.

A distinctive feature of the plans is that residential development will be a driving force; about 72 per cent of all new floor space proposed over the next 30 years is earmarked for residential use, with homes for 11,000-13,000 ranging from luxury apartments to key worker and assisted housing. It is hoped Ilford will become a prime residential hub serving the City, Docklands and central London.

The council's plans for Ilford sit well with its vision of the borough as an essentially suburban area, playing a support role in London's overall economy. About two-thirds of its population commute elsewhere to work; 90 per cent of its 6,500 businesses employ fewer than ten people and there is little land for industrial expansion. Since losing large numbers of industrial employers, and a back office insurance sector once heavily represented in the borough, the local economy has relied heavily on services. This has encouraged an emphasis on retaining existing businesses and has placed town centres at the heart of the council's regeneration activities.

Wandsworth

The disused Battersea Power Station, closed in 1983, is a monument to a type of employment that no longer exists in Wandsworth. Other closures included Battersea Flour Mills, Prices Candles, Shell Oil Terminal and Charrington/Distillers. There are now plans to reopen the Power Station site for entertainment, leisure, retail, hotel and residential uses, which will encompass all the changes that have taken place since the 1980s in the borough, from an economy containing extensive industrial employment to one based on services and small businesses.

Despite the loss of traditional skills, unemployment in the borough is at its lowest for 25 years – total numbers in work are higher than in the days of industrial employment, and VAT-registered businesses have increased by one third over the past decade. Wandsworth has one of the highest economic activity rates in inner London. Commercial property occupation is high in post-1988 schemes; availability of premises is seen as the biggest barrier to further growth in the borough's base of mainly smaller businesses.

Wandsworth has five main town centres as well as a number of local shopping parades. Improving the centres' ambience, promoting their individual characteristics and exploiting the potential for local business services alongside retail is a priority for the council. Town centres are identified as offering scope for accommodating employment and population growth, and mixed-use development is encouraged. Effective town centre management is seen as essential; this is undertaken on the basis of agreed town centre business plans. Benchmarking and health checks are conducted in each centre to monitor the effectiveness of management initiatives.

Appendix 2:
Fuzzy clustering of London wards

Fuzzy Clustering

The task of forming groups or clusters is well known in applied statistics: it usually goes by the name of cluster analysis. An essential difference of our classification system is the use of a technique called fuzzy clustering rather than standard methods of cluster analysis.

The aim of any clustering exercise is to identify groups of areas in ways that illustrate their similar characteristics and allow comparison with different types of areas. These patterns provide a way of understanding or describing the economic properties of areas.

In standard methods of clustering each area is allocated unequivocally to a single group. This procedure has a significant drawback as there is no way of distinguishing between those on the margin of any particular group from those with the strongest group characteristics. Fuzzy clustering offers a way around this drawback. It combines the ideas of standard clustering methods and fuzzy logic. Instead of forcing each area into a single cluster, it allows a degree of membership to every one of the clusters. In this way, an area can have some aspect of each of the clusters. This is not only a natural extension of the usual clustering techniques but a very powerful way of understanding patterns of local economies.

Data

The first sets of data used in the cluster analysis describe the spatial and demographic characteristics of the wards. The three variables used are land area (in square kilometres), employment density (in jobs per square kilometre) and population density (in people per square kilometre). This data is available at two time points, 1989 and 2000, allowing us to see how London has developed over the last decade in terms of these characteristics.

The second sets of data describe the distribution of employment by different industries, derived from a combination of the Annual Business Inquiry and the Census of Employment. The full set of data produces too much employment information to be useful without causing confusion, and the categories need to be combined into larger sectors for practical use. There are therefore standard ways of aggregating the categories that base them on their function. For example, anything to do with paper and printing is combined into one sector and can be considered to also be part of manufacturing. However, this takes no account of where these industries might be located, nor does it recognise different industries that are related and often found in the same place.

Rather than imposing such a standard classification, we obtained a much better description of employment patterns using sectors based on those categories that were most often located in the same place. These sectors better reflect the way industries are arranged than a system based on more

The aim of any clustering exercise is to identify groups of areas…

theoretical considerations about links between different sorts of jobs.

An important feature of this approach is that the sectors of employment we use are based upon industries which are in practice located near to each other. Conventional classifications are based upon industries whose outputs are similar to each other. In other words, they use a product-driven definition of which industries are part of an aggregate sector of the economy. Our classification is based upon the preferences of companies themselves, as expressed through market-based decisions.

In the employment analysis we use proportions of employment in each ward rather than the absolute levels. This puts all wards on the same footing, reducing the influence of the few central wards with particularly high employment levels. The category Other is made up of sectors of employment that do not fall neatly into the first five categories. This means that we would not necessarily expect types of employment in Other to be located near to each other. For this reason, inclusion of Other in the analysis reduces the statistical clustering power. We therefore only cluster on the first five categories.

In initial screening of the data we note a disparity between variable levels from the 25 wards in the City of London and all other wards in London. When excluding the City, financial employment made up on average 2.5 per cent of a ward's employment in 2000. In the City this average rises over twenty fold to 54 per cent. Average employment density outside the City was around 3,500 jobs per square kilometre in 2000/01. Inside the City the figure is more than thirty times higher at 117,000 jobs per square kilometre. This marked gap can lead to masking of more subtle and interesting results when performing the fuzzy clustering. We therefore exclude the 25 wards contained in the City of London from our analysis. It is worth noting, however, that for mapping purposes we can use a post hoc cluster allocation process to decide which clusters these wards belong to.

Cluster Results

We first look at the clustering results obtained from the area data. After experimentation with different values, the optimum number of clusters for this data turns out to relatively high, at six. With six clusters we get four levels of segregation for the bulk of the data and one further level at each end, representing peripheral City wards and large 'rural' fringe wards. Empirically, we can test for the optimum number of clusters with a statistic known as Dunn's coefficient. Dunn's coefficient tells us how well grouped a set of data is into different clusters. The higher the value, the better the clustering is. In figure 1, the highest Dunn's coefficient comes from a clustering with four clusters. However, it is not until we get up to seven clusters that the coefficient significantly

Employment analysis

Tax funded	*Chiefly education, health and social services and public administration.*
Selling	*Includes retailing and a few other categories such as real estate and estate agencies.*
Heavy	*Primarily manufacturing and construction.*
Intelligent	*Covers computer services, business services not covered by Financial and research and development work.*
Financial	*Financial intermediation, insurance (including broking) and pension funding.*
Other	*All areas of employment not otherwise covered.*

drops. This suggests that the data provides us with good evidence for using six clusters, even though the highest coefficient is for four.

Figure 1 shows the cluster centres of fuzzy clustering with the 1989/91 data. These numbers represent an average of the ward variable values, weighted according to the associated memberships. With the exception of cluster 1, a trend exists through the clusters for all three variables. As land area goes up, employment density and population density go down. We might suspect therefore that as the cluster number goes up we are moving away from central London. This theory is confirmed when we map the results – see the first map in annex 1 of this appendix.

There are several observations we can make about the cluster locations on this first map. Firstly, the periphery of the City spreads slightly to the west. Cluster 2 is also predominantly located in west central London. Clusters three and four are tightly packed, with strong concentrations in south west London. With the exception of Wimbledon Common, Richmond Park and one ward north of the river in Newham, cluster 6 wards are the most countrified, at the edge of greater London. Finally, cluster 5 seems to 'fill-in' the gaps, not having as strong a grouping. One explanation for this is that this cluster represents a lack of employment and population density, unlike clusters 3 and 4 which represent a presence of high employment and population density.

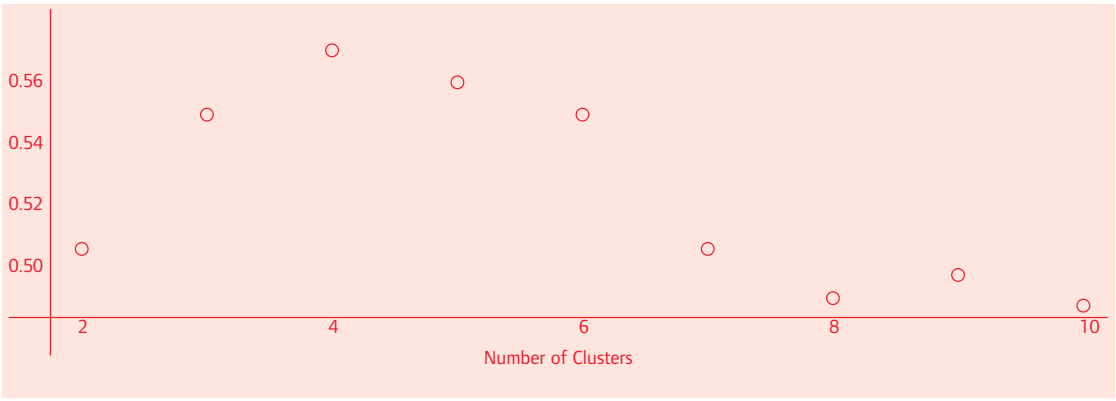
Taking the 1989/91 area fuzzy clustering as a base, we can now 'project' the 2000/01 data onto the same clustering and see how the clusters have changed over the decade. The cluster centres are dictated by strengths of the memberships of the wards to each cluster. After calculating the new 2000/01 memberships with the 1989/91 data, we can use this new weighting to see where the 1989/91 centres have shifted to in 2000/01.

Table 2 shows where the cluster centres have moved to in 2000/01 and table 3 gives percentage differences between the 1989/91 centres and the 2000/01 data cluster centres with the 1989/91 clustering.

Examining table 3, there appears to be one significant trend between 1989/91 and 2000/01. While employment density has risen in cluster 1, and cluster 2 has expanded to include 22 extra wards, employment density has been decreasing in most of outer London – clusters 3, 4 and 5. Also, we can see that population density has been on the increase throughout London, but particularly in central London.

Total London employment experienced a net decrease of around one per cent (there was an increase in jobs of around seven per cent) between 1989 and 2000. Employment has clearly therefore been becoming

Figure 1 Dunn's coefficient for 1989/91 area data – set with 2-10 clusters



See annex 3 for mathematical details

Source: Volterra, November 2002

more centralised. The total population of London on the other hand increased by around 6.5 per cent over the period. Clearly the focus of this population increase has also been in the centre.

We can also reverse the previous process by clustering on the 2000/01 data and seeing how 1989/91 differs from 2000/01 retrospectively. The cluster centres in table 4 look to be very similar to the centres of the 1989/91 clustering. When we map on the 1989/91 data to the 2000/01 clustering, however, we see a mirror image of the previous transition. Moving backwards in time, we see in table 6 that employment density is decreasing in central London while increasing in outer London. Population densities are now falling throughout the six clusters.

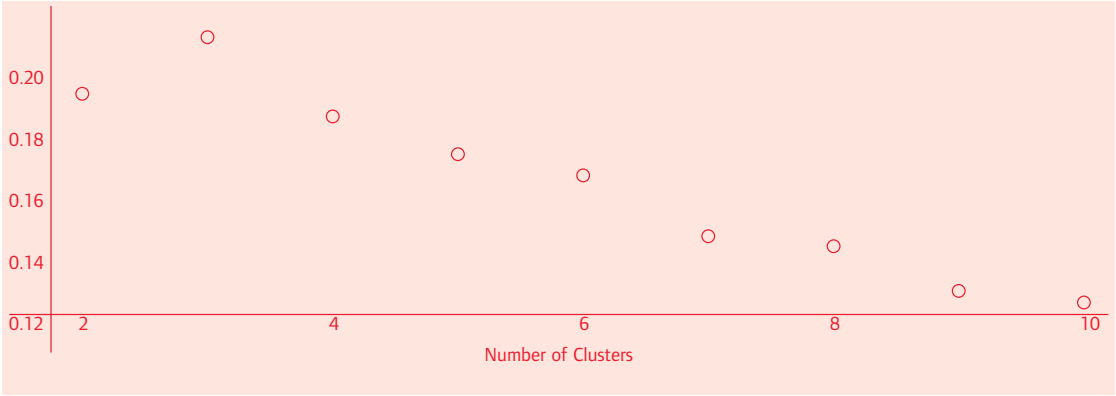
Studying all four of the area clustering maps in annex 1, it is clear that with the exception of a small positive central employment shift over the period, the area characteristics of London have not changed much between 1989/91 and 2000/01. Moving onto the second set of data, we find that the changes in the distribution of employment have been more dramatic.

We start again with a base clustering of the employment proportion data in 1989. Three clusters naturally emerge, which we have named Commercial, Industrial and Public Sector, due to the relative locations of their cluster centres within the five employment types. Examining the Dunn's coefficient results for the employment clustering, it is clearer this time that three is the optimum number of clusters to study, (see figure 2). The associated map for the 1989 employment clustering can be found in the appendix where we see a completely different location distribution of the clusters to the area clustering.

All three clusters can be found throughout London, but particular concentrations are apparent. The Commercial cluster spreads out from the City towards the north west and south west, with a further pocket in the south east. Industrial is predominantly found in the outer west and outer south, with a band also along the Thames corridor. Public Sector is found mainly in a band running east to west in inner south London, and also in the outer north east.

Mapping the 2000 employment data onto the 1989 clustering, we can see that London experienced some large changes to its employment structure during the 90s. Firstly, Heavy employment decreases all over London with the weighting dropping by around 20 per cent in all three of the clusters. Secondly, many wards shift from being members of the Industrial and Public Sector clusters to the Commercial cluster. Examining the associated map for the 2000 data projected onto the 1989 clustering, we see a sea of blue commercial wards. The only remaining groups of wards that

Figure 2 Dunn's coefficient for 1989 employment data – set with 2-10 clusters



Source: Volterra Consulting, November 2002

are not commercial are those wards in the west and along the Thames corridor that are still classified as Industrial.

Once again, we can reverse this process and see what happens when we start from the modern day clustering and project on the 1989 employment data.

In the 2000 cluster centres we see that Industrial has changed completely, and in fact now gives more weight to Selling employment than Heavy employment. Looking backwards in time we see the same effects of change highlighted. It is also worth noting that financial type employment has decreased significantly between 1989 and 2000, particularly in the Commercial cluster which accounts for much of the City fringe. Examining the maps again, the 2000 cluster results look relatively similar in distribution to the 1989 results. Mapping the 1989 data onto the 2000 clustering we see the dramatic shift back to Industrial and Public Sector, with only a handful of what would be described in 2000 terms as Commercial wards occupying mainly the central and northern areas.

Table 1 Cluster centres for fuzzy clustering with 1989/91 area data

Cluster	*Area (sq. km)*	*Employment density (people per sq. km)*	*Population density (people per sq. km)*	*Cluster size*
1	*1.3*	*46189*	*6903*	*13*
2	*0.6*	*4887*	*14257*	*107*
3	*1.0*	*3502*	*9169*	*174*
4	*1.7*	*1658*	*5572*	*268*
5	*3.2*	*1413*	*3282*	*156*
6	*8.9*	*570*	*1446*	*39*

Source: Volterra Consulting, November 2002

Table 2 Cluster centres for 2000/01 area data projected on to 1989/91 area fuzzy clustering

Cluster	*Area (sq. km)*	*Employment density (people per sq. km)*	*Population density (people per sq. km)*	*Cluster size*
1	*1.2*	*49182*	*7801*	*12*
2	*0.7*	*4919*	*14700*	*131*
3	*1.1*	*3299*	*9395*	*170*
4	*1.7*	*1493*	*5673*	*255*
5	*3.2*	*1333*	*3360*	*150*
6	*9.0*	*578*	*1505*	*39*

Source: Volterra Consulting, November 2002

Table 3 Percentage change from 1989/91 cluster centres to 2000/01 cluster centres with 1989/91 area fuzzy clustering

Cluster	*Area (% change)*	*Employment density (% change)*	*Population density (% change)*	*Cluster size*
1	*-4.5*	*6*	*13*	*-7.7*
2	*4.4*	*1*	*3*	*22.4*
3	*7.5*	*-6*	*2*	*-2.3*
4	*1.6*	*-10*	*2*	*-4.9*
5	*1.1*	*-6*	*2*	*-3.8*
6	*0.3*	*1*	*4*	*0.0*

Source: Volterra Consulting, November 2002

Table 4 Cluster centres for fuzzy clustering with 2000/01 area data

Cluster	*Area (sq. km)*	*Employment density (people per sq. km)*	*Population density (people per sq. km)*	*Cluster size*
1	*1.3*	*52599*	*7558*	*12*
2	*0.6*	*5101*	*15204*	*112*
3	*1.1*	*3263*	*9668*	*185*
4	*1.7*	*1489*	*5654*	*272*
5	*3.3*	*1314*	*3289*	*138*
6	*9.1*	*564*	*1483*	*38*

Source: Volterra Consulting, November 2002

Table 5 Cluster centres for 1989/91 area data projected on to 2000/01 area fuzzy clustering

Cluster	Area (sq. km)	Employment density (people per sq. km)	Population density (people per sq. km)	Cluster size
1	1.2	50754	6925	10
2	0.6	5278	14734	94
3	1.0	3530	9486	176
4	1.7	1667	5575	296
5	3.3	1412	3220	143
6	9.1	570	1430	38

Source: Volterra Consulting, November 2002

Table 6 Percentage change from 2000/01 cluster centres to 1989/91 cluster centres with 2000/01 area fuzzy clustering

Cluster	Area (sq. km)	Employment density (people per sq. km)	Population density (people per sq. km)	Cluster size
1	-1.6	-4	-8	-16.7
2	-4.2	3	-3	-16.1
3	-7.6	8	-2	-4.9
4	-1.9	12	-1	8.8
5	-1.4	7	-2	3.6
6	-0.3	1	-4	0.0

Source: Volterra Consulting, November 2002

Table 7 Cluster centres for fuzzy clustering with 1989 employment data

Percentage change in employment proportions						
Cluster	Tax funded	Selling	Heavy	Intelligent	Financial	Cluster size
Commercial	22.6	27.6	17.9	16.4	4.8	302
Industrial	13.7	25.3	40.6	8.5	2.7	234
Public Sector	54.5	15.5	13.8	7.2	1.9	221

Source: Volterra Consulting, November 2002

Table 8 Cluster centres for 2000 employment data projected on to 1989 employment fuzzy clustering

Percentage of employment by type						
Cluster	*Tax funded*	*Selling*	*Heavy*	*Intelligent*	*Financial*	*Cluster size*
Commercial	*21.9*	*28.7*	*14.5*	*20.4*	*2.9*	*469*
Industrial	*15.1*	*26.9*	*33.0*	*13.6*	*2.0*	*122*
Public Sector	*48.7*	*18.0*	*10.7*	*12.4*	*1.5*	*166*

Source: Volterra Consulting, November 2002

Table 9 Percentage change from 1989 cluster centres to 2000 cluster centres with 1989 employment fuzzy clustering

Percentage change in employment proportions						
Cluster	*Tax funded*	*Selling*	*Heavy*	*Intelligent*	*Financial*	*Cluster size*
Commercial	*-3.1*	*4.1*	*-19.0*	*24.3*	*-39.1*	*55.3*
Industrial	*10.0*	*6.5*	*-18.6*	*61.2*	*-25.9*	*-47.9*
Public Sector	*-10.6*	*16.8*	*-22.7*	*70.9*	*-18.5*	*-24.9*

Source: Volterra Consulting, November 2002

Table 10 Cluster centres for fuzzy clustering with 2000 employment data

Percentage of employment by type						
Cluster	*Tax funded*	*Selling*	*Heavy*	*Intelligent*	*Financial*	*Cluster size*
Commercial	*19.7*	*26.0*	*14.2*	*26.0*	*3.0*	*249*
Industrial	*17.4*	*31.5*	*24.7*	*13.5*	*2.4*	*265*
Public Sector	*43.5*	*20.1*	*12.2*	*13.1*	*1.6*	*243*

Source: Volterra Consulting, November 2002

Table 11 Cluster centres for 1989 employment data projected on to 2000 employment fuzzy clustering

Percentage of employment by type						
Cluster	*Tax funded*	*Selling*	*Heavy*	*Intelligent*	*Financial*	*Cluster size*
Commercial	*20.8*	*24.6*	*20.5*	*19.3*	*4.6*	*121*
Industrial	*17.1*	*28.7*	*31.2*	*9.8*	*3.3*	*330*
Public Sector	*47.4*	*17.5*	*16.2*	*8.7*	*2.3*	*306*

Source: Volterra Consulting, November 2002

Table 12 Percentage change from 2000 cluster centres to 1989 cluster centres with 2000 employment fuzzy clustering

Percentage change in employment proportions						
Cluster	*Tax funded*	*Selling*	*Heavy*	*Intelligent*	*Financial*	*Cluster size*
Commercial	*5.7*	*-5.3*	*44.6*	*-25.9*	*54.5*	*-51.4*
Industrial	*-1.7*	*-8.7*	*26.3*	*-27.8*	*35.9*	*24.5*
Public Sector	*8.9*	*-12.7*	*32.6*	*-34.0*	*42.8*	*25.9*

Source: Volterra Consulting, November 2002

Area Clusterings

In terms of demographic characteristics and absolute levels of employment, London has changed relatively little between 1991 and 2001. The population has been rising everywhere with the sharpest percentage changes observed in central London. The most countrified cluster, occupying wards on the outer edge of London, shows the greatest stability. When we project the 2001 data onto the 1991 clustering (and in fact also vice-versa) no wards leave or join this cluster.

Employment as a whole has seen a small but significant shift away from outer London into the inner belt surrounding central London. The bulk of this belt is north of the river in areas such as Kensington, Camden, Islington and Spitalfields. South of the river it occupies only one grouped area located around Clapham North and Stockwell.

Employment Clustering

In terms of its sectoral distribution of employment, the fuzzy clustering technique reveals some interesting patterns. In our 1989 data we see that there are three distinct clusters of different employment type. Examining the location of their cluster centres, we name them Commercial, Industrial and Public Sector. In the Public Sector cluster the average proportion of 'Tax funded' employment in its member wards is 54 per cent. Over 40 per cent of the employment in the Industrial cluster's members is in Heavy jobs. The members of the commercial sector on the other hand have 44 per cent of their employment in retail and Intelligent jobs. Examining a map of the 1989 clusters we find that all three are well grouped. The commercial cluster is mainly in west London, the Public Sector dominates the inner south east and Industrial can be found mostly in the west and along the Thames corridor.

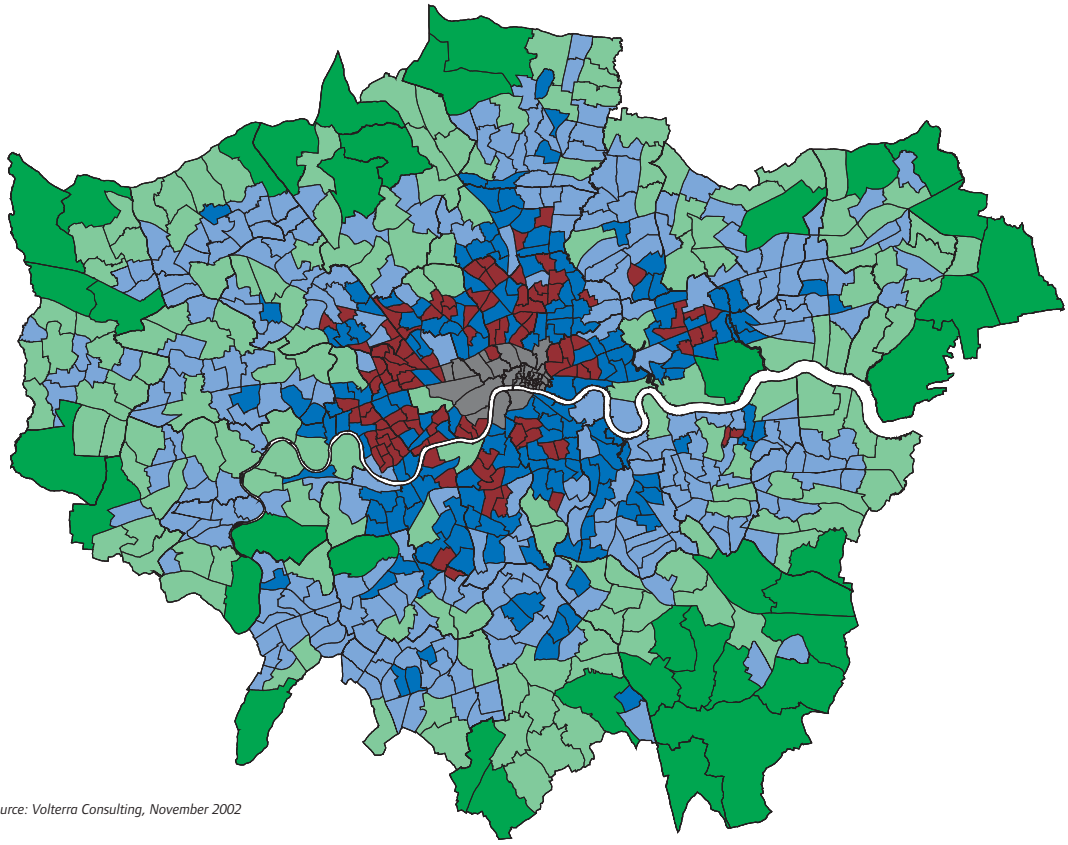
When we project the 2000 data onto the 1989 clustering, we find that there is a strong shift away from the Industrial and Public Sector clusters, decreasing in size by 48 per cent and 25 per cent respectively, and a 55 per cent increase in the size of the Commercial cluster. The centres of clusters also move. The Heavy employment in Industrial and Public Sector drops, moving primarily towards Intelligent employment. Financial employment drops in all three clusters, but mostly in the Commercial cluster where it is halved.

In the 2000 employment clustering we see that the average proportion of Heavy employment for the Industrial cluster members stands at 25 per cent, while the average employment proportion for Selling in the Industrial cluster stands at 32 per cent. This tells us that Heavy employment levels have fallen throughout London to such an extent that when we perform the fuzzy clustering, Industrial employment no longer identifies itself as a separate cluster.

In terms of demographic characteristics and absolute levels of employment, London has changed relatively little between 1991 and 2001.

Annex 1

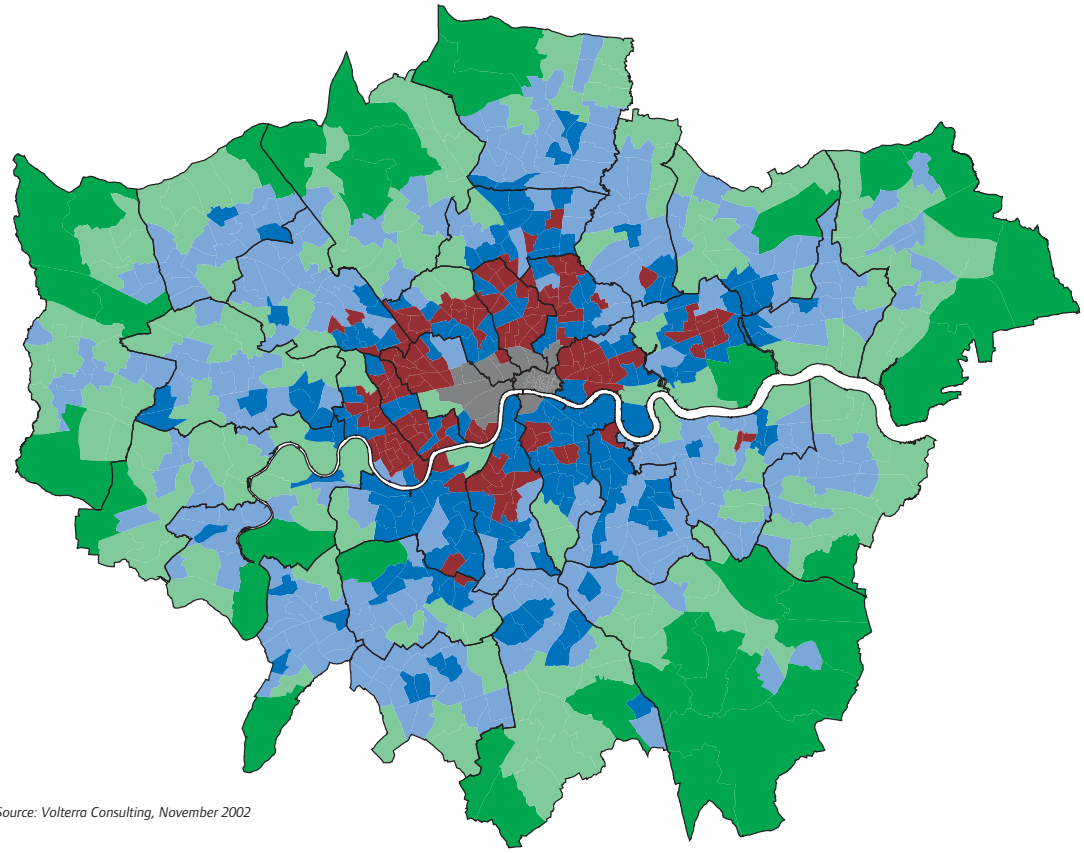
Figure 1 Area clustering 1989/91



Source: Volterra Consulting, November 2002

- Cluster 1 (38)
- Cluster 2 (107)
- Cluster 3 (174)
- Cluster 4 (268)
- Cluster 5 (156)
- Cluster 6 (39)

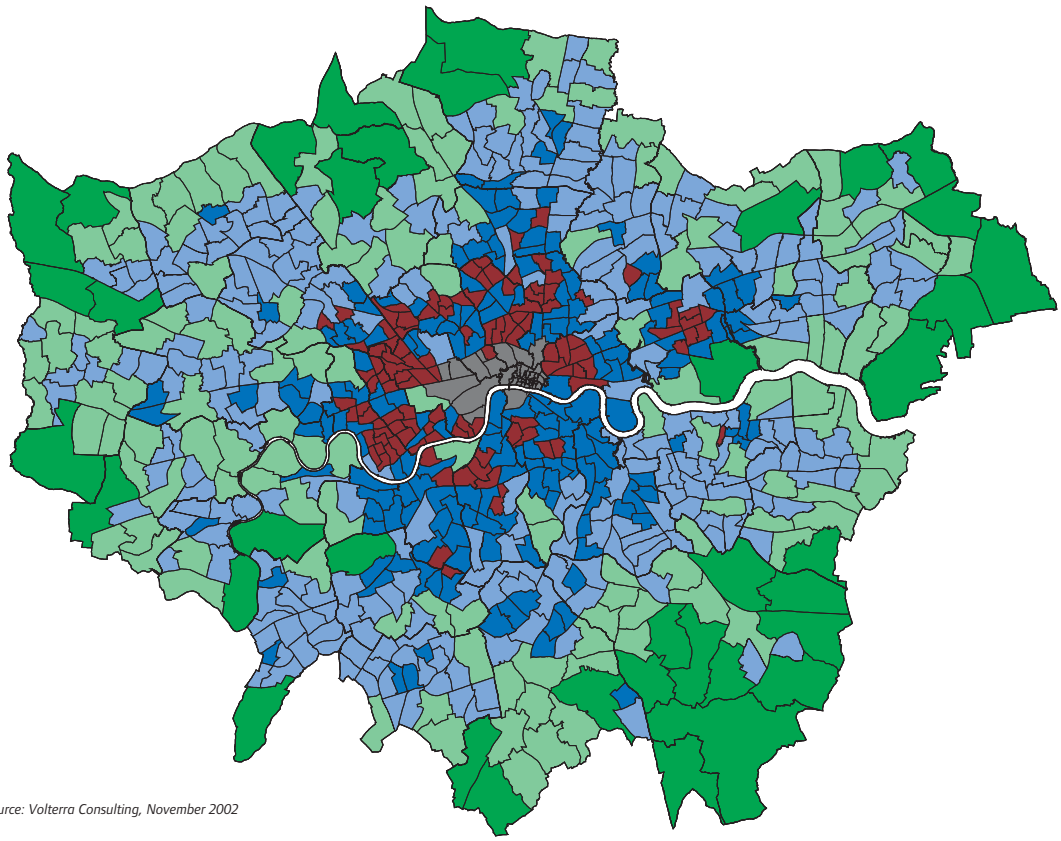
Figure 2 Area data 2000/01 with 1989/91 clustering



Source: Volterra Consulting, November 2002

- Cluster 1 (37)
- Cluster 2 (131)
- Cluster 3 (170)
- Cluster 4 (255)
- Cluster 5 (150)
- Cluster 6 (39)

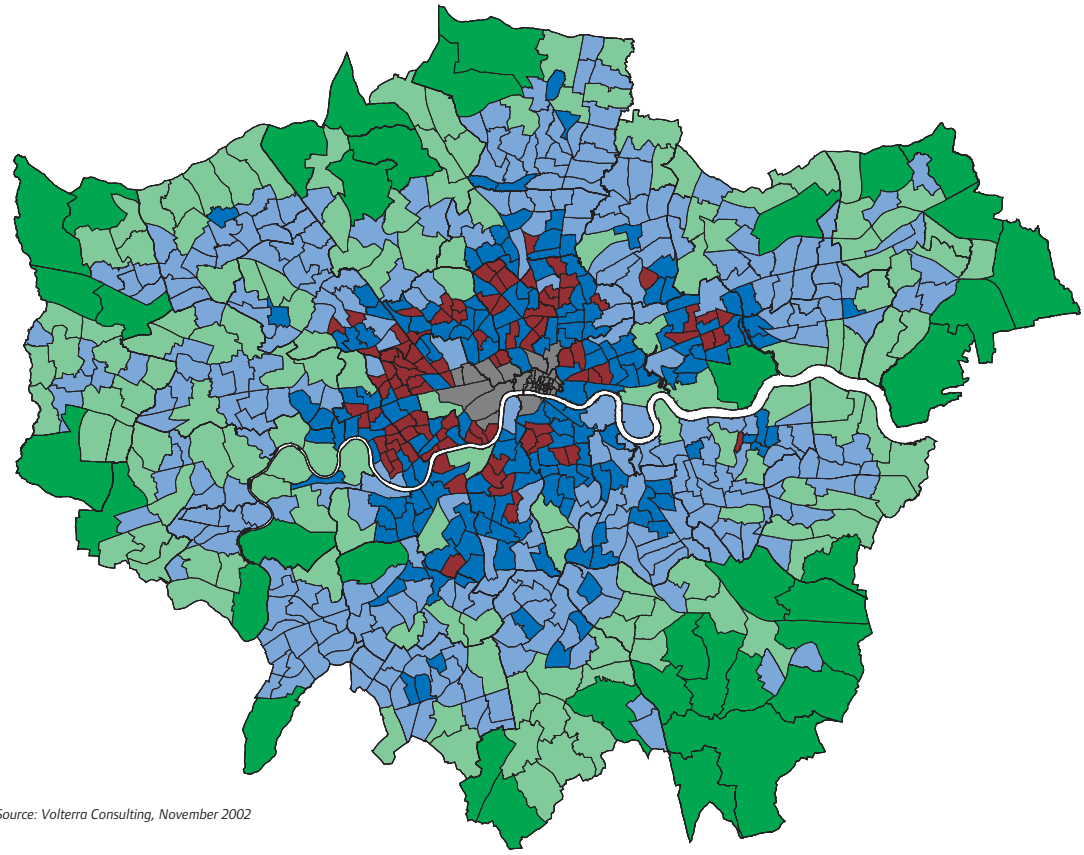
Figure 3 Area clustering 2000/01



Source: Volterra Consulting, November 2002

- Cluster 1 (37)
- Cluster 2 (112)
- Cluster 3 (185)
- Cluster 4 (272)
- Cluster 5 (138)
- Cluster 6 (38)

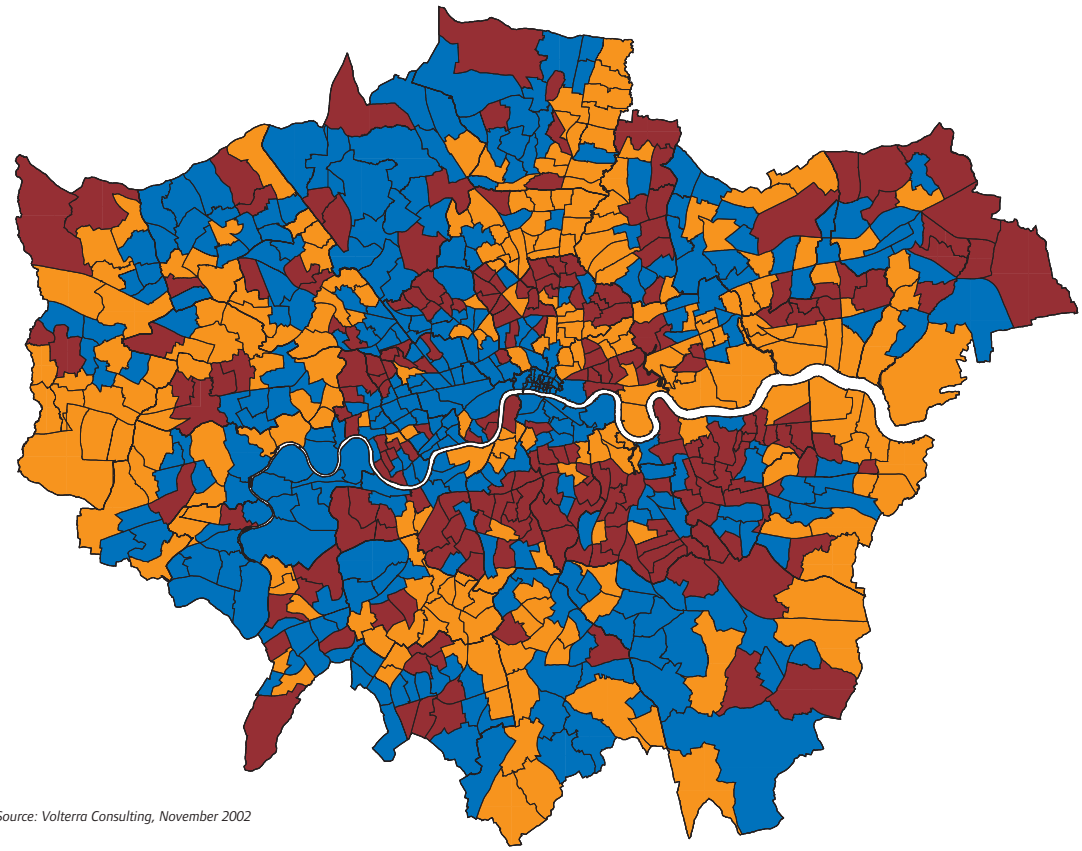
Figure 4 Area data 1989/91 with 2000/01 clustering



Source: Volterra Consulting, November 2002

- Cluster 1 (35)
- Cluster 2 (94)
- Cluster 3 (176)
- Cluster 4 (296)
- Cluster 5 (143)
- Cluster 6 (38)

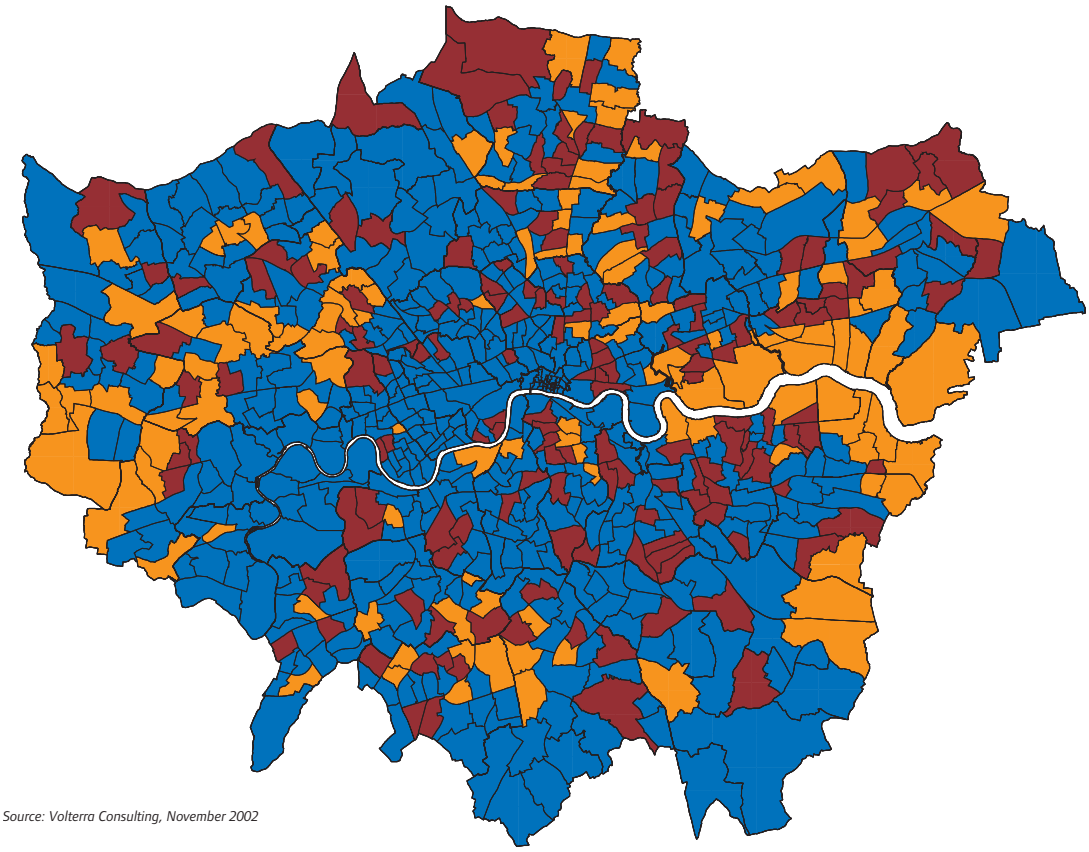
Figure 5 Employment clustering in 1989



Source: Volterra Consulting, November 2002

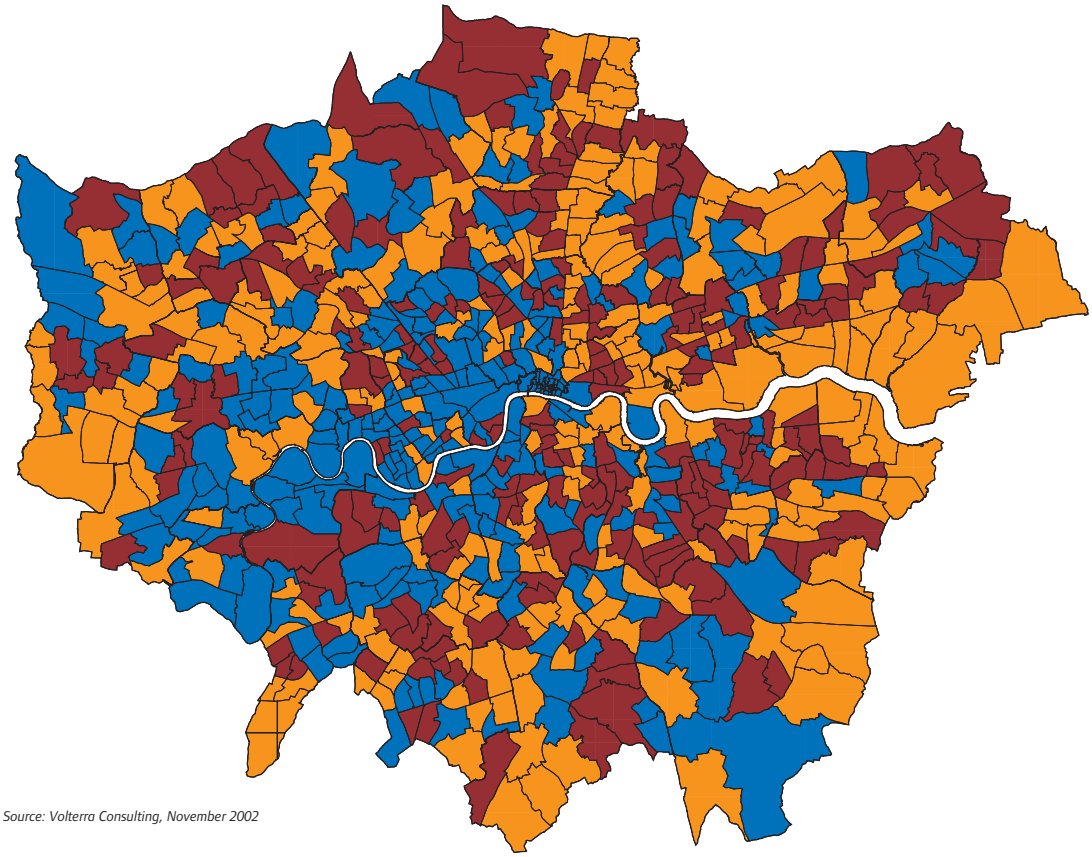
Public Sector (221)
Industrial (234)
Commercial (327)

Figure 6 Employment data 2000 with 1989 clustering



Source: Volterra Consulting, November 2002

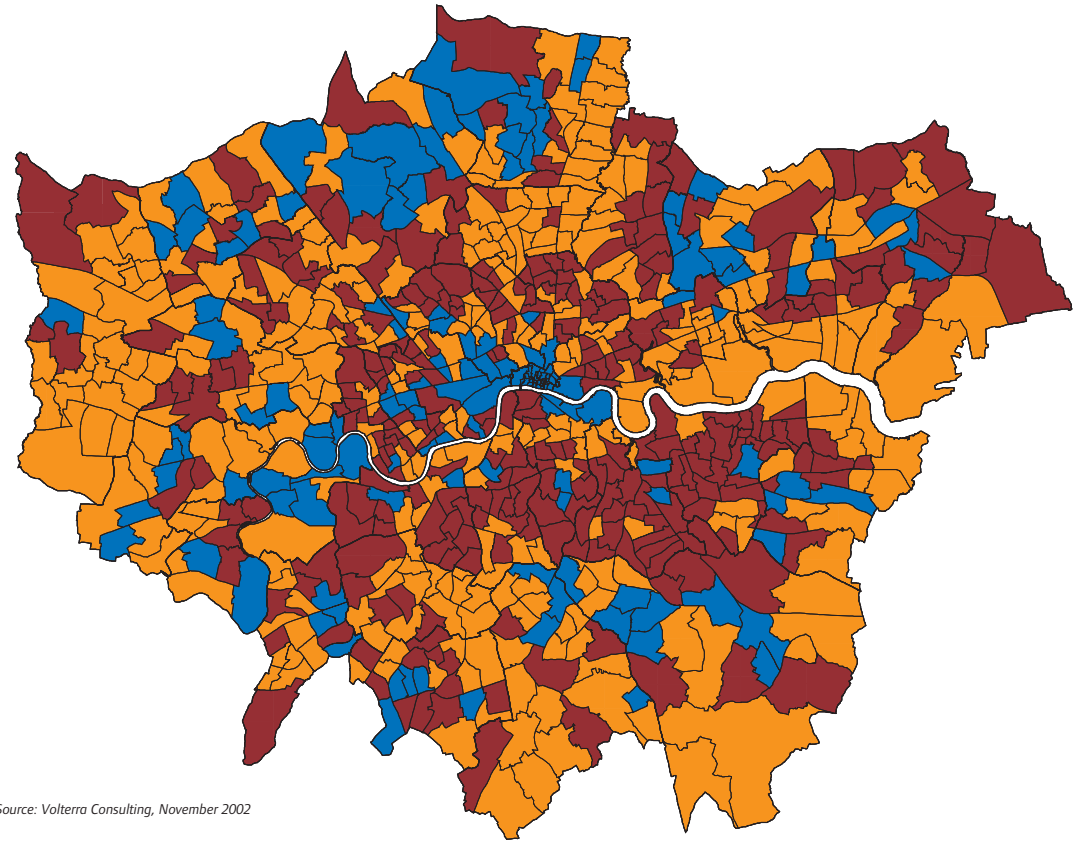
Figure 7 Employment clustering 2000



Source: Volterra Consulting, November 2002

Public Sector (243)
Industrial (265)
Commercial (274)

Figure 8 Employment data 1989 with 2000 clustering



Source: Volterra Consulting, November 2002

Annex 2:
Formation of employment cluster groups
from 1989 employment categories

Original 1989 employment data sectors	*New sectors for cluster analysis*
Public administration and defense; compulsory social security *Education* *Health and social work*	*Tax funded*
Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel *Wholesale trade and commission trade, except motor vehicles and motorcycles* *Retail trade, except of motor vehicles and motorcycles, repair of personal and household goods* *Real estate activities* *Recreational, cultural and sporting activities* *Other service activities plus sewage and refuse disposal*	*Selling*
Manufacturing excluding print and publishing *Construction* *Transport and communications*	*Industrial*
Computer and related activities *Other business activities plus research and development*	*Intelligent*
Financial intermediation, except insurance and pension funding *Insurance and broking*	*Financial*
Primary and utilities *Printing and publishing* *Hotels and restaurants* *Renting of machinery and equipment (without operator) and of personal and household goods* *Activities of membership organisations not elsewhere classified*	*Other*

Source: Volterra Consulting, November 2002

We start with a data set X consisting of n observations, where each observation is a vector in d dimensions. The aim of fuzzy clustering is to divide the data into c clusters, where c can be between 2 and n. The divisions should be such that within the clusters the data have similar characteristics and the average difference between cluster characteristics is maximised.

$$X = \{x_1, x_2, \ldots, x_n\} \qquad x_j \in R^d \tag{1}$$

The attributability of observation x_j to cluster k is u_{kj} .With classical clustering u_{kj} can only take the value 0 or 1, but with fuzzy clustering it can take any value between 0 and 1.

$$u_{kj} \in \{0,1\} \qquad \text{Classical clustering (2)}$$

$$u_{kj} \in [0,1] \qquad \text{Fuzzy clustering (3)}$$

However for each type of clustering we still have the condition:

$$\sum_j u_{kj} > 0 \qquad \sum_k u_{kj} = 1 \qquad \text{(4) and (5)}$$

The objective function, whose size is to be minimised for an optimal solution is:

$$J_m(U,v) = \sum_{j=1}^{n} \sum_{k=1}^{c} (u_{kj})^m \|x_j - v_k\|^2 \quad 1 \le m < \infty \tag{6}$$

In this equation we have U, the matrix of memberships and v_k , the centre of cluster k. The variable m determines the type of clustering that is done. When $m = 1$ and $u_{kj} \in \{0,1\}$ the minimalization of (6) is what is known as ordinary k-means. When m takes a value greater than 1 and $u_{kj} \in \{0,1\}$ we have fuzzy clustering. In this case the values of u_{kj} and v_k that minimise (6) are:

$$\hat{u}_{kj} = \left(\sum_{g=1}^{c} \left(\frac{\|x_j - \hat{v}_k\|}{\|x_j - \hat{v}_g\|} \right)^{\frac{2}{(m-1)}} \right)^{-1} \quad \forall j,k \tag{7}$$

$$\hat{v}_k = \frac{\sum_{j=1}^{n} (\hat{u}_{kj})^m x_j}{\sum_{j=1}^{n} (\hat{u}_{kj})^m} \quad \forall k \tag{8}$$

Source: Volterra Consulting, November 2002

As the centres of the clusters are not known before the clustering process, the memberships cannot be calculated directly, and an iterative process has to be used. The optimal ukj can be found by repeating the following process:

(i) m and cluster number c are assumed, and a norm in equation (6) is defined appropriately (for our purposes, the standard Euclidean norm). In addition, an initial value $U^{(0)} \in M_{fc}$ is set for U (where M_{fc} is the space satisfying the above conditions (3), (4) and (5)). The value can be taken at random.

(ii) The cluster centre $v_k^{(0)}$ is calculated using $U^{(0)}$ and equation (8).

(iii) $U^{(1)}$ is calculated using $v_k^{(0)}$ and equation (7).

(iv) Defining an appropriate norm and threshold value e, the preceding steps are repeated until $\|U^{(p)} - U^{(p-1)}\| \leq \epsilon$.

When the inequality in step (iv) is satisfied, we are left with the c optimal cluster centres , $v_k^{(0)}$, whose memberships $U^{(p)}$ are given by equation (7).

Information criterion used in selecting the number of cluster

$$D = \frac{1}{n} \sum_{j=1}^{n} \sum_{k=i}^{c} (\hat{u}_{kj})^2$$ Dunn's coefficient (9)

$$D_s = \frac{D - (\frac{1}{c})}{1 - (\frac{1}{c})}$$ standardised Dunn's coefficient (10)

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Hindi

यदि आप इस दस्तावेज़ की प्रति अपनी भाषा में चाहते हैं, तो कृपया निम्नलिखित नम्बर पर फोन करें अथवा दिये गये पता पर सम्पर्क करें।

Vietnamese

Tiếng Việt
Nếu bạn muốn bản sao của tài liệu này bằng ngôn ngữ của bạn, hãy gọi điện theo số hoặc liên lạc với địa chỉ dưới đây.

Bengali

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

Greek

Urdu

اگر آپ اِس دستاویز کی نقل اپنی زبان میں چاہتے ہیں، تو براہِ کرم نیچے دیئے گئے نمبر پر فون کریں یا دیئے گئے پتہ پر رابطہ قائم کریں۔

Turkish

Bu brosürü Türkçe olarak edinmek için lütfen asagidaki numaraya telefon edin ya da adrese basvurun.

Arabic

Punjabi

Gujarati

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