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Structural Change and Productivity Growth in Cities

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Abstract

It is now widely acknowledged that structural change is integral to the process of economic growth and the evolution of capitalist development. Given the veritable explosion of interest in recent years in cities as 'engines' of wealth creation, trade, innovation and creativity, the issue of structural change would seem highly relevant to understanding the evolving economic performance of cities, particularly given the ongoing debates over structural specialisation versus diversity. This paper examines the differing productivity growth paths of some 85 British cities since the beginning of the 1970s, and explores how far these paths reflect differences across cities in the pace and nature of structural change. We first find evidence that while productivity tended to converge across cities between 1971-1991, thereafter convergence ceased and was replaced by weak divergence. The paper then analyses the extent and nature of structural transformation in the various cities, using particular measures applied to 82 sectors of activity, between 1971 and 2014. We find evidence of considerable structural convergence across cities and a general tendency for the degree of specialisation to fall. This then leads to a decomposition analysis which identifies the relative contribution of within-sector and between-sector (sectoral re-orientation and relocation) effects to city productivity growth. The analysis reveals that within-sector productivity developments outweigh structural change in accounting for differences in productivity growth across most British cities. As such, the paper raises questions over the importance often assigned to specialisation as a motor of city growth, and points to the role of city-specific factors that influence the growth performance across most of a city's sectors.

Key Words: Cities Productivity growth Structural change

JEL Classification: **R10 O47 R11**

> Productivity isn't everything, but in the long run it is almost everything. (Paul Krugman, 1994, p.11).
>
> Productivity is the challenge of our time… The gap in labour productivity between the UK's two largest city economies, London and Manchester, is larger than in any other G7 country and more than double that in both Germany and Japan. A dynamic economy needs thriving cities. (HM Treasury, 2015, pp. 3, 68).

1. Introduction

As Paul Krugman states, while productivity is certainly not the only measure of an economy's performance, it is certainly a key attribute, since it influences the generation of the wealth necessary to support high incomes and public services. As such, it is a basic determinant of societal welfare. A low level or a slow growth of productivity is thus understandably a cause for concern. And in many advanced economies, there is just such concern, for in most instances labour productivity growth has been on a downward trend since the 1970s (Carmody, 2013). There has in fact been considerable debate over this slowdown in productivity growth. Some attribute the apparent decline to measurement problems, to the fact that technological advances and shifts simply do not show up in conventional measures of (both labour and total factor) productivity (the so-called 'Solow Productivity Paradox' – see Triplett, 1999; Crafts, 2002). Others dispute this argument, however and contend that the slowdown is real (Cowen 2016; Gordon, 2016; Syverson, 2016). According to Gordon (2016), for example, innovation has stalled, and technological progress no longer produces the gains in GDP that it once did (see also Pilat et al, 2002; Dupont et al, 2011). A similar view is espoused by Cowen (2016), that high-tech developments have not saved advanced economies from a slowdown in productivity. Yet another explanation points to the fall in business dynamism over the past two to three decades (European Central Bank, 2016), as reflected in new firm formation rates: new firms are assumed to embody more advanced technology and to be more productive than old existing firms. Still others suggest that the slowdown derives in part at least from an over-regulation of product and labour markets (e.g. Conway and Nicoletti, 2007), while others focus on misallocations and mismatching of skilled and educated labour (OECD, 2015).

One of the most provocative arguments locates the cause in the secular shift to services that has typified all advanced economies over recent decades. The contention is that many services (such as retail, hospitality, personal services, and even some professional and business services) have limited potential for high productivity growth, and may even be 'stagnant' as far as productivity is concerned (Baumol, 1967; Baumol et al, 1985; Williamson, 1991; Kim, 2006). What this narrative suggests, in other words, is that a slowdown in productivity

growth is an inevitable consequence of the progressive shift to a 'post-industrial' service economy. Other authors, however, take a more guarded view, pointing out that just as some services may have limited scope for productivity advance, so too do some manufacturing activities. Further, many services function as intermediary inputs to the manufacturing sector, and may not only help to raise the productivity of the latter, but themselves may have as much scope for increasing their own productivity (Oulton, 2001). The trend for manufacturing firms to outsource certain routine service activities that were previously carried out 'in house', while at the same time often developing their own customer-orientated service activities (from finance to after-care), may well also have impacted on the measurement and allocation of productivity advance as between 'manufacturing' and 'services' in complex ways. The impact of structural change on productivity growth is thus a key issue, the more so since it is widely acknowledged that structural change is integral to the process of economic growth (Kuznets, 1957, 1971; Pasinetti, 1993; Freeman and Louca, 2001; Cornwall and Cornwall, 1994; Metcalfe et al, 2006; Kruger, 2008; Roncolato and Kucera, 2014). Yet, as Kruger (2008) points out, despite the key relevance of structural change for growth theory, the topic of structural change and its potential relevance for productivity growth are frequently neglected topics in economic research.

This issue is not just of national, macro-economic interest, however. In recent years, there has been a veritable explosion of interest in cities as the 'engines' of wealth creation in the national economy (Jacobs, 1984; Glaeser, 2011; Moretti, 2013). One of the many facts to have emerged from this burgeoning body of work is that cities appear to differ in their growth paths of employment and per capita incomes (see for example, Glaeser, 2005; Markusen and Shrock, 2006; Moretti, 2012; Power et al, 2010; Hobor, 2013; Dijkstra et al, 2013; Michaels et al, 2013; Cowell, 2014, Storper et al, 2015; Martin et al, 2016). In most of these studies, the differences (and often divergence) in growth paths between cities is attributed, in part at least, to differences in their economic structures and specialisms, and particularly the extent to which cities have suffered from deindustrialisation and the success with which they have managed to rebuild their economies around a service-based mode of growth. Less is known about the consequences of major structural changes of this sort for city productivity growth paths.[1] This is the focus of this paper. More specifically the aim is to reveal what has been happening to the productivity growth paths of British cities since the beginning of the 1970s, and to explore how far these paths can be

[1] Most of the literature on city productivity has been concerned instead with estimating the effects of agglomeration economies, usually proxied by the size or density of a city, on the *level* of productivity. Such estimates typically suggest that a *doubling* of city size would lead to an increase in the level of city productivity of between 5-10 percent (Puga, 2010). This seems a very modest increase indeed, and moreover what is a *one-off* gain, since repetitive doubling of a city's size (or density) is hardly a realistic (or even desirable) prospect for a variety of reasons.

accounted for by changes in the economic structures of those cities over this period. These questions are particularly pertinent in the British case since there is concern not only over the slowdown of national productivity growth, but also over what appear to be significant geographical differences in productivity across the country, especially between London and other cities (HM Treasury, 2015, 2016). How far and in what ways these differences can be attributed to different patterns of structural change across Britain's cities could thus have potential implications for policies aimed at raising the productivity growth rate in the national economy as a whole. Indeed, there is an explicit recognition of the need for a 'place-based' dimension to national industrial policy (HM Treasury, 2015; Department of Business, Energy and Industrial Strategy, 2017). Further, the 2016 UK referendum vote to leave the European Union – so-called 'Brexit' - makes the need to improve the productivity of the nation's cities and regions all the more urgent, given that they could well face tariffs on their exports to Europe and will need to compete in other overseas markets to export their goods and services.

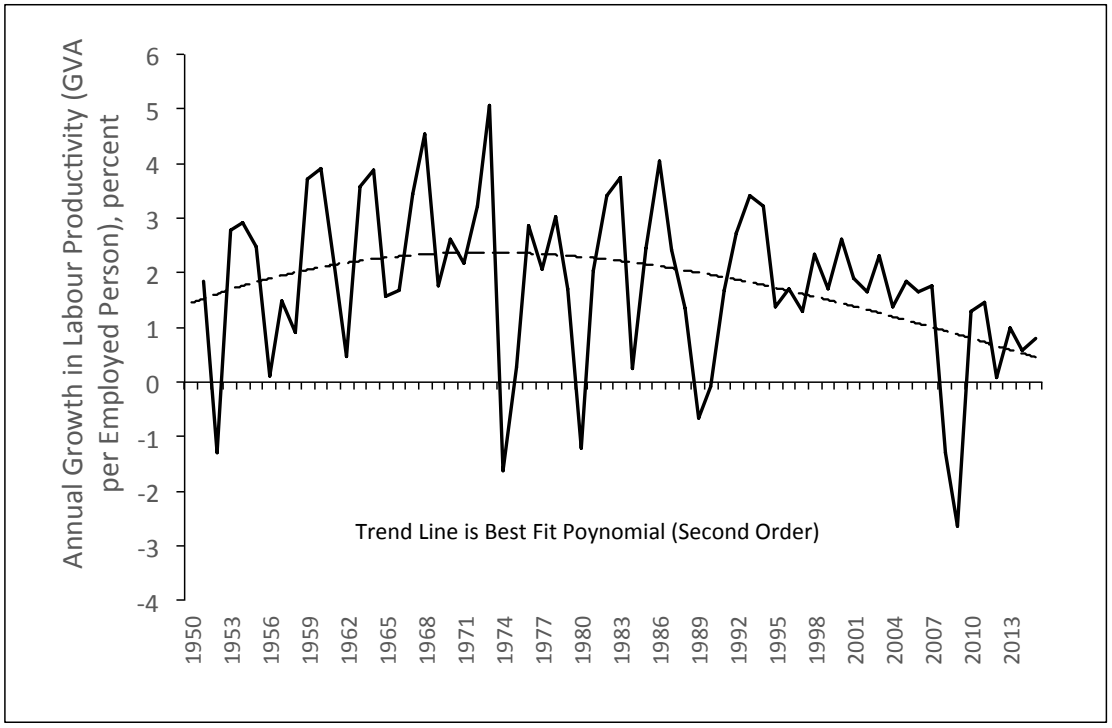
We begin by first analysing the productivity evolutions of British cities over the past forty years or so. This is followed by an analysis of what has been happening to the economic structures of the cities in question. A key issue within this context is whether city economic structures have become more or less specialised, and whether they have converged or diverged. The paper then moves on to assess the contribution of structural change to the evolution of productivity across the study cities.

2. Productivity Growth Paths of British Cities

As mentioned above, the issue of productivity growth in the British economy has long been a recurring topic of academic and political debate. Figure 1 shows how labour productivity growth in the UK economy has been highly variable from year to year since 1950. But it also shows a striking and worrying feature. While the annual rate of productivity growth actually trended upwards from 1950 to 1973, since then the trend has been on a downward path. In fact, while the UK annual rate of growth over 1971-1991 averaged 2.13 percent, over 1991-2014 the average fell to 1.46 percent. How far the 'turning point' in the underlying trend of productivity growth around 1973 reflected the end of the post-war expansion of employment in manufacturing, or the impact of the recession of the early-1970s associated with the first of the OPEC oil price hikes, are interesting questions. While all of the major sectors of the economy have experienced productivity growth, it is evident that since the beginning of the 1980s, productivity advance in manufacturing or production (manufacturing plus construction) has been faster than in market (private) services, especially if

finance and insurance are excluded from the latter (Figure 2). The overall growth in labour productivity (GVA per worker) in private market services (excluding finance) over the 1971-2014 period was only about 60 percent of that recorded by manufacturing. On the face of it, shifts in the economic structure of cities away from manufacturing towards services might well be expected, therefore, to have had potentially significant implications for city aggregate productivity growth.

Figure 1: Annual Growth Rate of Labour Productivity in the UK, 1950-2015

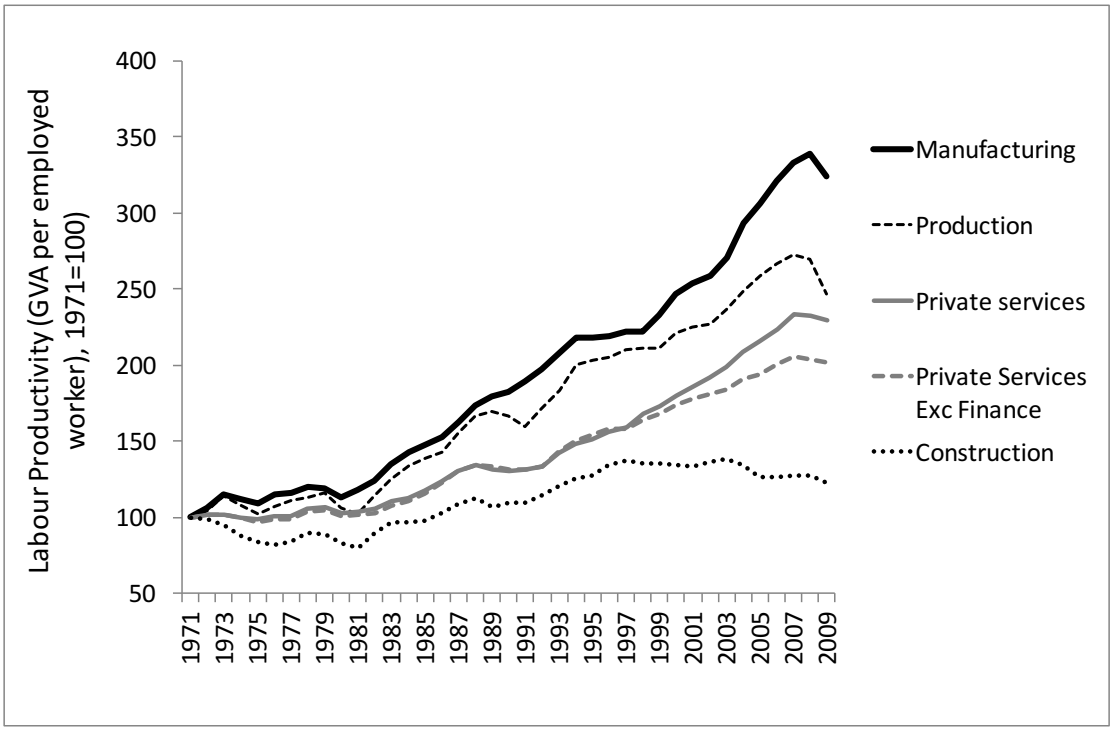


Source: Office for National Statistics

With regard to measuring productivity trends in British cities, an immediate major issue is the lack of any comprehensive and consistent official economic time series data. As part of a larger programme of research on city economic evolutions, we have constructed new data series on employment, gross value added (GVA), and labour productivity (GVA per employed worker) for some 85 cities for 82 sectors of activity, yearly from 1971 to 2014 (and on 249 sectors from 1991 to 2014). We have defined these cities spatially on the basis of the 2011 travel-to-work area (TTWA) boundaries as delineated by the UK Office for National Statistics. There are some 228 TTWAs covering the whole of the UK. The criteria for defining TTWAs is that generally 75 percent of an area's resident workforce work in the area and at least 75 percent of those who work in the area also live there. For TTWAs with a working population of 25,000 or more, self-

containment rates as low as 66.7 percent are accepted. Only those areas based on an identifiable city with a total TTWA population of at least 200,000 were selected as our final set of 85 cities. Together these cities, in 2014, accounted for some 83 percent of British employment and 85 percent of British output (gross value added).[2] They thus make up the bulk of the national economy.

Figure 2: Labour Productivity in Selected Major Sectors of the British Economy (Gross Value Added per Employed worker, 2005 Prices), 1971-2009 (1971=100)



Source: Office for National Statistics (https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/labourproductivity/datasets/labourproductivity

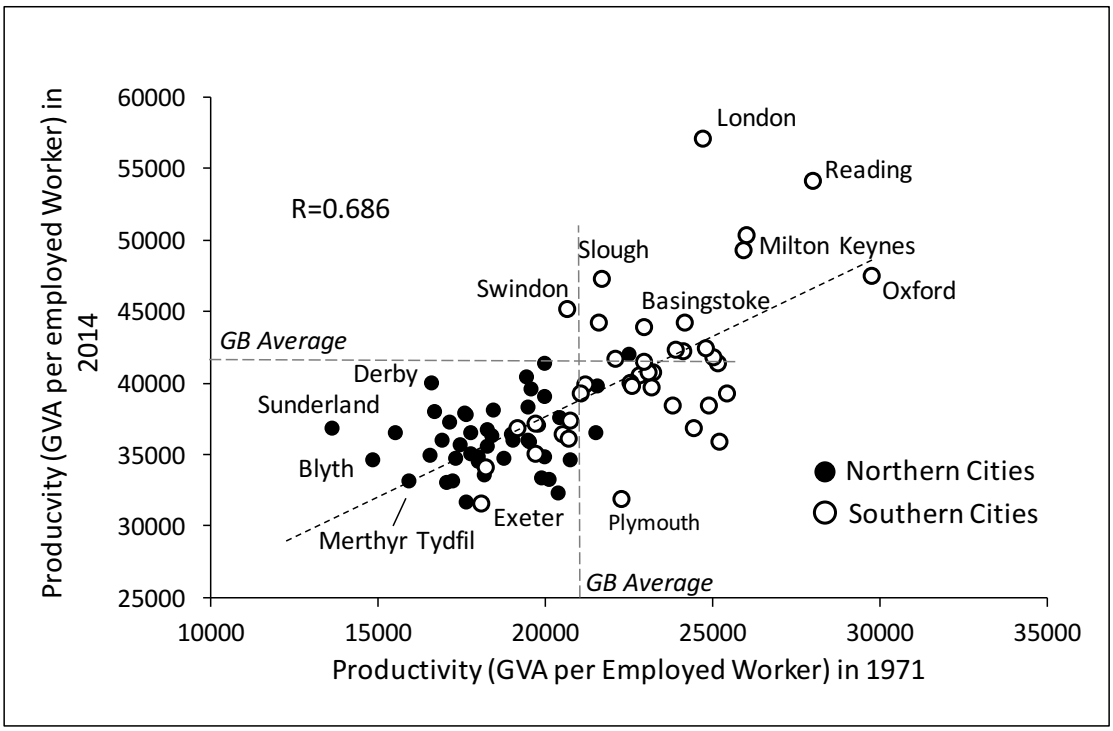
Note: Production includes manufacturing, construction, and utilities (energy and water).; Private Services exclude Public Sector Services.

The variation in labour productivity levels across the 85 cities in 1971 and in 2014 is shown in Figure 3. The cities have been grouped into 'northern' and 'southern' sets according to the region of their location, using the conventional way of dividing the UK into these two broad geographical areas. Also shown is the national average (Great Britain) productivity level for the two years. What is striking is that all bar three northern cities (Crew, Chester and Telford) are in the bottom left-hand quadrant of the Figure, having productivity levels less than the national average both at the beginning of the period and at the end. However, at

[2] Because of lack of basic data we were unable to include any cities in Northern Ireland. Correspondingly, we use Great Britain rather than the UK as the base for such calculations.

the same time, the correlation between productivity levels in 1971 and 2014, though significant (R=0.686) is not particularly high, indicating certain shifts in relative position occurred over the period; in other words, productivity growth rates across cities have not been proportionate.

Figure 3: Labour Productivity Across 85 British Cities, 1971 and 2014 (Gross Value Added per employed worker, 2011 prices)

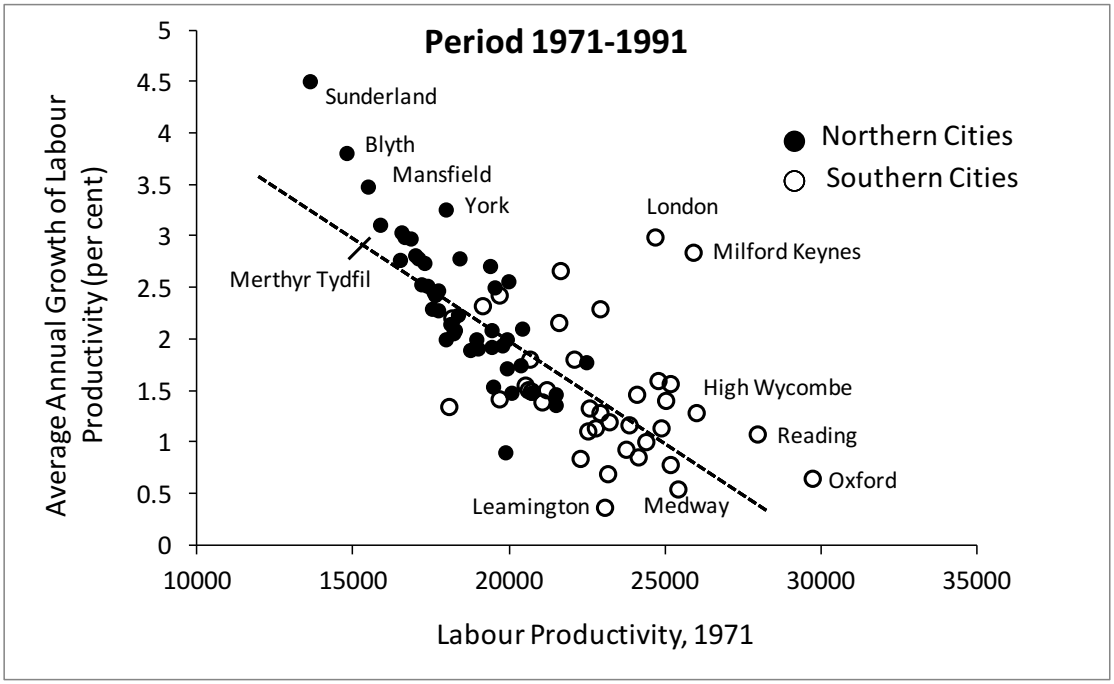


Source: Authors' data
Note: Southern cities defined as those in the following regions: London, South East, East of England, South West and East Midlands. Northern cities defined as those in the West Midlands, Yorkshire-Humberside, North East, North East, Scotland and Wales.
Great Britain averages shown by intersecting pecked lines.

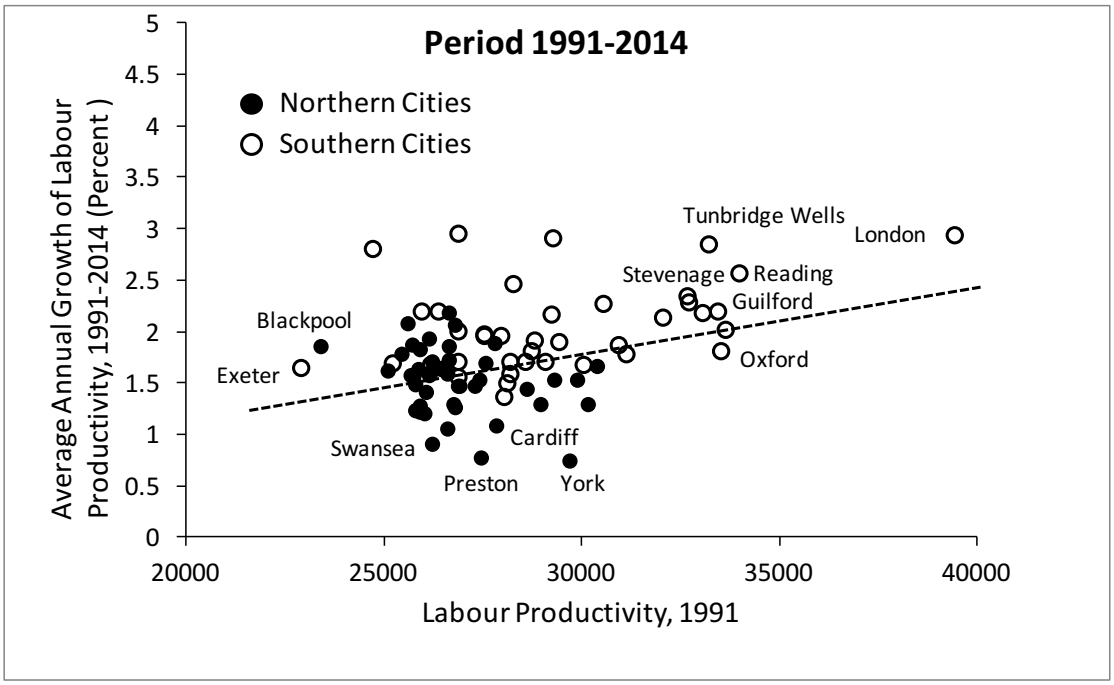
In this context, an interesting feature emerges in the relationship across cities between their initial productivity levels and their subsequent productivity growth when the whole study period is divided into the two sub-periods (Figure 4). In the first sub-period, 1971-1991 (Figure 4 (a)), which corresponds to when national productivity advance was higher, the relationship is negative (R=-0.581). A negative relationship indicates that cities which had initially low labour productivity levels tended subsequently to experience faster productivity growth, that is to 'catch up' with cities that initially had higher productivity levels. This is in line with the predictions of standard neoclassical growth theory (for example, Barro and Sala-i-Martin, 2003). But for the second sub-period,

Figure 4: Shifting Patterns of Labour Productivity Growth across British Cities, 1971-2014 (Gross Value added per employed worker, 2011 prices)

(a)

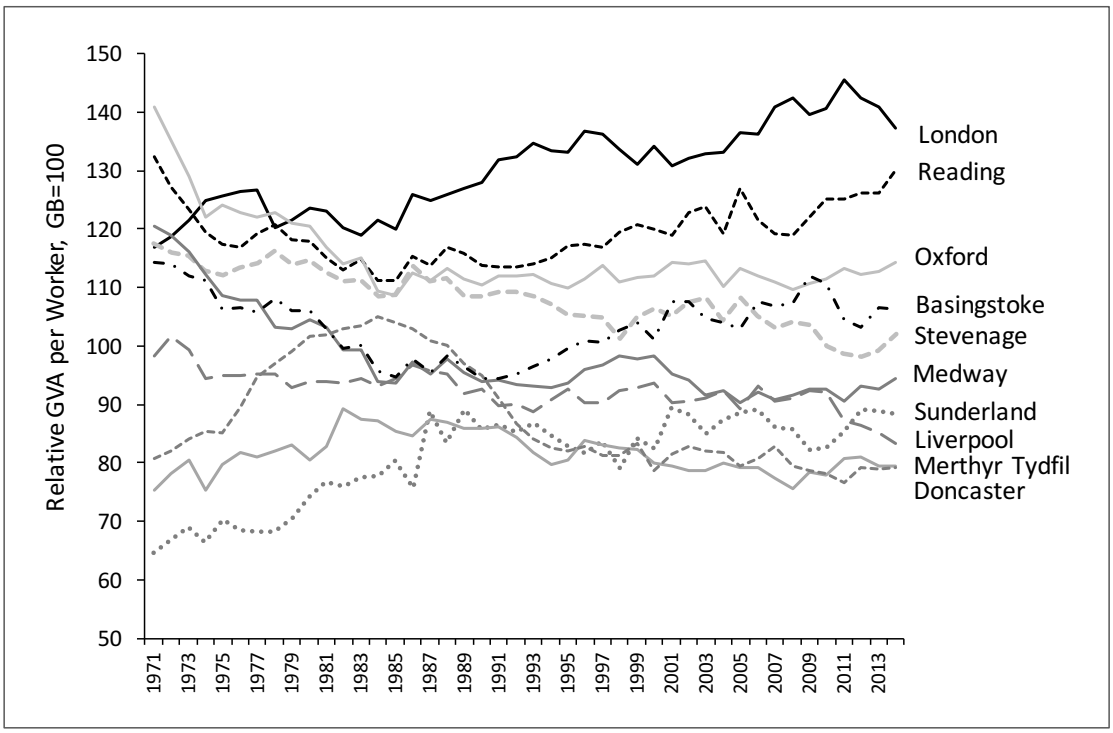


(b)



Source: Authors' data
Note: Southern cities and northern cities defined as in Figure 2.

Figure 5: Relative Time Paths of Labour Productivity for Selected Cities, 1971-2014, Indexed to GB=100



Source: Authors' data

1991-2014 (Figure 4 (b)), the relationship is no longer negative but weakly positive (R=0.109).

The changing pattern evident in Figure 4 indicates that while British cities converged in terms of productivity in the 1970 and 1980s, this tendency disappeared over the 1990s and 2000s, with some suggestion of slight divergence. The detailed time paths of productivity for some selected cities illustrate this changed dynamic (see Figure 5, in which the series are indexed at Great Britain=100). For example, Oxford, Reading, Medway and Stevenage, initially high productivity cities, all lost ground against the national average until around 1991, while Sunderland, Doncaster and Merthyr Tydfil, initially low productivity cities, all gained ground. The general pattern of convergence suggested in Figure 4(a) is clearly evident (aside from London). From around 1991 onwards, however, divergence is apparent. London has been a major exception, and continued to pull ahead throughout the period. Further, and significantly, if we group the 85 cities into those in the 'south' of Britain, and those in the 'north', there is clear evidence of a 'switch' in relative productivity growth between these two geographical groups between 1971-1991 and 1991-2014, with northern cities as a group outpacing southern cities in the first sub-period, but the latter out-performing the former in the more recent sub-period

(Table 1). No doubt many factors could be invoked as possible explanations of these trends. The key question of interest here, however, is whether, how far and in what ways, these changing patterns of productivity across the British cities have been influenced by structural economic change since the beginning of the 1970s. To explore this issue, we first examine how the economic structures of the cities themselves have been evolving over this period.

Table 1: Productivity Growth in Northern and Southern Cities (Average annual growth in GVA per employed person, percent per annum)

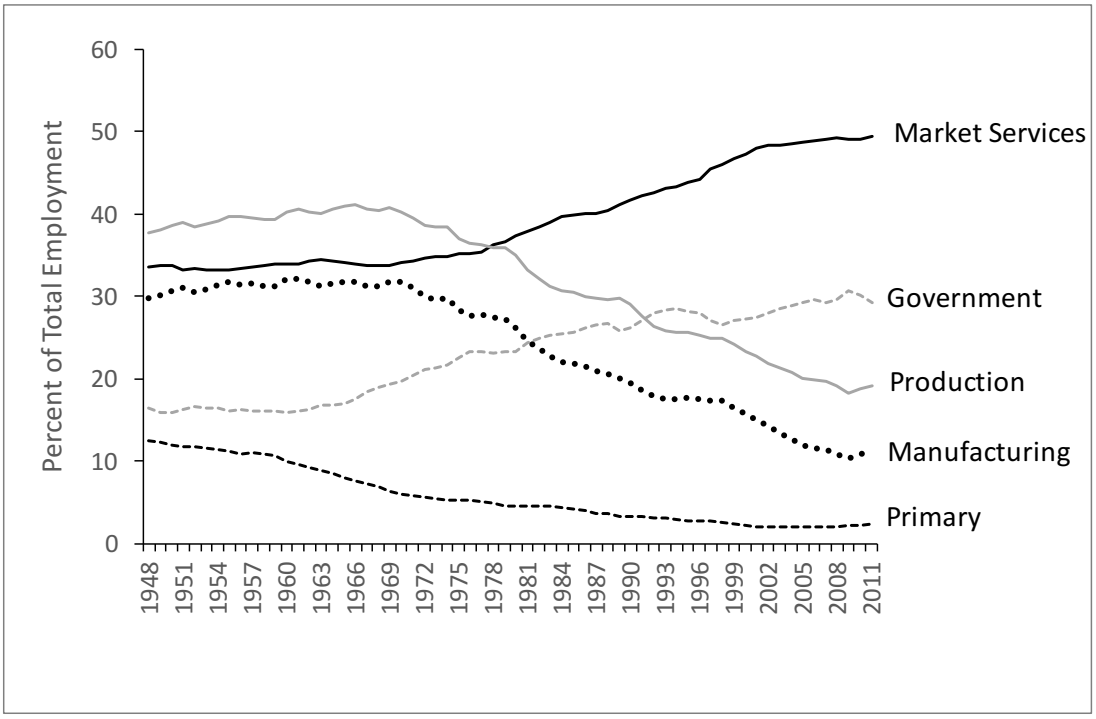
	1971-1991	1991-2014
Southern Cities	1.84	2.05
Northern Cities	2.28	1.51
Great Britain	2.08	1.69

Source: Authors' data

3. Structural Change in British Cities

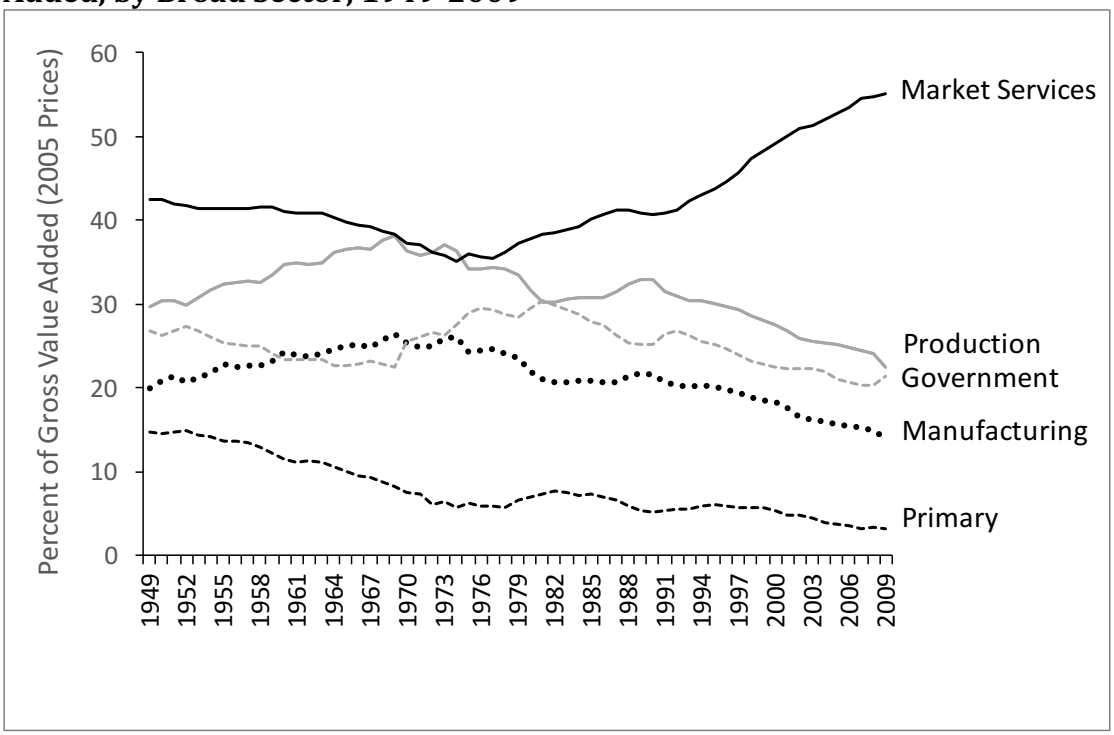
That pronounced ongoing structural changes have transformed the UK economy over the past fifty years or so is clearly evident from Figures 6 and 7. In broad terms, the most profound change has been the shift from an economy based on production industries (manufacturing, construction and utilities) to one dominated by private market services. The decline in production employment from its peak of just over 11 million (or 41 percent of total jobs) in 1966 to 5.5 million (19 percent) in 2010 represents one of the most rapid rates of deindustrialisation in the western world. Likewise, having increased over the two decades after the Second War, the share of production industries in total output steadily increased to reach a peak of 38 percent in 1969, and thereafter progressively declined, falling to 22 percent by 2009. At the same time employment in private market services increased from 8.8 million (34 percent) in 1969 to 14.4 million (50 percent) in 2009. If we add in local and central government, the service economy increased its share of total employment from 53 percent in 1969 to 80 percent in 2009, and its share of total national Gross Value Added from 38 percent to 55 percent over the same period. The macro-structure of the national economy on the eve of the financial crisis in 2007 looked very different indeed from that in 1970.

Figure 6: Structural Change in the British Economy: Employment Shares by Broad Sector, 1949-2011



Source: Office for National Statistics, UK
Note: Production includes manufacturing, construction, and utilities (energy and water). Government includes central and local public services and administration.

Figure 7: Structural Change in the British Economy: Shares of Gross Value Added, by Broad Sector, 1949-2009



Source: Office for National Statistics, UK
Notes: Sectors defined as in Figure 6.

How have these structural shifts and changes worked out across British cities? Have British cities all undergone a similar transformation, or has the extent of structural change varied – have cities become more similar in structure or have they become more specialised? These questions are of interest in their own right given the debate over the role of specialisation versus diversification in the literature on regional development literature (Kemeny and Storper, 2015; Storper et al, 2015; Martin, 2016; Boschma, 2016). And how do patterns of structural change across British cities help account for their productivity growth paths, identified in the previous section?

There are several indicators which can be used to capture local economic structure and with which to compare different areas at any particular point in time. Early discussions of a range of alternative measures can be found in Isard et al (1960) and Bahl et al (1971). More recently, Palan (2010) reviewed no fewer than nine different measures. Some of these were 'absolute' measures, in which the actual sectoral distribution of a local area's employment or output is compared to a defined 'base-line' metric, usually that of a perfectly equal distribution of sectoral shares; while others were 'relative' measures, where the comparison is with some chosen 'norm' or 'reference' economy, for example the national sectoral structure. Palan assessed the various measures for the extent to which they satisfy certain criteria (or what she called axioms)[3] and then used them to examine and compare the economic structures of European countries. She found that the different measures do not yield consistent results, and that no one approach could be said to be superior: to some extent the choice of measures depends on the specific purpose in mind.

One of the most commonly used measures of city or regional economic structure is the *coefficient of relative specialization* (see Isard, 1960; Thirlwall and Dixon, 1975). This has been deployed by Krugman on a number of occasions to examine city and regional specialization (Krugman, 1991; 1993), and for that reason is often called the 'Krugman Index'. It takes the form

$$CRS_{jt} = \sum_{i=1}^{N} | s_{ijt} - s_{it}^{*} | \qquad (1)$$

where, s_{ij} is the share of total employment (or output) in city *j* accounted for by sector *i* at time *t*, s_i^* is the corresponding employment (or output) share of that sector in the comparator 'reference economy' also at time *t*, and *N* is the number of sectors involved in the analysis. The sum is over the absolute differences between the industry shares of a given city's employment (or output) and the

[3] Palan lists four such axioms: anonymity, or invariance to ordering of sectors; progressive transfers, or the principle of rank-preserving equalisation; having defined upper and lower bounds; and decomposability into within and between components (such as sectors or firms) .

corresponding industry shares in the reference economy. As defined, the index takes the value of zero when a city (or region) has exactly the same structure as the reference economy (since each absolute sectoral share difference in (1) would itself be zero). The index increases the more that the city's (region's) economic structure differs from the reference economy. If the city (region) shared no sector in common with the reference economy (which might be another city or region), then the maximum value the index would be 2, since each absolute sectoral difference in (1) would be counted in full. This is not the case, however, if the national economy is taken as the reference norm, since by definition the national economy must share at least one sector in common with at least one of its cities (regions). In this case the upper bound of the index is 2[(N-1)]/N. Alternatively, the 'national reference economy' could be calculated individually for each city (region) as the weighted sum of all other cities (regions) minus the city (region) in question. This would seem advisable if one or two cities (or regions) dominate the national average.

According to Krugman, the index is a "rough way of quantifying differences in structures, and hence regional specialization" (1993, p. 250). Strictly speaking, however, it tells us more about *structural dissimilarity* between regions, or cities, than about regional or city specialization per se, since even if the index for a city is close to zero, suggesting little difference from the reference economy, the reference economy itself could be narrowly specialised in particular sectors, so in this case both the city and the nation would be equally and similarly specialized.

Thus an additional measure is required in order to capture whether a city is absolutely specialised or diversified economically. The obvious approach to measuring the *degree of diversity* of a city's economic structure is to compare actual sectoral (employment or output) shares against an equi-proportion distribution of shares, that is a state of complete diversity or balanced structure. There are several possible measures that can be used for this purpose (see, for example, Isard et al, 1960; Gibbs and Postan, 1975; Kruger, 2006; Palan, 2010). These include Shannon's Entropy Index (for example, Aiginger and Davies, 2004; Aiginger and Pfaffermayr, 2004), the Index of Inequality in Production Structure (see Cuadrado-Roura et al., 1999; Haaland et al., 1999; Landesmann, 2000; Percoco et al., 2005), the Theil Index (Brülhart and Traeger, 2005; Ezcurra and Pascual, 2007), and the Hirschman-Herfindahl Index (for example, Sapir, 1996; Davis, 1998; Storper et al, 2002; Aiginger and Pfaffermayr, 2004; Beine and Coulombe, 2007). As Palan (2010) shows, although a simple measure, the Hirschman-Herfindahl index satisfies most of the key criteria required for a useful and meaningful measure of diversity.

The Hirchman-Herfindahl index is defined as the sum of the squared sectoral shares,

$$HHI_{jt} = \sum_{i=1}^{N} s_{ijt}^2 \qquad (2)$$

where, as in Equation (1), he shares s_{ijt} are expressed as proportions of a city's (or region's) total employment (or output). The index ranges from a minimum of $1/N$, when all sectoral shares are equal (maximum diversity) to an upper bound of 1, in which case a city would be mono-specialised, that is all of its activity is in just one industry. Because the sectoral shares are squared, the index gives more weight to large sectors. For this reason, the square root of the index is sometimes used (for example, Chisholm and Oeppen, 1973).

Both the CRS (Krugman) Index and the Hirschman-Herfindahl Index can be used for identifying and tracking structural change in individual cities and regions by comparing values of the indices at different points in time.[4] If structure is changing, the first place to look is at the patterns of the employment and output shares and the changes they evince over time. In the case of the CRS, by using the national economy as the reference economy for example, the index can illuminate whether, how far and how fast, city economic structures are converging (declining values of the index), or diverging (increasing values of the index). Note that the *CRS* can be also used to chart the changing economic structure of a city relative to its own 'starting' structure, at say *t=0*, by setting the reference 'norm' s_{ijt}^* in (1) to s_{ij0}. In this instance, structural change would be indicated by rising values of the index over time, as the city increasingly diverged from its original mix of sectors. With respect to the *HHI*, if there is proportional growth across sectors, and hence no structural change, the index would remain constant over time (Metcalfe et al, 2006). Changes in the index thus indicate structural change: successive values that moved towards $1/N$ over time would indicate increasing equality (diversity) in economic structure, whereas a trend towards 1 would indicate increasing specialisation. The rate of change of the *HHI* is proportional to the covariance between employment (or output) shares and employment (or output) growth rates:

$$dHHI/dt = 2\sum_{i=1}^{N} s_{ijt}(g_{ijt} - g_{jt})s_{ijt} \qquad (3)$$

where g_{ijt} is the growth rate of employment (or output) in sector *i* in city *j*, and g_{jt} is the city's aggregate employment (or output) growth rate.

[4] There are measures that are intended to capture the scale and speed of structural change in a region or city economy directly, for example the Lilien Index (Lilien, 1982; Ansari et al, 2013), but these do not of themselves tell us much about whether that change is leading to diversification or specialisation of a region's or city's structure

The calculated CRS (Krugman) indices of structural specialisation by employment and by output across 82 sectors for the 85 cities for 1971, 1991 and 2014 are given in Tables 2 and 3 respectively. For each city, the reference economy in Equation (1) was defined as Great Britain minus the city in question, so as to avoid double counting (which would not be insignificant in the case of the largest cities such as London, Birmingham, Manchester, Sheffield, Liverpool, Glasgow and Edinburgh). Several key features stand out. First, in 1971, cities differed markedly in the degree of relative structural specialisation, whether in terms of employment or output. Second, in both instances, the large cities (regional capitals) and London were less specialised than most other, smaller cities. Third, in the case of employment structure, all but one city (Slough) have experienced a decline in relative specialisation since 1971. The trends in output structures are broadly similar, although some thirteen cities experienced a slight increase in relative specialisation, or divergence from the structure of the national economy. Fourth, whether measured by employment shares or output shares, in general the more specialised a city was in 1971, the greater the reduction in specialisation over the ensuing period (see Figures 8 for the case of employment). Thus what the analysis shows, at the level of the 82 sectors used here, is a tendency for *structural convergence* across the British city system over the past forty years or so.

Table 2: CRS (Krugman) Employment Specialisation Indices for British Cities (82 sectors), 1971, 1991 and 2014
(Cities ranked in descending order of specialisation for 1971)

	1971	1991	2014		1971	1991	2014
Sunderland	0.717	0.417	0.385	Crewe	0.510	0.314	0.242
Mansfield	0.711	0.440	0.296	Stevenage	0.510	0.335	0.292
Halifax	0.686	0.430	0.407	Doncaster	0.504	0.339	0.363
Swansea	0.679	0.321	0.352	Plymouth	0.503	0.382	0.343
Merthyr Tydfil	0.677	0.409	0.380	Barnsley	0.502	0.398	0.354
Oxford	0.664	0.325	0.301	Leicester	0.501	0.313	0.280
Kettering& Wellingborough	0.659	0.419	0.349	Durham& Bishop Auckland	0.500	0.417	0.357
Wolverhampton	0.656	0.419	0.269	Tunbridge Wells	0.497	0.280	0.280
Blackpool	0.647	0.518	0.399	Bedford	0.493	0.272	0.234
Blackburn	0.634	0.410	0.348	Hull	0.483	0.320	0.316
Dudley	0.621	0.403	0.357	**Bristol**	**0.480**	**0.325**	**0.220**
Middlesbrough	0.617	0.444	0.305	Peterborough	0.480	0.335	0.289
Trowbridge	0.612	0.346	0.246	**Sheffield**	**0.479**	**0.252**	**0.278**
Coventry	0.609	0.379	0.296	Warrington & Wigan	0.468	0.296	0.278
Derby	0.606	0.430	0.295	Shrewsbury	0.462	0.259	0.279
Stoke-on-Trent	0.599	0.414	0.325	Medway	0.460	0.276	0.191
Newport	0.597	0.403	0.325	High Wycombe & Aylesbury	0.459	0.297	0.265
Aberdeen	0.592	0.524	0.474	Crawley	0.458	0.362	0.285
Huddersfield	0.589	0.380	0.351	Brighton	0.454	0.300	0.280
Birkenhead	0.584	0.394	0.289	Preston	0.453	0.295	0.286
Colchester	0.581	0.354	0.273	Cambridge	0.452	0.311	0.240
Motherwell &Airdrie	0.577	0.362	0.359	Guildford	0.450	0.285	0.257
Northampton	0.573	0.383	0.332	**Liverpool**	**0.447**	**0.265**	**0.234**
Bradford	0.568	0.363	0.307	**Nottingham**	**0.445**	**0.255**	**0.269**

Milton Keynes	0.551	0.324	0.315	Swindon	0.442	0.282	0.255
Falkirk and Stirling	0.550	0.365	0.288	Norwich	0.440	0.269	0.222
Dunfermline & Kirkcaldy	0.550	0.381	0.325	Lincoln	0.439	0.309	0.243
Basingstoke	0.549	0.376	0.366	Ipswich	0.436	0.310	0.251
Blyth & Ashington	0.548	0.398	0.408	**Edinburgh**	**0.434**	**0.316**	**0.314**
Exeter	0.544	0.338	0.268	Luton	0.434	0.298	0.281
Gloucester	0.540	0.313	0.297	Chelmsford	0.430	0.239	0.164
Bournemouth	0.535	0.329	0.287	Southend	0.423	0.393	0.224
Chester	0.535	0.322	0.261	Worcester & Kidderminster	0.418	0.309	0.264
Chichester	0.530	0.311	0.264	**London**	**0.411**	**0.387**	**0.387**
Wakefield	0.529	0.382	0.368	**Leeds**	**0.408**	**0.270**	**0.227**
Chesterfield	0.529	0.446	0.252	**Newcastle**	**0.396**	**0.258**	**0.252**
Birmingham	**0.526**	**0.308**	**0.175**	Southampton	0.368	0.249	0.184
Leamington Spa	0.525	0.322	0.338	Slough & Heathrow	0.352	0.330	0.370
Telford	0.522	0.450	0.376	**Cardiff**	**0.340**	**0.213**	**0.233**
Portsmouth	0.519	0.311	0.266	**Glasgow**	**0.328**	**0.209**	**0.224**
Dundee	0.518	0.345	0.304	**Manchester**	**0.324**	**0.187**	**0.169**
Reading	0.513	0.378	0.393				
York	0.512	0.357	0.263				
Eastbourne	0.511	0.492	0.270				

Note: London and major regional capitals ('Core cites') in bold

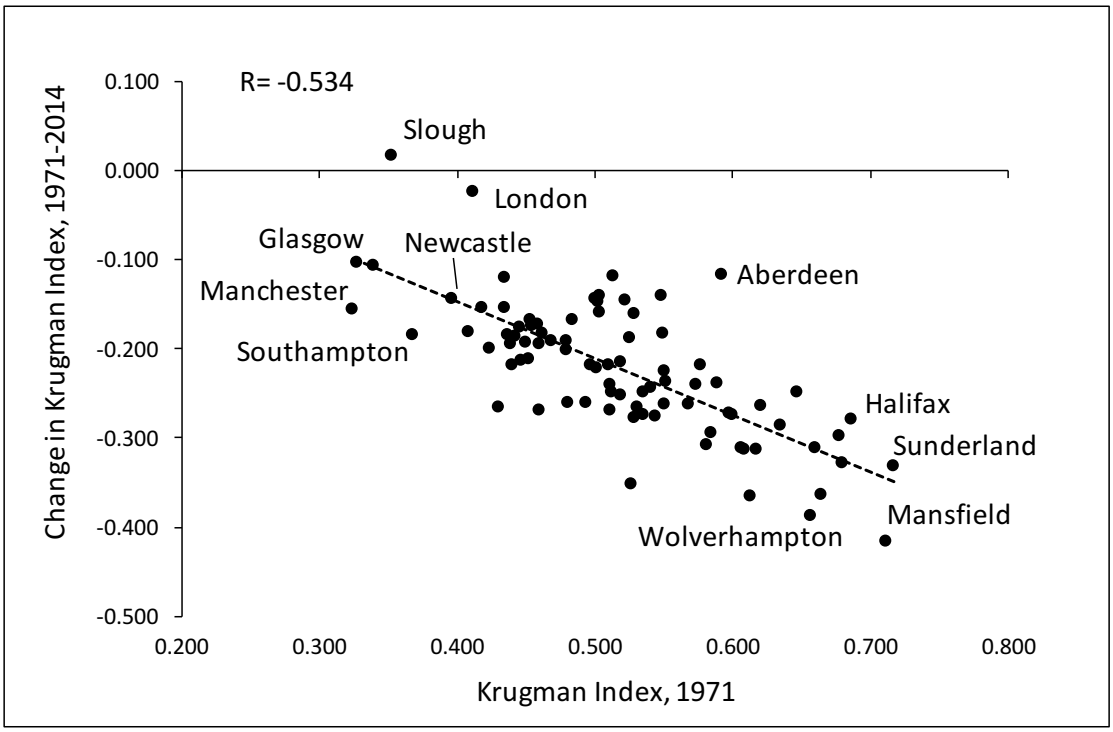
Table 3: CRS (Krugman) Output Specialisation Indices for British Cities, (82 sectors), 1971, 1991 and 2014 (Cities ranked in descending order of specialisation for 1971)

	1971	1991	2014		1971	1991	2014
Oxford	0.723	0.420	0.375	Stoke-on-Trent	0.488	0.466	0.432
Kettering & Wellingborough	0.709	0.498	0.513	Leicester	0.488	0.348	0.368
Blackpool	0.668	0.488	0.516	Dundee	0.488	0.471	0.432
Wolverhampton	0.659	0.450	0.402	Stevenage	0.487	0.418	0.398
Basingstoke	0.644	0.433	0.477	**Sheffield**	0.484	0.345	0.403
Swansea	0.634	0.454	0.511	Bournemouth	0.484	0.365	0.313
Leamington Spa	0.634	0.420	0.539	High Wycombe & Aylesbury	0.481	0.330	0.399
Plymouth	0.633	0.509	0.500	Chelmsford	0.481	0.334	0.279
Blackburn	0.633	0.508	0.485	Exeter	0.480	0.397	0.408
Trowbridge	0.600	0.451	0.281	Tunbridge Wells	0.479	0.380	0.332
Birkenhead	0.593	0.552	0.400	Bedford	0.479	0.384	0.341
Chester	0.590	0.416	0.399	Cambridge	0.479	0.405	0.365
Crewe	0.590	0.439	0.412	Peterborough	0.478	0.360	0.323
Halifax	0.582	0.443	0.432	Telford	0.478	0.507	0.511
Merthyr Tydfil	0.580	0.491	0.547	Hull	0.477	0.418	0.500
Middlesbrough	0.576	0.517	0.489	Blyth & Ashington	0.476	0.472	0.541
Portsmouth	0.567	0.427	0.372	Shrewsbury	0.472	0.405	0.424
Coventry	0.559	0.527	0.432	**London**	**0.468**	**0.548**	**0.643**
Sunderland	0.558	0.447	0.525	Dunfermline & Kirkcaldy	0.467	0.439	0.436
Derby	0.554	0.503	0.535	Doncaster	0.465	0.483	0.538
Medway	0.551	0.361	0.297	York	0.463	0.532	0.419
Mansfield	0.551	0.515	0.483	Worcester & Kidderminster	0.457	0.483	0.361
Chesterfield	0.551	0.505	0.444	Guildford	0.456	0.443	0.358
Reading	0.546	0.446	0.587	Eastbourne	0.453	0.494	0.366
Dudley	0.544	0.463	0.454	Brighton	0.446	0.372	0.333
Huddersfield	0.542	0.459	0.450	Ipswich	0.438	0.432	0.309
Aberdeen	0.542	1.044	0.744	Crawley	0.437	0.490	0.342
Barnsley	0.535	0.488	0.487	Norwich	0.432	0.343	0.292
Milton Keynes	0.532	0.359	0.423	**Birmingham**	**0.427**	**0.374**	**0.275**
Preston	0.529	0.502	0.377	Swindon	0.426	0.316	0.435
Gloucester	0.522	0.349	0.385	Lincoln	0.418	0.443	0.487

Bristol	**0.518**	**0.363**	**0.255**	**Nottingham**	**0.414**	**0.329**	**0.409**
Wakefield	0.515	0.486	0.479	Southampton	0.413	0.350	0.314
Newport	0.508	0.455	0.492	Southend	0.386	0.397	0.331
Liverpool	0.507	0.328	0.328	**Newcastle**	**0.384**	**0.302**	**0.393**
Falkirk and & Stirling	0.507	0.456	0.430	**Edinburgh**	**0.381**	**0.389**	**0.430**
Colchester	0.504	0.426	0.358	**Leeds**	**0.381**	**0.288**	**0.236**
Motherwell & Airdrie	0.501	0.443	0.475	Luton	0.371	0.386	0.331
Bradford	0.501	0.390	0.392	**Manchester**	**0.353**	**0.332**	**0.200**
Warrington & Wigan	0.498	0.388	0.401	**Cardiff**	**0.339**	**0.330**	**0.373**
Durham &Bishop Auckland	0.497	0.509	0.526	**Glasgow**	**0.316**	**0.271**	**0.271**
Northampton	0.491	0.442	0.438	Slough & Heathrow	0.294	0.397	0.489
Chichester	0.489	0.419	0.340				

Note: London and major regional capitals ('Core cites') in bold

Figure 8: Sectoral Convergence in Employment Structures Across Cities, 1971-2014



The corresponding HH indices for 1971, 1991 and 2014 are given in Tables 4 and 5, with the detailed temporal trends for selected cities shown in Figures 9 and 10. These show several interesting features. In general, cities tend to be more specialized in terms of output structures than in employment structures; this was especially the case in the 1970s and 1980s. With respect to employment structures, more than half of the cities experienced a decline in specialization over the period 1971-2014. Those cities that were more specialized initially underwent the largest declines, while some of the cities least specialised initially experienced an increase in employment specialization. The

HH structural indices for output shares, however, show a more definite pattern, with most cities becoming less specialized over the four decades. As in the case of the Krugman indices, it would appear that the decline in specialisation was most evident in the 1971-1991 sub period, and that structural change since then has been slower.

Table 4: Hirschman-Herfindahl Employment Specialisation Indices for British Cities, (82 sectors), 1971, 1991 and 2014
(Cities ranked in descending order of specialisation for 1971

	1971	1991	2014		1971	1991	2014
Oxford	0.081	0.052	0.054	York	0.046	0.045	0.045
Sunderland	0.077	0.043	0.045	**Edinburgh**	**0.045**	**0.043**	**0.043**
Huddersfield	0.072	0.041	0.046	Peterborough	0.045	0.039	0.045
Stoke-on-Trent	0.071	0.050	0.044	Aberdeen	0.045	0.041	0.042
Halifax	0.071	0.037	0.045	Newport	0.045	0.042	0.048
Dudley	0.067	0.043	0.045	Luton	0.044	0.043	0.044
Trowbridge	0.066	0.050	0.041	Cambridge	0.044	0.044	0.044
Bradford	0.060	0.045	0.045	Chesterfield	0.043	0.047	0.042
Middlesbrough	0.060	0.045	0.050	Worcester & Kidderminster	0.043	0.048	0.043
Reading	0.060	0.043	0.048	Chichester	0.043	0.046	0.044
Exeter	0.059	0.044	0.047	Leamington Spa	0.043	0.039	0.036
Plymouth	0.059	0.056	0.051	Motherwell & Airdrie	0.043	0.045	0.044
Mansfield	0.059	0.042	0.042	Preston	0.043	0.041	0.046
Gloucester	0.059	0.039	0.043	Nottingham	0.043	0.042	0.050
Kettering & Wellingborough	0.059	0.039	0.041	Lincoln	0.042	0.038	0.043
Basingstoke	0.058	0.040	0.041	Bedford	0.042	0.042	0.046
Swansea	0.056	0.047	0.052	**Birmingham**	**0.042**	**0.037**	**0.042**
Wolverhampton	0.056	0.039	0.043	Crewe	0.042	0.040	0.036
Portsmouth	0.056	0.044	0.049	Durham & Bishop Auckland	0.042	0.041	0.048
Falkirk and Stirling	0.055	0.048	0.047	Wakefield	0.041	0.046	0.045
Colchester	0.054	0.054	0.052	**Liverpool**	**0.041**	**0.047**	**0.048**
Dunfermline & Kirkcaldy	0.054	0.043	0.046	Chester	0.041	0.041	0.038
Medway	0.053	0.041	0.044	Tunbridge Wells	0.041	0.043	0.041
Dundee	0.053	0.047	0.054	Norwich	0.041	0.040	0.044
Blackburn	0.052	0.039	0.044	Brighton	0.040	0.044	0.049
Coventry	0.051	0.042	0.043	**Newcastle**	**0.040**	**0.043**	**0.049**
Chelmsford	0.050	0.045	0.041	High Wycombe & Aylesbury	0.040	0.039	0.044
Sheffield	**0.050**	**0.042**	**0.048**	Guildford	0.039	0.040	0.041
Eastbourne	0.049	0.058	0.050	**Cardiff**	**0.039**	**0.040**	**0.047**
Birkenhead	0.049	0.050	0.050	Hull	0.039	0.046	0.043
Stevenage	0.049	0.046	0.047	**Glasgow**	**0.039**	**0.042**	**0.044**
Blyth & Ashington	0.048	0.045	0.047	Leicester	0.038	0.037	0.040
Swindon	0.048	0.039	0.037	Milton Keynes	0.038	0.041	0.041
Bristol	**0.047**	**0.040**	**0.042**	Shrewsbury	0.038	0.042	0.045
Ipswich	0.047	0.046	0.041	Southampton	0.038	0.042	0.045
Barnsley	0.047	0.047	0.045	Warrington & Wigan	0.038	0.039	0.039
Bournemouth	0.047	0.043	0.045	**Leeds**	**0.038**	**0.039**	**0.039**
Northampton	0.046	0.039	0.038	**Manchester**	**0.037**	**0.040**	**0.039**
Doncaster	0.046	0.049	0.051	**London**	**0.037**	**0.038**	**0.039**
Telford	0.046	0.045	0.042	Blackpool	0.037	0.047	0.045
Derby	0.046	0.041	0.041	Slough & Heathrow	0.035	0.036	0.037
Merthyr Tydfil	0.046	0.038	0.049	Crawley	0.034	0.034	0.038
Southend	0.046	0.047	0.047				

Note: London and major regional capitals ('Core cities') in bold

Table 5: Hirschman-Herfindahl Output Specialisation Indices for British Cities, (82 sectors), 1971, 1991 and 2014

(Cities ranked in descending order of specialisation for 1971)

	1971	1991	2014		1971	1991	2014
Oxford	0.145	0.057	0.046	Middlesbrough	0.060	0.052	0.047
Trowbridge	0.124	0.063	0.037	Southampton	0.059	0.048	0.038
Plymouth	0.104	0.078	0.054	**Sheffield**	**0.059**	**0.045**	**0.049**
Gloucester	0.104	0.044	0.037	Doncaster	0.059	0.055	0.053
Portsmouth	0.103	0.054	0.045	Chelmsford	0.058	0.044	0.040
Basingstoke	0.096	0.043	0.041	Bournemouth	0.058	0.043	0.040
Reading	0.092	0.047	0.071	Norwich	0.058	0.043	0.041
Exeter	0.086	0.056	0.048	Halifax	0.057	0.040	0.042
Swansea	0.084	0.049	0.053	Tunbridge Wells	0.057	0.048	0.040
Falkirk and Stirling	0.084	0.055	0.039	Crewe	0.056	0.034	0.032
Medway	0.083	0.045	0.042	Mansfield	0.056	0.042	0.041
Leamington Spa	0.082	0.041	0.039	Worcester & Kidderminster	0.055	0.050	0.035
Swindon	0.074	0.043	0.040	York	0.054	0.045	0.041
Durham & Bishop Auckland	0.072	0.051	0.048	Huddersfield	0.054	0.042	0.043
Colchester	0.072	0.052	0.046	Brighton	0.054	0.048	0.044
Kettering & Wellingborough	0.070	0.042	0.042	Bradford	0.053	0.042	0.042
Dundee	0.069	0.054	0.045	Motherwell & Airdrie	0.053	0.049	0.040
Dunfermline & Kirkcaldy	0.069	0.045	0.040	Derby	0.052	0.044	0.047
Bristol	**0.069**	**0.046**	**0.039**	Luton	0.052	0.040	0.039
Eastbourne	0.069	0.057	0.045	Birkenhead	0.052	0.047	0.038
Wolverhampton	0.066	0.044	0.040	Chester	0.052	0.038	0.032
Telford	0.066	0.050	0.040	Milton Keynes	0.052	0.040	0.044
Edinburgh	**0.065**	**0.052**	0.047	Preston	0.052	0.040	0.044
Dudley	0.065	0.045	0.042	**Glasgow**	**0.051**	**0.049**	**0.038**
Stoke-on-Trent	0.064	0.048	0.040	Wakefield	0.051	0.047	0.044
Coventry	0.064	0.054	0.039	**Birmingham**	**0.051**	**0.041**	**0.039**
High Wycombe & Aylesbury	0.064	0.040	0.045	Stevenage	0.050	0.040	0.042
Aberdeen	0.063	0.144	0.060	Bedford	0.050	0.043	0.044
Lincoln	0.063	0.044	0.047	Shrewsbury	0.050	0.046	0.042
Cardiff	**0.063**	**0.044**	**0.042**	**London**	**0.050**	**0.046**	**0.045**
Chichester	0.062	0.049	0.040	Southend	0.049	0.042	0.044
Sunderland	0.062	0.043	0.045	Slough & Heathrow	0.048	0.036	0.040
Blyth and Ashington	0.062	0.050	0.044	Warrington & Wigan	0.047	0.036	0.034
Peterborough	0.061	0.039	0.039	Crawley	0.047	0.035	0.035
Northampton	0.061	0.043	0.040	Leeds	0.046	0.038	0.038
Merthyr Tydfil	0.061	0.043	0.047	Leicester	0.046	0.040	0.038
Barnsley	0.061	0.053	0.046	**Liverpool**	**0.045**	**0.041**	**0.039**
Ipswich	0.061	0.053	0.038	**Nottingham**	**0.045**	**0.040**	**0.046**
Chesterfield	0.061	0.051	0.043	**Manchester**	**0.044**	**0.043**	**0.035**
Newcastle	**0.061**	**0.046**	**0.049**	Blackburn	0.043	0.037	0.038
Cambridge	0.060	0.044	0.039	Hull	0.043	0.045	0.039
Newport	0.060	0.043	0.046	Blackpool	0.039	0.045	0.043
Guildford	0.060	0.042	0.041				

Note: London and major regional capitals ('Core cities') in bold

5. Structural Change and Productivity Growth Across British Cities

As was discussed in the Introduction, the relationship between structural change and productivity growth is not a simple nor self-evident one. Productivity growth can be of a 'within-sector' kind, arising from technological, organisational and related improvements amongst firms in that sector, including the development of better (high value-added) products; and 'between-sector', or structural-change induced, arising from the shift and reallocation of capital and labour from low productivity growth sectors into higher productivity growth ones (see Table 6). There have been various recent attempts to assess the

Figure 9: Sectoral Diversification in Selected Cities: The Hirschman-Herfindahl Index of Employment Shares, 1971-2014. (A smaller value of HH indicates greater sectoral diversity or balance)

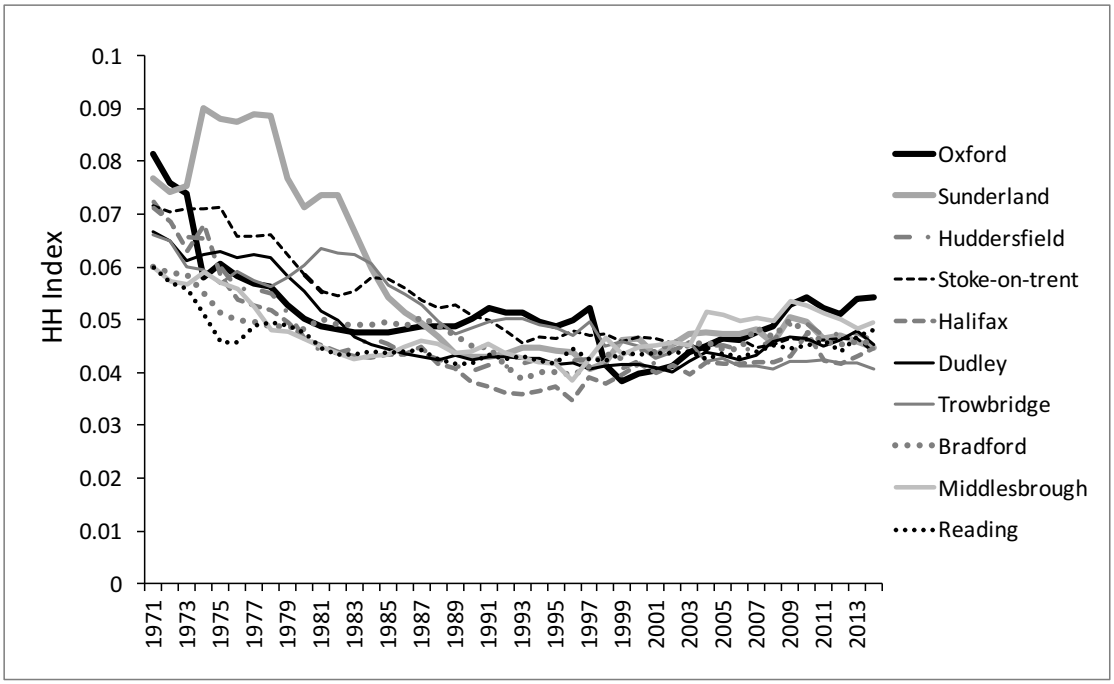
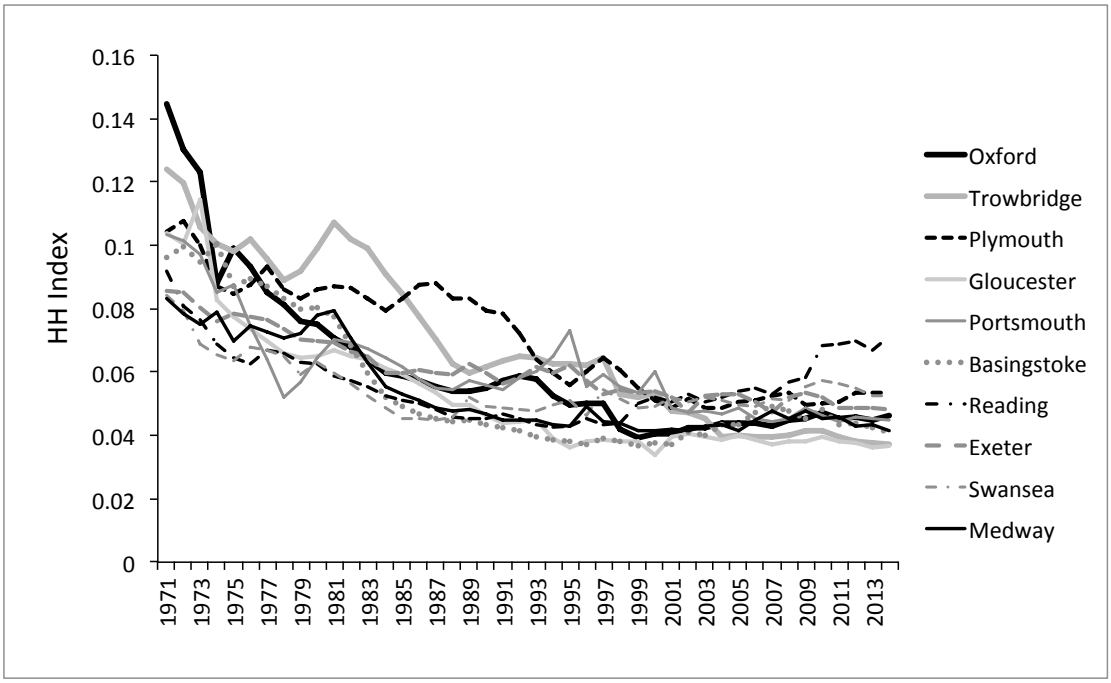


Figure 10: Sectoral Diversification in Selected Cities: The HH index of Output Shares, 1971-2014 (A smaller value of HH indicates greater sectoral diversity or balance)



relative contribution of such 'within' and 'between' effects to aggregate productivity growth. Some of these have used such a 'within' and 'between' sectoral decomposition to examine a nation's productivity growth, and others to examine differences in productivity growth between countries (Fagerberg, 2000; Pieper, 2000; Peneder, 2003; Kruger, 2006; Ocampo et al, 2009; Timmer and de Vries, 2009; and Kucera and Roncolato, 2012; McMillan and Rodrik, 2011). Although the results vary across time periods, data frequency, according to whether structure is measured by employment shares or output shares, the choice of labour productivity or total factor productivity, and the particular decomposition technique used, the balance of the findings is that the 'within-sector' effect dominates the 'between-sector' effect, ie. the effect due to structural change. Haltiwanger (2000) has argued that structural change is much more intense within industries (that is among the firms within different sub-branches of an industry) than between industries, even at detailed levels of industrial disaggregation. Yet the various studies that have used a 'within' and 'between' firm decomposition to investigate productivity growth of a given broad sector (Baily et al, 1992, 2001; Foster et al, 1998; Bartlesman and Doms, 2000; Disney at el, 2003, Cantner and Kruger, 2006) also tend to find the 'within-firm' effect is greater than the 'between-firm' effect.

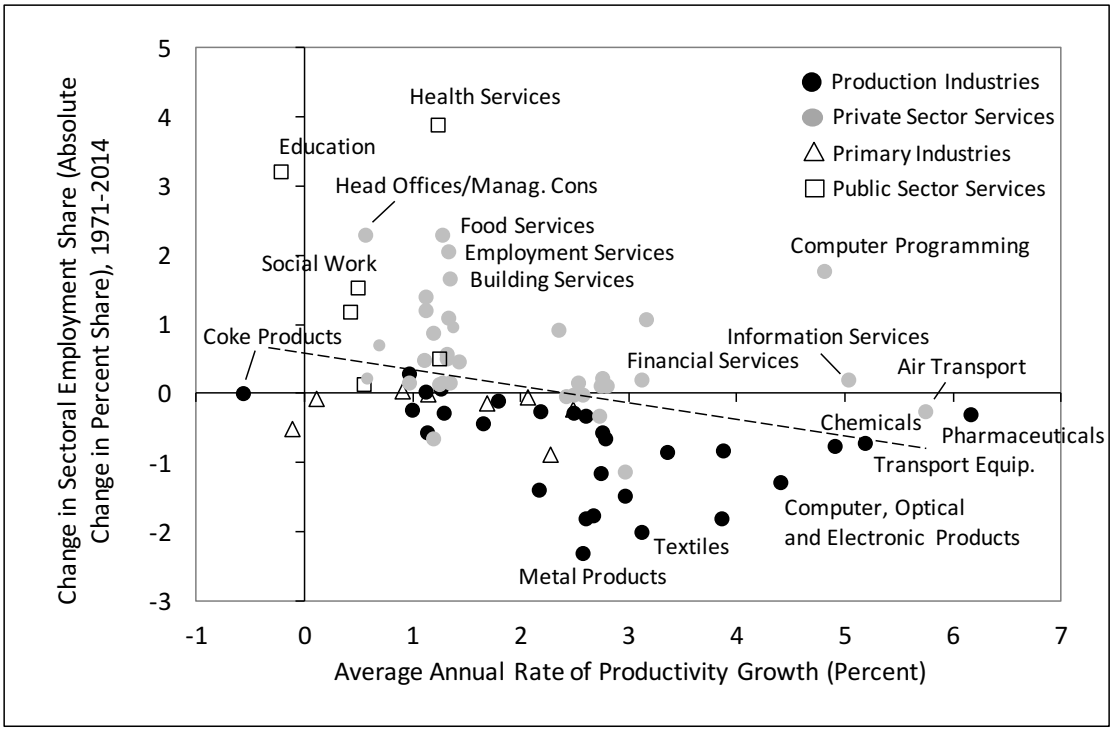
Table 6: Within and Between Sector Sources of City Productivity Growth

Within sector developments (firm dynamics)	**Between sector developments (cross sectoral structural shifts and reallocations)**
Death of low productivity firms and birth of new higher-productivity firms	Broad switch from Primary Industry to Manufacturing to Services
Adoption of new organizational and operational methods and technological innovations	Decline of low productivity activities and birth and development of high productivity activities
Production of new higher-value products and services and switch into new markets	Industry restructuring – mixing and new combinations with other sectors to produce higher productivity industries

To provide background to the city analysis, Figure 11 shows the national –level relationship between productivity growth and the change in employment share for our 82 sectors over the whole period 1971-2014. Several features are evident. Almost all of the manufacturing sectors have experienced a fall in employment share, consistent with deindustrialisation trend depicted in Figure 6. the in most cases of between 2-4 percent per annum. But all except 'coke and refined petroleum products' also experienced productivity growth, in most cases of between 2-4 percent per annum. Some key sectors, however, achieved rates

much higher than this, of between 4 and 6.5 percent per annum: pharmaceuticals, transport equipment, chemicals, computer equipment, and vehicles. In the case of private market services, these fall into two main groups: one in which annual productivity growth has averaged around 2.5 percent, but employment shares have changed only marginally (eg. Financial Services, information services); and another in which employment shares have grown but the annual rate of productivity growth has averaged only around 1.0 percent per annum (eg. Food Services, Building Services, Head Offices, Management Consultancies). Information services, air transport, finance and computer programming services have recorded high rates of productivity growth, though only the last of these saw any significant increase in employment share. What is particularly striking is that, overall, there is a negative relationship between productivity growth and employment share across sectors (R= -0.201): the employment structure of the national economy has been away from those sectors – manufacturing, construction and utilities - which have shown the highest rates of productivity growth into those sectors – private and public services – most of which have experienced the slowest rates of productivity growth. How far this helps to account for the declining trend in national aggregate productivity growth shown in Figure 11 is thus an interesting question in its own right.

Figure 11. Productivity Growth and Change in Employment Share by Sector, Great Britain, 1971-2014



Source: Authors' data

Our interest here, however, is in the relationship between structural change and productivity growth across Britain's cities. As mentioned above, various authors have sought to identify the relative contribution of 'within-sector' and 'between-sector' (structural change) contributions to country-level and industry-level productivity growth. For example, in their study of differences in productivity performance among developing countries, McMillan and Rodrik (2011) use a simple decomposition of the absolute change in productivity, which when applied to our cities takes the form:

$$\Delta Y_{jt} = \sum_{i=1}^{n} s_{ijt-k}\, \Delta y_{ijt} + \sum_{i=1}^{n} \Delta s_{ij}\, y_{ijt} \qquad (4)$$

where Y_{jt} and y_{ijt} refer, in our case, to total and sector-specific labour productivity levels (real GVA per employed worker) in city *j* at time *t*. The Δ operator denotes the change, in productivity and in employment shares, between *t-k* and *t*. The first term in (4), what McMillan and Rodrik call the 'within sector' contribution, is the weighted sum of productivity change within individual sectors, arising for example from improvements in production technique or the other factors identified in Table 6, where the weights s_{ijt} are the shares of city employment in those sectors at the beginning of the time period concerned. The second term captures the productivity effect of employment reallocations across or between different sectors. It is essentially the inner product of sectoral productivity levels (at the end of the time period) with the change in employment shares across those sectors (since the beginning of the period). It is this component that McMillan and Rodrik refer to as 'structural change'. When changes in employment shares are positively correlated with productivity levels, this term will be positive, and structural change will have operated to increase the city-wide rate of productivity change over the study period. If it is negative, it indicates that a city's employment structure has shifted overall towards sectors that have lower productivity than the sectors that are losing employment share.

A variant of this decomposition approach is used by Kruger (2006), in his study of study of productivity growth in US manufacturing (see also Disney, et al, 2003; Foster, et al, 1998; Kucera and Roncaolato, 2012; Roncolato and Kucera, 2014). In this version, a city's aggregate productivity growth (rather than the absolute change in productivity studied by McMillan and Rodrik) is decomposed, using Kruger's notation, into three components:

$$\frac{\Delta Y_{jt+k}}{Y_{jt}} = \frac{\sum_{i=1}^{n} s_{ijt} \Delta y_{ijt+k}}{Y_{jt}} + \frac{\sum_{i=1}^{n} \Delta s_{ijt} (y_{ijt} - Y_{jt})}{Y_{jt}} + \frac{\sum_{i=1}^{n} \Delta s_{ijt+k} \Delta y_{ijt+k}}{Y_{jt}} \qquad (5)$$

where, as in (4), Y_{ijt} and y_{ijt} refer to total and sector-specific labour productivity levels in city *j*, and the Δ operator denotes the change in productivity or employment shares between *t* and *t+k*. The first term on the right-hand side of (5) is interpreted as the 'within-sector' effect, which is the share-weighted average productivity growth of the individual industries in city *j*. The second term represents the 'between-sector' effect. It is positive if sectors initially with above average productivity levels experience increasing shares between period *t* and *t+1* on average, and industries with below-average productivity levels experience falling shares of total city employment, on average. The third term is an interaction or 'covariance-effect' which is positive if industries with high rates of productivity growth tend to gain in terms of their shares (or more generally, if share change and productivity growth tend to have the same sign). The 'between effect' and 'covariance effect' together reflect the role of structural change in aggregate city productivity growth.[5]

Here we use Kruger's formula (Equation (5)). The results are shown in Figure 12 and Table 7. Figure 12 plots the three right-hand components of percentage productivity change in Equation (5) against the total percentage productivity change, for the whole period 1971-2017 for each of the 85 cities. As is clear, the overwhelming contribution to total productivity change across almost all of the cities was from 'within-sector' improvements. The 'between-sector' contribution whilst generally positive, is much smaller in virtually every case. There are only five cities in which the between-sector contribution is greater than the within-sector contribution: Birkenhead, Chester, Crawley, High Wycombe and Hull. The covariance component, by contrast, is negative in most cities, and is larger (in absolute terms) than the between-sector or structural contribution in half of the cities. This is consistent with a decline over time in the employment shares of those sectors with higher productivity growth – that is, manufacturing and production – or, conversely, the growth in employment share of those sectors with lower productivity growth. Given that this negative covariance effect generally exceeds the small positive between-sector component, the overall 'structural effect' on productivity across most cities would appear to have been negative. Table 8, which shows the detailed decomposition for the top 10 and bottom 10 cities in terms of total productivity growth for the two sub-periods 1971-1991 and 1991-2017, confirms these findings.

[5] It is further worth noting in passing that in the literature, several modifications and extensions of the two decomposition measures in Equations (4) and (5) have been proposed (Baily et al, 1992; Griliches and Regev, 1995; Olley and Pakes, 1995; Foster et al, 1998; Fagerberg and Peneder, 2000; Disney et al, 2003). For example, Baily et al (1992) and Foster et al (1998) derive versions with additional terms that represent the contributions of entering and exiting establishments to aggregate productivity growth. These effects cannot be investigated here for the time period that is of interest.

Figure 12. Decomposition of City Productivity Growth, 1971-2014, into Within-Sector, Between-Sector and Covariance (Interaction) Contributions

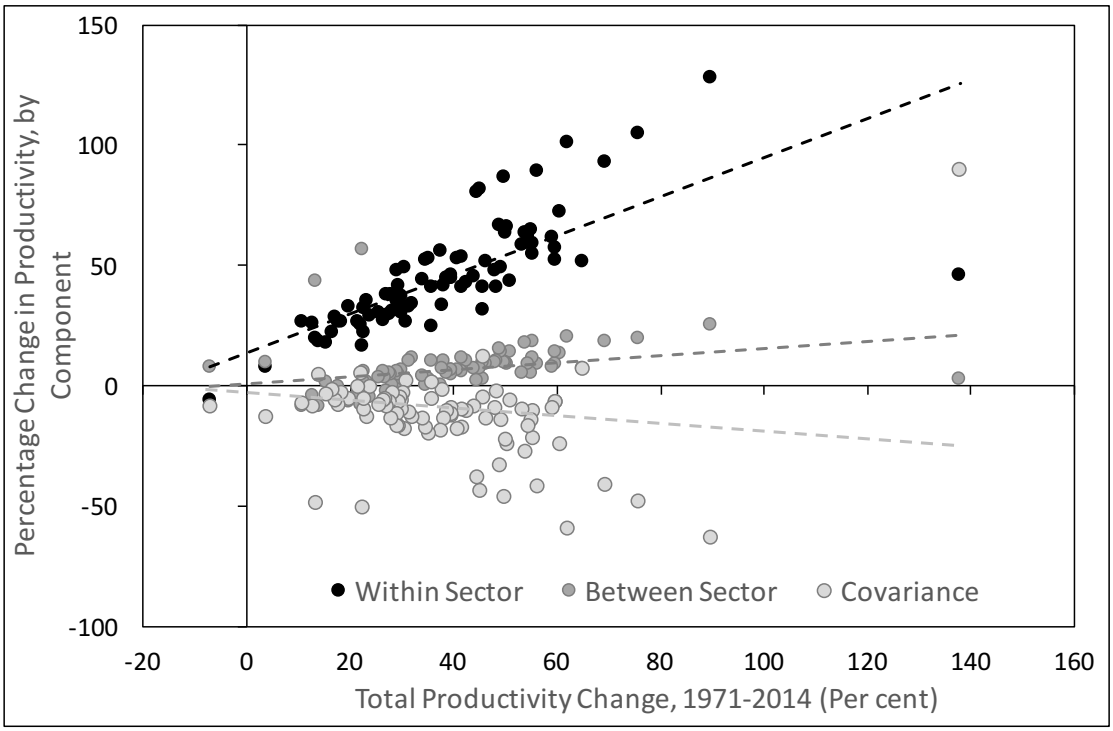


Table 7: Decomposition of City Productivity Growth, into Within-Sector, Between-Sector and Covariance Contributions, for the Top Ten and Bottom Ten Cities, 1971-1991 and 1991-2014

	1971-1991								
	TOP TEN					BOTTOM TEN			
	Total	Within	Between	Covar		Total	Within	Between	Covar
Aberdeen	138.1	110.51	7.26	20.39	**Blackpool**	17.86	26.47	-046	-8.32
Sunderland	89.80	127.76	25.41	-63.36	**Basingstoke**	17.12	28.20	-4.75	-6.33
Blyth	75.89	104.51	19.77	-48.40	**Plymouth**	16.59	22.25	-4.10	-1.55
Mansfield	69.33	92.42	18.11	-41.19	**Colchester**	15.43	17.41	1.40	-3.38
York	64.93	51.19	6.90	6.83	**Eastbourne**	13.86	18.37	-8.89	4.39
Merthyr Tydfil	62.02	101.04	20.05	-59.06	**Hull**	13.42	19.26	43.02	-48.85
Derby	60.52	71.99	13.09	-24.56	**Oxford**	12.77	25.77	-4.53	-8.46
London	59.77	57.21	9.12	-6.54	**Medway**	10.85	26.53	-8.41	-7.25
Halifax	59.62	52.08	14.11	-6.55	**High Wycombe**	3.7	7.44	9.54	-13.28
Middlesborough	59.11	61.29	7.31	-9.50	**Leamington**	-7.10	-5.99	7.35	-8.46

1991-2014									
	TOP TEN					BOTTOM TEN			
	Total	Within	Between	Covar		Total	Within	Between	Covar
Swindon	67.81	61.14	5.40	1.26	**Bedford**	25.04	41.29	-4.96	-11.29
Reading	59.10	58.27	4.79	-3.97	**Cardiff**	24.82	27.84	-0.78	-2.24
Basinstoke	56.42	67.97	-2.44	-9.10	**Doncaster**	23.89	37.66	-5.71	-8.06
Leamington	55.20	54.42	38.66	-37.89	**Colchester**	23.42	33.72	-2.84	-7.45
Crewe	54.24	58.30	99.25	-103.31	**Plymouth**	22.63	34.28	8.36	-3.28
Eastbourne	50.40	83.88	2.79	-36.26	**Hull**	22.54	26.93	35.70	-40.09
Derby	49.95	54.06	1.86	-6.50	**Swansea**	20.66	28.09	-0.14	-7.29
Bradford	47.56	51.06	15.97	-19.48	**Preston**	17.51	29.73	18.72	-30.93
Milton Keynes	46.51	57.65	-3.63	-7.49	**York**	16.92	39.21	-9.98	-12.31
Tunbridge	45.97	48.04	-1.30	-0.76	**Aberdeen**	0.12	2.81	3.51	-6.20

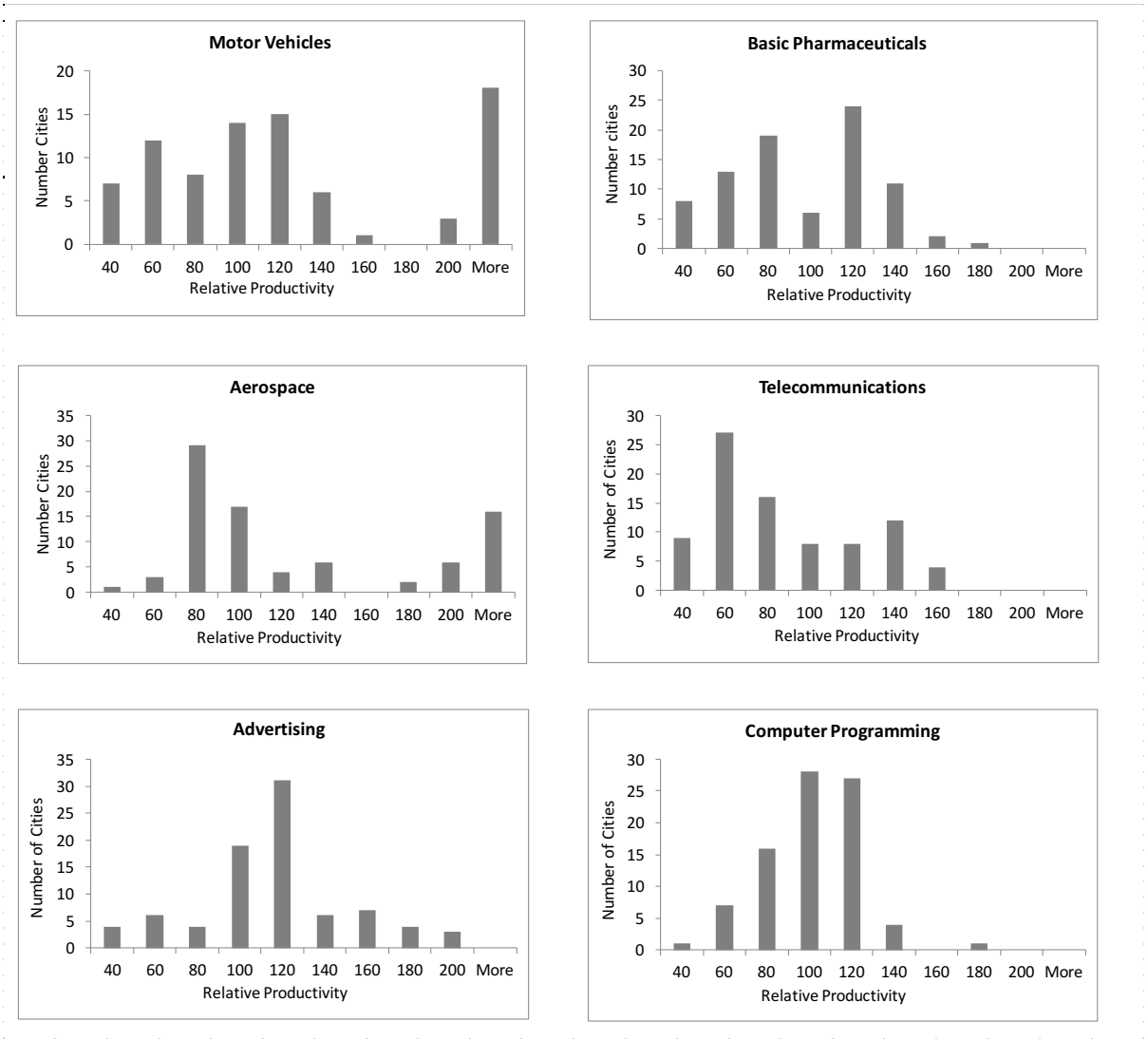
These results are somewhat surprising, in that they suggest that structural change has played a relatively minor, and in many cases a negative role in accounting for the variations in productivity growth across British cities. However, in this respect, they do tend to be consistent with the results obtained from studies that have sought to assess the significance of differential structural change in accounting for the patterns of productivity growth across countries, as referred to above. And given that our analysis in Section 4 suggests that city economic structures have converged, the implication is that city differences in productivity growth have mainly reflected differential productivity performance within the same sectors: put another way, it would appear that *the same sector performs differently across different cities*. Figure 13 shows that such within-sector variation in relative productivity across cities can be substantial. A much finer level of industrial disaggregation might change this conclusion, and give more (possibly positive) weight to between-sector and structural effects. On the other hand, the finer the grain of sectoral disaggregation, the smaller are the corresponding sectoral employment weights are likely to be, which may not therefore do much to change the importance of within-sector and structural change effects.

6. Implications and Conclusions

This paper has identified an 'urban productivity puzzle' to add to the numerous other puzzles and problems that beset research on productivity. We have seen that while sectoral structures in British cities have converged overall since the

early 1970s, most of that convergence took place during 1971-1991, and since then convergence has stopped and been replaced by slight divergence. We have

Figure 13: Within-Sector Variation in Relative Productivity across Cities, Selected Key Sectors, 2014 (GB=100)



found a growing imbalance in the productivity performance of cities which undoubtedly has serious implications for spatial inequalities in Britain. It might be expected that the convergence of urban economies on service sectors would have led to an ongoing convergence in their productivity, but this has not been the case. How then can we start to explain this conundrum? For a start, productivity variations within some service industries are difficult to measure but appear to be large (Baily and Solow, 2001). Moreover, the results of our decomposition analysis of city productivity growth show that growth has been dominated by within-industry productivity developments, rather than by the

transfer of employment and output across industries, or what is generally termed structural change. Underlying this are the substantial variations in both productivity levels and growth that exist across plants and industries within the same industry or sector. Significant firm heterogeneity in productivity, product quality, and management practice, even with narrowly defined industrial sectors, has been well documented (Melitz, 2003; Melitz and Redding, 2012). In this sense, our results confirm the findings of earlier studies that emphasise that in mature industrialised economies there are persistent and large productivity differentials *within* individual industries and sectors which tend to dominate productivity growth (Bartelsman and Doms, 2000; Haltiwanger, 2000; Krüger, 2006). The challenge this poses is how can we best explain the sources of these intra-industry spatial variations in productivity?

There are several possible sources of this urban geography of productivity growth. The first, of course, is that agglomeration economies and localised increasing returns may benefit firms to a greater degree in some cities than others. While there are no simple relationships between city size and productivity growth in the British case (see Martin et al, 2014), the possible effects of agglomeration economies and especially those across related industries, need to be examined more carefully (for example, see Essletzbichler and Rigby, 2002), as well as the importance of proximity to London (Webber et al, 2009). However, given that the weight of economic research shows that agglomeration only has at best a modest or marginal effect on productivity – the bulk of the evidence on this suggests that a doubling of city size seems to be associated with an increases in productivity of only between about 4-8 percent (see also, Rosenthal and Strange, 2003) - we suspect that agglomeration economies are at best a small contributory factor rather than a major driver.[6]

Returning to Table 6, it is evident that there are two key causes of within-sector productivity change. The first is a 'recomposition or reallocation effect' and involves the entry and exit of firms and the re-allocation of market shares between incumbent firms. In general, a higher rate of firm and plant entry leads to faster productivity growth as new entrants tend to have higher productivity than those that exit or are closed.[7] If large, efficient and well-organized firms and plants gain market share this will also of course push up productivity growth. Thus varied entrepreneurial dynamics and large firm investments in

[6] There is also the intriguing issue of whether the effects of agglomeration may increase up to a certain size of city but thereafter either increase at a decreasing rate or even begin to decline. For example, Potter and Watts (2011) find that agglomeration economies may first rise and then fall over time.

[7] Harris and Moffat (2015) argue that firm entry and closure have been the most important cause of change to total factor productivity differentials across Local Enterprise Partnership areas in the UK, but struggle to link this to the economic characteristics of these areas.

new plants across cities will strongly shape their productivity growth. The second major set of (within-sector) processes centres on technological and organizational change among surviving firms which includes both the adoption of innovations as well as management, organizational practices and formats. Typically these are shaped by the intensity of competition faced by firms, and by their regulatory and institutional context, and in the UK they are often proxied by the amount of capital employed per worker and linked to foreign ownership of the firm (see Webber et al, 2009). Existing industry research implies that both of these two processes are likely responsible for the intra-industry urban variations in productivity that we have found (Disney et al, 2003), although the relative importance of these two processes may change in different periods (see, for example, Riley and Bondibene, 2016). It is highly likely that the two sets of processes are combined in cities in reinforcing ways, especially through the growth of the highest-productivity firms. In many industries, market share is dominated by a small minority of firms (Hottman et al, 2016). Not only do these leading 'frontier' firms tend to be exporters but they also have high productivity, complex organisation, and better product quality and scope, and their growth reallocates market share away from weaker, less productive competitors (Melitz and Redding, 2012; Andrews et al, 2015). Micro-evidence suggests that the distribution of firms by productivity levels is more right-skewed and stretched in some British city-regions (Oguz, 2017), which indicates that some cities have a greater prevalence of these 'frontier' and exporting firms. It is highly probable, then, that city productivity levels and trends depend considerably on the degree to which cities manage to host and encourage the emergence and growth of these efficient, exporting firms. The processes causing the emergence and growth of such firms in particular cities require much more attention.

There is thus a growing recognition that industry classifications may not capture those forms of activity change and restructuring that are widening differences *within* particular industries. Many industries now include firms that vary significantly in terms of the occupations they involve, the markets they reach, and the tasks and functions that they perform (see Baldwin, 2016). Partly, of course, this is due to the new divisions of labour emerging from supply chain re-organisation and the specialisations of areas and cities in specific tasks, stages and occupations rather than in particular sectors or supply chains. Further, greater exposure of a city's economy to global markets and competitors tends to produce a divergence in the performance of its higher and lower productivity firms (Ottaviano, 2011). In several ways the uneven diffusion of globalisation has widened differences amongst firms within industries. In addition, ICT and digitisation are bound up with firm entry and exit, are changing firm activities and leading to the emergence of digital activities that blur industry boundaries

(including, in some instances, between what constitutes 'manufacturing' and 'services'). In this context, revisions to industry classifications are lagging well behind the growth of new activities and reorganisation of older ones. What this may imply is that the geography of 'structural change' is no longer well measured by changes in industrial classes and categories but needs to be analysed in a more fine grained way within particular industries, for example in terms of firm capabilities, or occupational or task 'bundles'. At present however, these conclusions are speculative, and our future research will endeavour to examine in more depth some of these processes underlying the puzzle of disparities in productivity growth across contemporary urban Britain.

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