The spatial footprint of the knowledge economy: the role of intangible investment in shaping regional inequalities in Great Britain [†]

Konstantinos A Melachroinos & Nigel Spence
School of Geography, Queen Mary University of London, London E1 4NS, England;
e-mail: K.Melachroinos@qmul.ac.uk, N.Spence@qmul.ac.uk

ABSTRACT
Since the advent of the knowledge economy it has become evident that the territorial footprint of investment in intangible assets is largely asymmetrical. First, these types of assets tend to be distributed unevenly across space. Second, intangible assets are an important source of productivity growth and competitiveness. Although significant advances have been made in measuring intangible assets and accounting for their effects in economic outcomes, their exact nature remains vague. Within the National Accounts framework the majority of intangibles are, even now, still treated as intermediate expenditure. Consequently, intangibles are largely excluded from conventional measures of output and investment, making it difficult to account for their spatial effects. The present paper adjusts Gross Value Added (GVA) data for NUTS3 regions in Great Britain for intangibles. The adjusted series are then used to investigate trends in regional inequalities in GVA per employee in this country during the pre-recession period 1995-2007.

Key words: intangibles, convergence, divergence labour productivity, Great Britain, regions

[†] This paper is dedicated to the loving memory of Ekaterini Melachroinou.

1. INTRODUCTION

During the past decade the notion of intangibles has come to public prominence in several developed economies. The increased tendency of many firms in European Union (EU) countries and North America to invest more in skills, innovation and intellectual property rather than physical capital, alongside the economy-transforming production shift from manufacturing to services that has been taking place since the 1970s, has led many economists to question the soundness of the National Accounts approach of invariably treating intangibles as intermediate consumption. It is true that only a very few intangibles have been incorporated into national accounts for many years. More recently these have been augmented but most intangibles are still excluded. This means that what is produced is still under-reported and labour productivity is lower than it really is.

In the UK, Marrano et al (2009) demonstrate convincingly that once intangibles are treated as investment rather as intermediate consumption, market sector GVA in the UK rises significantly (13% in 2004). In a parallel study Marrano & Haskel (2006) estimate that expenditure on intangibles amounted to £130.8bn in 2004, which is about 10% of UK Gross Domestic Product (GDP). In the United States (US) Corrado et al (2005) report that the value of annual intangible investment represented almost 12% of the non-farm business output during the period 2000-2003. Corrado et al (2012) attempt to develop harmonized estimates for intangibles across the EU member states. A brief indication of what this work has discovered for the period 2005-2009 is that EU15 countries invest less (although a still substantial 6.6% of output) in intangibles than the US (10.6%). Nonetheless, the UK (8.7%) is more like the US than its EU15 partners.

Undoubtedly, empirical findings such as the above represent good news for macroeconomic and international trade policy makers in the EU and the US. The capitalisation of intangible investment entails that these economies appear to be more competitive globally than initially thought. It is not only that the treatment of intangibles as investment raises GVA. It is also that assets that are usually classed as intangibles (e.g. software development, R&D, design, training & skills development, etc.) are closely associated, either as a production factor or as output, with knowledge-based activities – generally considered as important drivers of economic growth.

Nonetheless, from a regional policy making and analysis perspective, the rise of expenditure in intangibles raises some key questions for economic geographers. First, these assets tend to be distributed unevenly across space. Second, intangible assets are an important source of productivity growth (see for instance, Iammarino & Jona-Lasinio, 2015) and therefore are likely to offer a strong competitive edge to the regions where they are concentrated. From this viewpoint the territorial footprint of investment in intangible assets, such as R&D and human capital, is likely to be largely asymmetrical. In addition, as Suriñach & Moreno (2012) emphasise intangibles both enhance performance within firms and also create positive externalities within and across regional economies. Intangibles are not like their tangible private sector counterparts. They are usually not fixed in situ and only fit for purpose. Instead they tend to be polyvalent, highly mobile or usable from distance, and expropriatable. They are a prime candidate for 'spillovers' and thus have an

enhanced geographical relevance. From this perspective, it is important to examine various types of intangibles at various scales. Key examples in the literature at the micro level are Iammarino et al (2012) who look at the ways innovation cooperation takes place in UK firms, while at the macro level Dettori et al (2012) look at the role of intangibles (human, social and technological capital) in EU regional total factor productivity.

The present paper aims to chart the footprint of intangibles investment across 128 NUTS3 regions of Great Britain. It aspires to make a contribution to the regional convergence literature, which often overlooks the presence of intangibles on the left hand-side of the production equation as part of the GVA. Furthermore, the analysis will allow to consider the role spatial heterogeneity in determining the effects of intangible assets, an issue that has received attention from a growing number of studies (Lopez-Bazo & Moreno, 2012; Lopez-Bazo & Motellon, 2012; Manca, 2012). The first priority is to allocate the national expenditure on intangible assets across regions. Subsequently, regional GVA is adjusted for intangibles. The adjusted regional GVA series are then used to investigate the evolution of regional inequalities in GVA per employee in this country between 1995 and 2007. The choice of this particular time frame for the analysis is not accidental. This is the most recent period of protracted economic growth in GB. It helpfully avoids the recession of the early nineties and the last (great) recession starting in 2008, while both the starting and ending year correspond to similar positions in the economic cycle, something that facilitates the investigation for regional convergence/divergence trends. Furthermore, this period incorporates the first ten years of New Labour, under the Blair administration, during which significant progress was made towards regional employment objectives (Jones, 2012). Last, as Goodridge et al (2013 and 2018) argue the evolution of labour productivity in the country since 2008 constitutes a puzzle. Since the crisis, labour productivity at the national scale has hardly grown at all, making problematic the extension of the period of regional analysis beyond 2007. This paper represents the first excursion of this research methodology into the fine spatial scale of NUTS3 regions for GB. Earlier papers help to provide a context (Melachroinos & Spence, 2013a; 2013b; 2014) but only at a NUTS1 level.

2. IDENTIFYING AND MEASURING INTANGIBLES AT NATIONAL AND REGIONAL SCALES

The term ‘intangible’ as applied to investment is often used interchangeably with the broad notion of investment in human capital and related more widely to the development of the knowledge economy. It should be made clear that when this happens intangibles encompass a broad spectrum of activities - not least ‘education’ provided at so many levels. Sure, investment in intangibles broadly viewed this way does sometimes produce assets that can be thought of as possibly generating returns in the future, which in the present cannot be seen or foreseen. Authors such as Bianchi & Labory (2004), and Hand & Baruch (2003) helpfully review a range of studies falling into this remit. In the present research, however, (and the studies upon which it is based) the definitional rules about what exactly constitutes an intangible investment are somewhat more tightly drawn. The underlying idea is the same of course - opportunities for current consumption are eschewed in favour of intangible investment - but the purpose or intent of this decision opportunity has but one

objective and that is to assist directly future production. Not all investment in human capital has this driving characteristic. Little or no investment in physical capital, at least in the private sector, does not have it and thus provides a parallel for the definition of intangibles investment used here.

The UK National Accounts has until very recently considered investment in most intangible assets as intermediate consumption assuming that they are fully used in the production process. They are not regarded as contributing to national wealth as capital investment and or as additional GVA. Some progress has been made since 2013 with the incorporation of own-account software and R&D into the National Accounts (ONS 2013; 2014), but still a large amount of intangibles remains outside of the remit of the National Accounts and thus unmeasured. The reason for this traditional underestimation of national wealth is that it is not easy to develop meaningful estimates of many intangibles (Webster & Jensen, 2006). It is often the case that intangible investments are made in the companies that use them – 'pharma' companies are good examples. But in contrast there are also companies that specialise in developing intangible assets for the purpose of supplying them to other companies to use in their production. It is true of course that some companies do both so it is never easy to see which companies own them and/or use them. Some intangibles are also said to be 'non-rival' meaning that they can sometimes be used without the owner's knowledge or sanction. Intangible investments also, just like tangible investments, sometimes turn out to be misguided in that their production-focused purpose remains unfulfilled. Furthermore, it is the case that many intangibles are highly firm specific and great efforts are made to encourage them to remain so to prevent their exploitation by competitors – 'tech' companies are good examples. However, this reasoning about identification and measurement difficulties also applies to tangibles too (Corrado et al, 2009).

More important than the fact that intangibles are difficult to measure is that their creation and propagation increases future output and therefore wealth. Intangibles are an investment representing foregone consumption. Thus, they should be included in the measurement of GVA and capitalised as intangible capital stock for the purposes of future production just like any other investment. The more an economy moves away from a manufacturing production dependence in favour of a structure where tertiary activities dominate producing less tangible output, the more crucial investment in intangibles becomes.

The Marrano et al (2009) national estimates of intangibles private sector GVA, as extended in the NESTA (2009)[1] report, are the main data source for the present research. They provide a time series from 1995 to 2007 for six types of intangibles - R&D, design, organisational improvement, training & skills development, software development and market research & advertising[2]. A variety of sources, ranging from official surveys to industry publications, are used to measure the investment aspect of such expenditures. This approach to measuring intangible investment is necessarily conservative because of the high likelihood of double counting errors that can be encountered in making such estimates. Nonetheless, the end results are theoretically coherent annual estimations of investment in intangible assets at the national scale and these can be used to construct regional series. The national estimates of intangible investment are allocated to NUTS3 regions according

to spatial distribution of employment in intangible producing sectors. The basic notion is that intangible assets are created by skilled labour. Thus, the locations where different types of intangibles are produced should coincide with the locations where relevant skilled labour is employed in generating them. Intangibles will be produced more efficiently in some places than others, but here an operationally necessary assumption is that regional productivity in this respect does not vary. These estimates then will offer somewhat conservative measures of spatial variation in the value of intangible GVA across GB regions. This approach has two main advantages in relation to conventional efforts to measure the spatial effect of specific types of intangible assets, such as R&D based on regional data (see for instance, Audretsch & Keilbach, 2004; Artis et al, 2009; Ramos et al, 2010). First, it is comprehensive in covering most intangibles. Second, it is measured as GVA in monetary terms since the regional estimates derive directly from and sum to national intangibles GVA estimates. As a result, official regional GVA statistics (ONS, 2016) can be adjusted or augmented by the addition of intangible investment measured in this way. Thus, more realistic regional GVA and labour productivity figures can be derived.

National intangibles GVA by type is distributed to NUTS3 regions proportionally in relation to each region's share of the total national employment in the four-digit Standard Industrial Classification (SIC) sector from the Annual Business Survey (ONS, various dates) that produces them (see Table 1). These sectors most closely match the NESTA descriptions of intangibles types. Matching SIC sectors and intangibles classes is not always unproblematic as SIC sectors are subject to change. In the case of the software consultancy and supply sector there are some modest changes to the scheme that is used prior to 2003 as the sector was split into two sectors (publishing of software and other software consultancy and supply).

TABLE 1 HERE

Having allocated the national investment in intangibles across regions the regional intangibles are summed by type and then added to the totals of the official regional GVA values to provide an overall (adjusted for intangibles) measure of output. The adjusted regional GVA series can then be used to provide a more accurate measure of regional GVA per employee and consequently suitable for investigating the evolution of regional inequalities in GB. These data are compiled for the 128 NUTS3 regions of England, Scotland and Wales. Northern Ireland is excluded due to the lack of fine detail employment data. The definitions and sources of the data used in this study along with some descriptive statistics can be found in Table 2.

TABLE 2 HERE

3. THE SPATIAL DISTRIBUTION OF INTANGIBLE INVESTMENT IN GREAT BRITAIN

The evolution of the spatial distribution of intangible investment in GB between 1995 and 2007 is depicted in Figures 1 and 2 which show each NUTS3 region's share of GB total intangibles. In Figure 1 some clear concentration can be seen in London & South East with

Inner London (both West and East), and most of Outer London, as well as Berkshire and Surrey being especially prominent. Elsewhere there are some other 'hotspots' such as Greater Manchester South, Birmingham and Tyneside, as well as Aberdeen in Scotland. But the clear contrasting pattern from the map is a low intangibles investment periphery that includes large parts of Scotland, Wales, the North and the South West. By 2007 (Figure 2) this highly clustered and clear pattern remains largely intact.

FIGURES 1 & 2 HERE

Table 3 provides additional detail identifying the regional intangibles hotspots in listing the top 30 regions (ranked by value) in 2007. The list of parent standard regions from which these NUTS3 regions stem confirms the spatial clustering present on the previous maps. All five of the London NUTS3 regions are represented and they are joined by a further seven regions from the wider South East region. Inner London West is where the main concentration of intangibles investment in the country can be found, having more than twice as much by value as the next region - its contiguous companion in the adjacent Inner London East. Together they amount to about one fifth of all intangibles investment in GB. Greater Manchester South breaks into the higher ranks of the list and its adjacent counterpart Greater Manchester North just makes the top 30. It is salient to point out that the top 30 NUTS3 (out of 128) regions for intangible investment make up some 68% of the GB total.

TABLE 3 HERE

But where do intangibles have the greatest impact on GVA? In Table 3 the unadjusted GVA values do not follow a perfect matching ranking with intangibles, but there is much correspondence. This list of 30 regions only makes up some 58% of the GB total figure. When intangibles are added to unadjusted GVA to generate an adjusted GVA measure, the fraction of the GB total rises only modestly, by an additional percentage point.

Perhaps more helpful are Figures 3 and 4 where for 1995 and 2007 respectively the contribution of intangibles investment to regional adjusted GVA is illustrated. Naturally intangibles make a contribution everywhere, but again the 1995 map shows a mainly concentrated pattern of high contributions. The South East, supported by regions in the East and London, form the main clustering of NUTS3 regions where intangibles raise GVA substantially. But it is the ring of counties surrounding London to the west (Berkshire, Buckinghamshire, Oxfordshire and Surrey) which is especially clear. There are, of course, other regions of substantial GVA for which intangibles were important, with Manchester and parts of Cheshire, places like Derby and Aberdeen for special industry-based reasons, and Caithness in Scotland prominent (the R&D associated with the decommissioning of nuclear energy facilities was important in the scale of the local economy at this time). The 2007 map drawn with the same classification scale shows not dissimilar patterning, but clearly there is some movement in the relative contributions made by intangibles in the main South East, East and London concentration. The Berkshire M4 corridor region seems to be benefiting most from the ways intangibles add value to the regional economy.

Figures 3 & 4 HERE

In summary, the spatial distribution of intangibles investment across the NUTS3 regions of GB and the contributions that such activities make to regional economies is highly clustered. There are three patterns of performance here. The first is the high performance contiguous concentration of a selection of NUTS3 regions from London, the South East and the East. The second is a sporadic distribution of standalone, relatively high performing localities. The last is practically anywhere else constituting an area that covers most of the country.

4. Mapping the contribution of intangibles to regional inequalities in GVA per employee

This section switches focus more to the role of intangibles in influencing patterns of regional inequalities in GVA per employee. All regional values are indexed by GB GVA per employee which is set to 100. Are intangibles a force for reducing regional inequalities in labour productivity or otherwise?

Figures 5 and 6 show unadjusted regional GVA per employee for 1995 and 2007 respectively. In 1995 few areas can be mapped in the class of the highest index numbers. Parts of London are there (Inner London - both West and East - generating high value added in global city activities), as are, in the context of somewhat smaller scaled local economies, Flintshire and Wrexham (high value added in vehicle and aircraft manufacturing as well as steel) from the North West and West Lothian (component of 'Silicon Glen' generating, at the time, high value added in new technology based on semi-conductors) in Scotland. But there are at the same time also rather few areas that can be classed in the lowest class. In short, the pattern of values gives the overall effect of being - in the main - relatively even. In contrast, the patterning for 2007 is different. The productivity map of Britain has been re-drawn in this short time frame. In 2007 the indices are highly clustered in the South East and London and substantial tracts of the country have been relegated to the lowest value index number group. The high concentration includes NUTS3 regions of both Inner London constituents, Outer London - West and North West, as well as Berkshire, Buckinghamshire, Surrey and Swindon. It is easy to discern here the patterns of performance that were mentioned previously.

FIGURES 5 & 6 HERE

Figures 7 and 8 show regional inequalities in intangibles GVA per employee in the same index form. The 1995 map shows a clear regional concentration of high value intangibles output per employee in the South East, the East and London – in a pattern which has become to be known as the 'western crescent of high technology activities around London' (Breheny & McQuaid, 1987). This concentration is truly exceptional for this reason. The NUTS3 regions of Berkshire, Inner London West, Buckinghamshire, Oxfordshire and Surrey have index numbers way beyond 200 (GB = 100). Although there are some high value NUTS3 regions elsewhere – Cheshire county and nearby Halton and Warrington (Unilever) as well as Aberdeen and Caithness (both mentioned before) in Scotland are

examples - these represent much smaller local economies and the remainder of the country is largely 'second tier'. The 2007 intangibles per employee map at first sight depicts an even more concentrated pattern, but in reality the concentration has extended northwards to the West Midlands and southwards down into Hampshire. The difference between the fortunes of this concentration and those of most of the rest of the country is clear. So as far as intangibles inequalities are concerned, the story seems to be one of moving from an intense concentration in a handful of London & South East NUTS3 regions in the nineties to a concentration containing slightly more constituents, extending into neighbouring regions, but at somewhat less intense levels by 2007.

FIGURES 7 & 8 HERE

Inevitably Figures 9 and 10 showing regional GVA adjusted for intangibles per employee in 1995 and 2005 respectively represent a combination of the two stories mentioned above. The position in 1995 was clustered for sure in London & South East. This remains in 2007, but the rest of the country seems to have fallen even further behind. The map for 2007 represents the clearest picture possible of a 'two tier' Britain on this more accurate measure of labour productivity.

Figures 9 & 10 HERE

5. INTANGIBLES AND REGIONAL CONVERGENCE IN GREAT BRITAIN

There is now, as for most countries, a sizable literature of various attempts to measure such economic convergence (or rather lack of) in GB/UK. Whether the metric is GDP or income per head the evidence for regional economic convergence has been meagre over the last half century or so. Lagging regions still lag and the map of those regions eligible for regional assistance remain stubbornly the same over such a long period of economic history. Gripaios et al (2000) and Bishop & Gripaios (2005) pitch their work at the scale of counties examining GDP per capita for the period 1977-1995. They discover only divergence trends. Chatterji & Dewhurst (1996) and Dewhurst (1998), however, do find some convergence in their studies of GDP changes between 1977 and 1991 and income changes between 1984 and 1993 respectively. Nonetheless, this seems to be far from a consistent finding over time, for it would appear only to be present during times of national economic downturn. When the national economy is buoyant leading regions seem to benefit most and start moving ahead. Roberts (2004) using the same data introduces the notion of differing 'regimes' of β-convergence made up of sub-regions of a larger region or a group of larger regions constituting less than the country. This will be returned to later. Despite their unusually imaginative approach (accounting additionally for regional differences in educational standards and returns to educational provision), Duranton & Montastiriotis (2002), using earnings levels change between 1982 and 1997, still find regional inequalities to widen. More recently, Henley (2005) also suggests that the inclusion of region-specific steady states and specific regional levels of human capital stock can help uncover evidence of sub-regional convergence in the UK (under certain types of model specification).

All of these studies, however, are based on measures of economic well-being that exclude intangibles. Section 4 has demonstrated that intangibles are unevenly distributed across regions so the real research question here is whether this distribution influences the overall measure of economic performance sufficiently to increase the divergence trends that have been reported in the majority of studies (Melachroinos and Spence, 2013b).

The conventional measures of σ-convergence and β-convergence are calculated for unadjusted GVA, intangibles GVA and GVA adjusted for intangibles each per employee for 128 NUTS3 regions between 1995 and 2007. Overall σ-convergence in this context occurs when the statistical dispersion (standard deviation) from the mean of the labour productivity measure for the set of regions is reduced from one year to the next. As it is useful to compare the rates of convergence between the three different labour productivity measures which have different arithmetic means, a relative measure of dispersion (coefficient of variation – CV) is used. The idea lying behind β-convergence (unconditional) essentially involves lagging regions growing faster than leading ones over a period of time (Barro & Sala-i-Martin 1991; 1992). Such a relationship is usually demonstrated by a regression (equation 1) of the regional growth rates of the selected measure of labour productivity over a specific period on the initial levels of labour productivity at the start of the period. A negative relationship means that less productive regions catch up (converge) with their highly productive counterparts and vice versa when positive.

(1) $$\mathbf{(1/T)\ ln(y_{it}/y_{i,t-T}) = a - b\ ln(y_{i,t-T}) + \varepsilon_i}$$

where i and t are regions and time respectively, T is the analytical timeframe, y is the chosen measure of labour productivity, a and b are estimated intercept and slope parameters, and ε is the error term. The rate of convergence (annual) is given by β in equation 2. An indication of the progress of convergence is given by H (half-life) in equation 3. This measures the time needed for half of the initial disparities between the regions to be removed, assuming that convergence trends are in fact exhibited over time

(2) $$\boldsymbol{\beta} = -\frac{\ln(1-Tb)}{T}$$ **(3)** $$\mathbf{H} = \frac{\ln(2)}{\beta}$$

Note this measure (β-convergence) is said to be unconditional in that it fails to take account of the effects that other factors might play in determining growth rates. The main purpose here of course is simply to compare the differences in convergence rates when intangibles are the measure of GVA and when they are either included in or excluded from the overall regional GVA.

Considering regional economies as a whole, Table 4 points to the absence of σ-convergence trends in the 128 NUTS3 regions of GB between 1995 and 2007. This is not an unusual finding, confirming as indicated above much previous work at different scales and at different times in the same country. For the unadjusted GVA per employee measure, variation across the whole set of regions is actually increasing from the start to the end of the period (CV up from 0.10 to 0.16). The variation in the levels of intangibles GVA per employee across these regions, however, is much greater, but this variation appears to be

reducing somewhat (CV down from 0.54 to 0.50). The outcome for the adjusted for intangibles GVA per employee measure tends more towards increased levels of regional variation and this is to be expected given the relative size of the intangibles contribution.

TABLE 4 HERE

The results regarding β-convergence for all NUTS3 regions for the full twelve year period contain some similar messages to the above (Table 5). But the underlying relationships between the initial conditions in 1995 and the growth fortunes over the period 1995-2007 are poorly specified by the model.. The underlying processes are just not captured by such a simple and all-embracing relationship. However, for intangibles GVA per employee there is some modest, but significant evidence of convergence (although the half-lives are long). This is certainly not the case for GVA per employee as a whole, with or without intangibles. The convergence tendency just mentioned in respect of intangibles GVA per employee does appear to be fairly consistent when the sub-periods are examined. The same is not true for the two overall measures of GVA per employee. Two points can be made. First, the initial years of the series (1995-2000) seem more 'convergence poor' and the later years more 'convergence rich'. The economy was growing slower after 2000, so these tendencies are in accord with the previously mentioned literature. The results then for the first sub-period (1995-2000) are not much different to those for the full period – intangibles GVA per employee converging over regions, but regional inequalities for the adjusted GVA measure of labour productivity are increasing. Second, during economic times when regional convergence seems to have a chance (2000-2007), intangibles are a force that enhances convergence. The results then for the second sub-period (2000-2007) are different – intangibles GVA per employee are still converging over NUTS3 regions, but so too are unadjusted and unadjusted GVA per employee. It is interesting to see that the early 2000s do coincide with a clear and statistically significant phase (2000-2004) of regional convergence across all three measures. During these years of lower labour productivity growth the convergence rates are high and half-lives relatively short.

TABLE 5 HERE

If from the above is concluded that convergence tendencies are not invariant over time, this begs the question about where such tendencies are found over space. To explore this idea further, the σ and β-convergence calculations have been repeated for specific groups of regions[3]. Table 6 shows the results for σ-convergence. For unadjusted GVA per employee it can be seen that while everywhere variation seems to be increasing, the largest values of increased variation lie in London & South East and South. For intangibles per employee the CV increases everywhere up to 1999 and then there is a dramatic decrease. The levels of variation are higher in London & South East and South. For the adjusted GVA per employee, the variation between NUTS3 regions increased much more within London & South East and the South than elsewhere in the country.

TABLE 6 HERE

The results for β-convergence in Table 7 are interesting. The model fit for London & South East improves markedly. In this part of the country for both unadjusted GVA per employee and adjusted for intangibles GVA per employee it appears that regions are diverging. Thus, despite the fact the highest concentrations of both GVA (and intangibles) are to be found in London & South East there is a group of NUTS3 regions within this area that are failing to keep pace with the growth of Inner London regions – the local leaders. For intangibles GVA per employee alone, however, lagging regions are catching up with local leaders because the trends indicate modest convergence and thus these ameliorate the picture for adjusted GVA per employee overall. The South looks much the same, but the rest of Britain is the opposite in fact. Here the available evidence points to convergence tendencies whatever the labour productivity measure. Two opposing forces depending on location seem to be in operation and it is little wonder that the conventional convergence model for the 128 regions fails to point to a clear outcome. Although the regions outside London & South East appear to be making little if any progress catching up with the national leaders, they do seem to reduce the gap with their local leaders. This process is more pronounced in the Midlands and Wales than in the North.

TABLE 7 HERE

It is perhaps helpful to note that the above findings are not the same as those about 'convergence clubs' in Chatterji & Dewhurst (1996) who searched for groups of regions that were behaving similarly in relation to their performance gap (convergence rates) relative to Greater London. Three such clubs were found having constituents from all over the country. This idea of constructing convergence clubs from scratch is an interesting one. The art of populating such clubs has been advanced by Phillips & Sul (2009) who formulate natural clusters or clubs of countries by adding one at a time to core groups of countries converging at similar rates. However, the present research focuses on exploring convergence trends within groups of NUTS3 regions defined by geographic criteria. Our findings resonate more with the 'β-convergence regimes' reported in Roberts (2004) who examines a variety of definitions of 'North'. His results varied by the exact definition selected, but more important demonstrated that there was a regime that represented divergence within the 'North' and that regime was much different from the national regime. Interestingly Roberts (2004) does also discover an X-shaped cluster of high GDP per capita performance centred on Buckinghamshire and this cluster seems to have been developed at the expense of bordering counties. Such a feature is still apparent in this research.
The β-convergence calculations derive from a cross-sectional framework in which region-specific aspects (e.g. technological and institutional differences) have not been taken into account, creating the possibility of an omitted variable bias. To address this shortcoming, the β-convergence analysis is extended by employing a panel data approach, which has been shown to allow for more powerful inferences, as regions are compared across both the cross-sectional and the temporal dimension (Islam, 1995; De Wachter & Tzavalis, 2012)[4].

For a dynamic panel data model equation 1 takes the (productivity level) form:

$$\mathbf{(4)} \qquad \ln(y_{it}) = \rho \ln(y_{i,t-1}) + \delta_i + \lambda_t + \varepsilon_{i,t}$$

where $\rho=(1-b)$, i and t are regions and time respectively y is the chosen measure of labour productivity as before, while δ_i denotes an unobserved specific for each region and fixed in time effect, λ_t represents deterministic trend that is common for all regions and $\boldsymbol{\varepsilon_{i,t}}$ t is a random error term. The speed of β-convergence (β) continues to derive from the beta coefficient by utilizing equation 2. However this time T is set equal to one as the time span of the analysis is one year. Thus, $\beta = -\ln(1-b)$.

In addition, a panel unit root framework is also deployed to test for stationarity and stochastic convergence. In the absence of stationarity idiosyncratic region-specific shocks would trigger divergence. Unit root tests are particularly useful in this respect (Harris & Tzavalis, 1999; Karavias & Tzavalis, 2016). The results of the Harris-Tzavalis test (Table 8) clearly indicate that the individual series of the panel reject the null hypothesis of unit roots in their level (implying divergence) against the alternative of stationarity around deterministic trends. This is true for all three productivity measures examined and every group of GB regions. The estimated values of the autoregressive coefficient ρ indicate a possible high rate of convergence during the period 1995-2007.

TABLE 8 HERE

The estimation of the parameters of equation 4 can shed further light into the issue. An Arrelano & Bond (1991) generalized method moments (GMM) estimator was used in order to account for the likelihood of autocorrelation in the error terms and endogenous control variables. A constant was also included in the first-difference specification of the data, which means that there are deterministic trends in the level of the series. The Arrelano-Bond estimates are presented in Table 9. Some caution is needed in the interpretation of the estimates. The outputs of the Sargan test offer evidence against the null hypothesis that the over-identifying restrictions are valid. Nonetheless, this is reasonable given the limited number of instruments. In addition, the Arellano-Bond test provides evidence of serial correlation in the first-differenced errors at order 2 on some occasions.

TABLE 9 HERE

In any case, the Arrelano-Bond estimates imply convergence rates for every group of GB regions in every measure of labour productivity, which are substantially higher than those derived from the cross-sectional regressions. This finding is in line with what has been reported in the literature (see for instance, Bonnefond, 2014; Bal-Domańska, 2016 and Naveed & Ahmad, 2016). As Islam (1995: 1149) points out “the process of convergence is thwarted to a great extent by persistent differences in technology level and institutions”. By taking into account these differences thus panel data models produce results that are significantly different from those of cross-sectional regressions. Furthermore, the Arrelano-Bond estimates take into account the time-dimension of the data and can smooth-out possible changes in the rates occurred over time in the sample.

6. CONCLUSION

Informed observers of regional economic trends in GB have long suspected that intangible investment is likely to have some impact everywhere, but that it tends to favour only very few places. For instance, Savic (2016) reports that although knowledge-intensive business services play a significant role in the local economic base of de-industrialised regions, they are not as important as their elite counterparts in metropolitan cities such as London. The results of the research here provide the evidence-base and the metrics to corroborate this intuition. Intangibles do have a significant, but variable territorial impact on GVA. London & South East are clearly favoured by the unbalanced territorial distribution of intangibles.

Although, the variation in intangibles GVA per employee across British regions declined slightly between 1995 and 2007, the actual magnitude of the spatial inequalities in this indicator has contributed to more pronounced overall labour productivity differences. Σ-divergence trends in GVA adjusted for intangibles per employee year on year prevail for the entire 1995-2007 period.

Unconditional β-convergence measures the relationship between initial conditions in 1995 and growth between 1995 and 2007 and hints at some interesting lessons.

First, despite the β-convergence trends in intangibles GVA per employee observed, not only for the entire 1995-2007 period, but also for each sub-period under examination, there is scant evidence of either convergence or divergence (probably more of the latter than the former) when it comes to overall labour productivity. This convergence tendency for intangibles carries insufficient weight to influence the results for the model calibrated for GVA per employee when adjusted for intangibles. This indicates the presence of 'β-convergence regimes' that seem to be different to the traditional North/South and advanced/lagging regions distinctions.

Second, it seems that general economic conditions have a role to play. During times of slower growth, regional convergence tendencies become more pronounced, and this is especially apparent here for the early 2000s. This is not a new finding in the literature, but since 2005 there is limited empirical evidence in relation to convergence dynamics in GB regions. The present study offers an updated picture of the trends until 2007, which marks the start of the last crisis to hit the British economy. There are yet no clear explanations of why regional convergence trends become more prominent during periods of slower growth, but the recent resilience literature offers promising possibilities in terms of understanding the reaction of regional economies to external shocks (Martin, 2012).

Third, it is also clear that examining the entire national set of regions together often masks an interesting and relevant reality. When the focus is on only London & South East regions there emerge considerable both σ and β-divergence trends. The select group of NUTS3 regions within this macro-region that benefit from the unbalanced territorial distribution of intangibles seem to be forging ahead in relation to their neighbours. London & South East as a whole leads Britain in terms of GVA per employee, but at a price of rising intraregional inequality within its confines. In contrast, although regions located in the Midlands and

Wales and the North are falling further behind the national leaders, they do appear to be able to catch up with their local leaders. Intangibles here support this local catching up process.

To summarise in the GB case it is clear that although the distribution of intangibles per employee becomes more egalitarian during the 1995-2007 period, this improvement is insufficient to reverse the divergence trends that still prevail in GVA per employee measured for all economic activities. In particular, again considering the productivity of local economies as a whole, spatial inequalities within London & South East - the powerhouse of the British economy - continued to increase despite modest convergence tendencies for intangibles. It is difficult to pinpoint the causes of such trends. They may be the outcome of local rivalry and competition (see for instance, Cainelli et al (2017) on the counterintuitive negative effect of specialisation economies on the export performance of Italian local labour markets). Nonetheless, one thing is certain. If these trends persist in future, then soon a new regional problem will arise in Britain, which potentially could be more difficult to address than the traditional North-South regional divide. The increased fragmentation of productivity performance within London & South East could have important consequences for the nation, ranging from the rise of serious social exclusion within such a limited area, to inflationary pressures due to the intense concentration of economic activities in Inner London and a few select nearby NUTS3 regions. This research has demonstrated that intangibles have always been highly concentrated spatially and remain so.

This paper aspires to make a contribution to the regional convergence literature, which has not included so far the role of intangibles as an output. There is much work, in contrast, that considers the role of intangibles solely as a production input. By incorporating intangibles into GVA and examining the resulting convergence/divergence trends, this imbalance can be addressed. If anything derives from this analysis it is that the effects of intangibles on the evolution of regional economic inequalities are not straightforward. Individual regions are affected by this type of assets in different ways.

Including intangibles in output inevitably raises overall labour productivity everywhere, but the variation in the geographic distribution of intangibles entails that regional inequalities in labour productivity (measured as adjusted GVA per employee) become sharper. Nonetheless, the results of the cross-sectional regression analysis suggest that lagging regions seem to catch up in terms of intangibles GVA per employee. It might well be the case that lagging regions are benefited more from this type of assets as (see for instance, the studies of Lopez-Bazo & Moreno, 2012 and Lopez-Bazo & Motellon, 2012 about the spatial effects of human capital). However, this convergence process in intangibles GVA per employee is not sufficient to override the divergence in overall labour productivity. The dynamic data panel model analysis demonstrates that once individual regional characteristics are taken into account then actually the productivity gap between lagging and advanced regions becomes narrower between 1995 and 2007. It is evident that there is a lot of heterogeneity among the GB NUTS3 regions, which thwarts the convergence process. More worryingly the inequalities seem to grow within the powerhouse of the GB economy which is London & South East.

Although, these findings are country specific they raise some important policy issues. The most important of them is that regional polices should take into account spatial heterogeneity. It is the characteristics of the individual regional economies that determine the extent to which they can benefit from the growth of intangible capital and the spillovers that it generates.

Notes

[1] The authors are grateful to Professor Jonathan Haskel for providing these data.

[2] The report also identifies a seventh category (copyright development and mineral exploration), which has been omitted from the present study as this relatively small category of intangible investment has been long considered as investment within the National Accounts framework.

[3] The calculations were carried out for five groups of regions. London & South East comprises of 19 NUTS3 regions belonging to these two NUTS1 regions. The Rest of Great Britain group includes the remaining 109 NUTS3 regions of the country. In a similar vein, South includes the 41 NUTS3 regions of London, South East, South West and East of England. Midlands & Wales comprise of the 34 NUTS3 regions of East Midlands, West Midlands and Wales. Finally, North includes the 53 regions of North East, North West, Yorkshire and the Humber and Scotland.

[4] The authors are grateful to an anonymous referee for suggesting to extend the regional convergence analysis by employing a data panel model. Furthermore, they would like to thank Professor Elias Tzavalis and Mr Dimitris Smyrnakis for providing expert advice in relation to this part of the econometric analysis.

REFERENCES

ARELLANO, M. & BOND, S. (1991), Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Review of Economic Studies* 58(2), 277–297.

ARTIS, M., MIGUELEZ, E. & MORENO, R. (2009), *Assessing Agglomeration Economies in a Spatial Framework with Endogenous Regressors*, Discussion Paper 23. London: Spatial Economics Research Centre, London School of Economics.

AUDRETSCH, D. & KEILBACH, M. (2004), Entrepreneurship capital and economic performance. *Regional Studies* 38(8), pp. 949-959.

BAL-DOMAŃSKA, B. (2016), The impact of economic crisis on convergence processes in European Union regions. *Prague Economic Papers* 25(5), pp.509-525.

BARRO, R.J. & SALA_I_MARTIN, X. (1991), Convergence across states and regions. *Brookings Papers on Economic Activity* 22(1), pp. 107-182.

BARRO, R.J. & SALA_I_MARTIN, X. (1992), Convergence. *Journal of Political Economy* 100(2), pp. 223-251.

BIANCHI, P. & LABORY, S. (2004), *The Economic Importance of Intangible Assets.* Aldershot: Ashgate.

BISHOP, P. & GRIPAIOS, P. (2005), Patterns of persistence and mobility in GDP per head across GB counties. *Tijdschrift voor Economishe en Sociale Geografie* 96(5), pp. 529-540.

BONNEFOND, C. (2014), Growth dynamics and conditional convergence among Chinese provinces: a panel data investigation using system GMM estimator. Journal of Economic Development 39(4), pp. 1-25.

BREHENY, M. & MCQUAID, R.W. *(*1987*),* The development of the UK's centre of high-technology. In: M. BREHENY & R.W. MCQUAID, eds., *The Development of High-Tech Industries: an International Survey*, pp 297-354. London: Routledge.
CAINELLI, G., DI MARIA, E. & GANAU, R. (2017), Does agglomeration affect exports? Evidence from Italian local labour markets. *Tijdschrift voor Economishe en Sociale Geografie* 108(5), pp. 554–570.
CHATTERJI, M. & DEWHURST, J.H.L. (1996), Convergence clubs and relative economic performance in Great Britain: 1977-1991. *Regional Studies* 30(1), pp. 31-39.
CORRADO, C., HASKEL, J., JONA-LASINIO, C. & IOMMI M. (2012*), Intangible capital and growth in advanced economies: measurement methods and comparative results.* Working Paper 6733. Bonn: Institute for the Study of Labor (IZA).
CORRADO, C.A., HULTEN, C.R. & SICHEL, D.E. (2005), Measuring capital and technology: An expanded framework. In: C.A. CORRADO, J. HALTIWANGER & D.E. SICHEL eds., *Measuring Capital in the New Economy*, Studies in Income and Wealth, Vol. 65, pp. 11-41. Chicago: The University of Chicago Press for the National Bureau of Economic Research.
CORRADO, C.A., HULTEN, C.R. & SICHEL, D.E. (2009), Intangible capital and U.S. economic growth. *The Review of Income and Wealth* 55(3), pp. 661-685.
DE WACHTER, S. & TZAVALIS, E. (2012), Detection of structural breaks in linear dynamic panel data models. *Computational Statistics and Data Analysis* 56(11), pp. 3020–3034.
DETTORI, B., MARROCU, E. & PACI, R. (2012) Total factor productivity, intangible assets and spatial dependence in the European regions. *Regional Studies* 46(10), pp 1401-1416.
DEWHURST, J.H.L. (1998), Convergence and divergence in regional household incomes per head in the United Kingdom, 1984-93. *Applied Economics* 30(1), pp. 31-35.
DURANTON, G. & MONASTIRIOTIS, V. (2002), Mind the gaps: the evolution of regional earnings inequalities in the UK, 1982-1997. *Journal of Regional Science* 42(2), pp. 219-256.
GOODRIDGE, P., HASKEL, J. & WALLIS, G. (2013), Can intangible investment explain the UK productivity puzzle? *National Institute Economic Review* 224, pp. 48-58.
GOODRIDGE, P., HASKEL,J. & WALLIS, G. (2018), Accounting for the UK productivity puzzle: a decomposition and predictions. *Economica* 85, pp.581-605.
GRIPAIOS, P., BISHOP, P. & KEAST, S. (2000), Differences in GDP per head in GB counties: some suggested explanations. *Applied Economics* 32(9), pp. 1161-1167.
HAND, J. & BARUCH, L. (2003), *Intangible Assets: Values, Measures, and Risks.* Oxford: Oxford University Press.
HARRIS, R.D.F. & TZAVALIS, E. (1999), Inference for unit roots in dynamic panels where the time dimension is fixed. *Journal of Econometrics* 91(2), pp. 201–226.
HENLEY, A. (2005), On regional growth convergence in Great Britain. *Regional Studies* 39(9), pp. 1245-1260.
IAMMARINO, S., PIVA, M., VIVARELLI, M. & VON TUNZELMANN, N (2012) Technological capabilities and patterns of innovative cooperation of firms in the UK regions. *Regional Studies* 46(10), pp 1283-1301.
IAMMARINO, S. & JONA-LASINIO, C. (2015), ICT production and labour productivity in the Italian regions. *European Urban and Regional Studies* 22(2), pp. 218–237.

ISLAM, N. (1995), Growth empirics: a panel data approach. The Quarterly Journal of Economics 110(4), pp.1127–1170.
JONES, P.S. (2012), Job creation and regional change under New Labour: a shift-share analysis. *Environment and Planning A* 44(6), pp. 1348 – 1362.
KARAVIAS, Y. & TZAVALIS, E. (2016), Local power of fixed-T panel unit root tests with serially correlated errors and incidental trends. Journal of Time Series Analysis 37(2), pp. 222–239.
LÓPEZ-BAZO, E. & MORENO, R (2012), Profitability of investments in education: Evidence from Spanish regions. *Regional Studies* 46(10), pp. 1333-1346.
LÓPEZ-BAZO, E. & MOTELLÓN, E. (2012), Human capital and regional wage gaps. *Regional Studies* 46(10), pp. 1347-1365.
MANCA, F. (2012), Human capital composition and economic growth at the regional Level, *Regional Studies* 46(10), pp. 1367-1388.
MARRANO, M.G. & HASKEL, J. (2006), *How Much Does the UK Invest in Intangible Assets*. Discussion Paper 6287. London: CEPR.
MARRANO, M.G., HASKEL, J. & WALLIS, G. (2009), What happened to the knowledge economy? ICT, intangible investment and Britain's productivity record revisited. *The Review of Income and Wealth* 55(3), pp. 686-716.
MARTIN, R. (2012), Regional economic resilience, hysteresis and recessionary shocks. *Journal of Economic Geography* 12(1), pp. 1-32.
MELACHROINOS, K. A. & SPENCE, N. (2013a), Intangible investment and regional productivity in Great Britain. *Regional Studies* 47(7), pp. 1048-1064
MELACHROINOS, K. A. & SPENCE, N. (2013b), The territorial impact of the knowledge economy: Intangibles and regional inequality in Great Britain. *European Planning Studies* 21(10), pp. 1491-1508.
MELACHROINOS, K. A. & SPENCE, N. (2014), The impact of intangible assets on regional productivity disparities in Great Britain. *Environment and Planning A* 46(3), pp. 629-648.
NAVEED, A. & AHMAD, N. (2016), Labour productivity convergence and structural changes: simultaneous analysis at country, regional and industry levels. *Journal of Economic Structures* 5(19), pp. 1–17.
NESTA (2009), *The Innovation Index: Measuring the UK's Investment in Innovation and its Effects*. Available at: https://media.nesta.org.uk/documents/innovation_index_2009.pdf (accessed 19 November 2018).
ONS (2013), Statistical Bulletin: Regional Gross Value Added (Income Approach): December 2013, available online at http://www.ons.gov.uk/economy/grossvalueaddedgva/bulletins/regionalgrossvalueaddedincomeapproach/2014-07-07 (accessed 19 November 2018).
ONS (2014), Statistical Bulletin: Regional Gross Value Added (Income Approach): December 2014, available online at http://www.ons.gov.uk/economy/grossvalueaddedgva/bulletins/regionalgrossvalueaddedincomeapproach/2014-12-10 (accessed 19 November 2018).
ONS (various dates), Annual Business Survey now Business Register and Employment Survey, available online from NOMIS https://www.nomisweb.co.uk (accessed 19 November 2018).

ONS (2016), Statistical Bulletin: Regional Gross Value Added (Income Approach), UK: 1997-2015, available online at https://www.ons.gov.uk/economy/grossvalueaddedgva/bulletins/regionalgrossvalueaddedincomeapproach/december2016 (accessed 19 November 2018).
PHILLIPS, P. C. B. & SUL, D (2009), Economic transition and growth. *Journal of Applied Econometrics* 24(7), pp 1153-1185.
RAMOS, R., SURINACH, J. & ARTIS, M. (2010), Human capital spillovers, productivity and regional convergence in Spain. *Papers in Regional Science* 89(2), pp. 435-447.
ROBERTS, M. (2004), The growth performances of the GB counties: some new empirical evidence for 1977-1993. *Regional Studies* 38(2), pp. 149-165.
SAVIC, M. (2016), What role for knowledge-intensive business services (KIBS) in de-industrialized regions? *Regional Studies, Regional Science* 3(1), pp. 445-454.
SURIÑACH, J. & MORENO, R. (2012), Introduction: Intangible assets and regional economic growth. *Regional Studies* 46(10), pp.1277-1281.
WEBSTER, E. & JENSEN, P.H. (2006), Investment in intangible capital: an enterprise perspective. *The Economic Record* 82(256), pp. 82-96.

Table 1 Types of intangibles proxied by four-digit SIC classes

1995-2003	2003-2007
R&D	**R&D**
7310 Research: natural sciences/engineering	7310 Research: natural sciences/engineering
7430 Technical testing and analysis	7430 Technical testing and analysis
Design	**Design**
7320 Research: social sciences/humanities	7320 Research: social sciences/humanities
7420 Architectural/engineering activities	7420 Architectural/engineering activities
6521 Financial leasing	6521 Financial leasing
6523 Other financial intermediation nec	6523 Other financial intermediation nec
6711 Administration of financial markets	6711 Administration of financial markets
6712 Security broking and fund management	6712 Security broking and fund management
Organisational improvement	**Organisational improvement**
7414 Business/management consultancy activ.	7414 Business/management consultancy activ.
7415 Management activities: holding companies	7415 Management activities: holding companies
Training & skills development	**Training & skills development**
8042 Adult and other education nec	8042 Adult and other education nec
Software development	**Software development**
7220 Software consultancy and supply	7221 Publishing of software
7240 Data base activities	7222 Other software consultancy and supply
	7240 Data base activities
Market research & advertising	**Market research & advertising**
7440 Advertising	7440 Advertising
7413 Market research/public opinion polling	7413 Market research/public opinion polling

Table 2 Descriptive statistics, 128 NUTS3 regions over 12 years (N= 128 x 12), 1995-2007

Variables	Definition	Source	Mean	Standard Deviation	Min	Max
GVA unadjusted for intangibles	Workplace GVA data converted from current basic prices to constant 2003 prices using the CGBV (£ million)	Office for National Statistics (ONS) (https://www.ons.gov.uk/)	7209	9032.5	207	101349
Intangibles GVA	Investment on intangible assets at constant 2003 prices (£ million)	Authors' calculations at regional level based on national series estimated by Marrano et al (2009)	778	1428.7	5	14890
GVA adjusted for intangibles	GVA unadjusted for intangibles plus intangibles GVA (£ million)	Authors' calculations	7988	10412.1	215	116239
Employment	Number of employees	ONS Annual business inquiry employee analysis	186984	180023.8	6386	1467486
GVA unadjusted per employee	GVA unadjusted for intangibles divided by employment (£ per head)	Authors' calculations	35965	4837.5	22564	69863
Intangibles GVA per employee	Intangibles GVA divided by employment (£ per head)	Authors' calculations	3218	1765.1	566	11539
GVA adjusted for intangibles per employee	GVA adjusted for intangibles divided by employment (£ per head)	Authors' calculations	39182	6167.1	23816	80127

Table 3 Top 30 NUTS3 regions that attract the largest share of intangible investment in Great Britain (£ millions), 2007

Standard Region	NUTS3 Region	Intangibles	Unadjusted GVA	Adjusted GVA
London	Inner London – West	16 557	112 700	129 257
London	Inner London – East	8 010	60 921	68 931
South East	Berkshire	4 667	25 950	30 617
South East	Surrey	4 551	26 971	31 522
London	Outer London - West and North West	4 038	39 736	43 774
North West	Greater Manchester South	3 846	31 094	34 940
South East	Hampshire CC	3 647	25 957	29 604
East of England	Hertfordshire	3 150	25 415	28 565
South East	Kent CC	2 377	23 328	25 705
South East	Oxfordshire	2 299	15 187	17 486
London	Outer London – South	2 160	21 153	23 313
Scotland	Aberdeen City and Aberdeenshire	2 027	11 716	13 743
East of England	Cambridgeshire CC	1 962	13 033	14 995
East of England	Essex CC	1 940	23 668	25 608
West Midlands	Birmingham	1 795	19 619	21 414
North West	Cheshire CC	1 792	14 509	16 301
West Midlands	Warwickshire	1 755	10 565	12 320
Scotland	Glasgow City	1 716	16 105	17 821
Scotland	Edinburgh, City of	1 714	15 476	17 190
South East	Buckinghamshire CC	1 592	10 820	12 412
Yorkshire and The Humber	Leeds	1 553	17 230	18 783
South East	West Sussex	1 430	15 497	16 927
North East	Tyneside	1 422	14 980	16 402
London	Outer London - East and North East	1 333	22 235	23 568
East Midlands	Leicestershire CC and Rutland	1 319	12 563	13 882
North West	Lancashire CC	1 279	19 016	20 295
South West	Bath and North East Somerset, North Somerset, etc.	1 253	13 614	14 867
North West	Greater Manchester North	1 214	15 317	16 531
Top 30 NUTS3 regions total		**84 615**	**697 082**	**781 697**
Great Britain		**123 964**	**1195 013**	**1318 977**
Top 30 NUTS3 regions share		**68.3%**	**58.3%**	**59.3%**

Figure 1 Spatial distribution of intangible investment in Great Britain, 1995

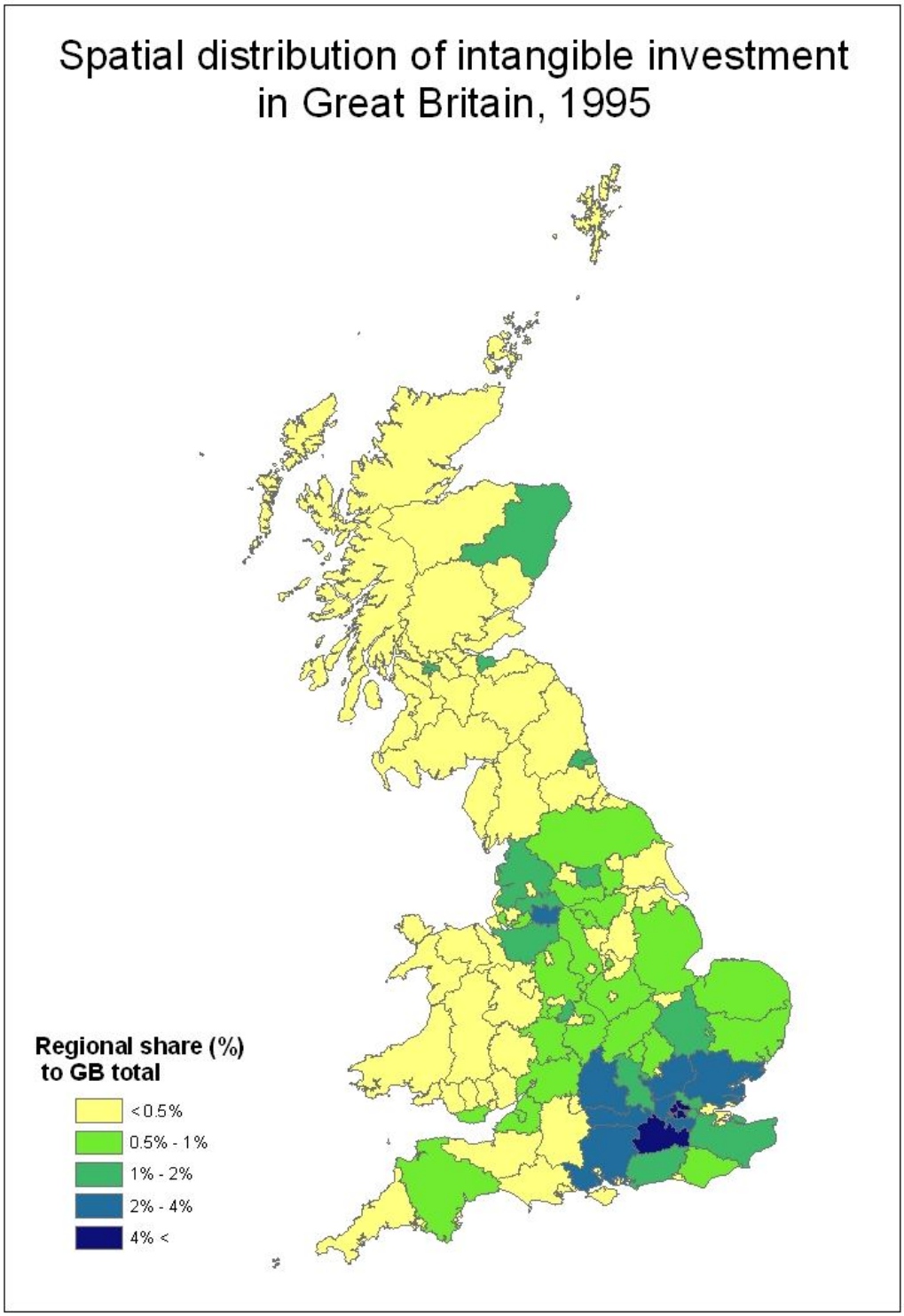

Figure 2 Spatial distribution of intangible investment in Great Britain, 2007

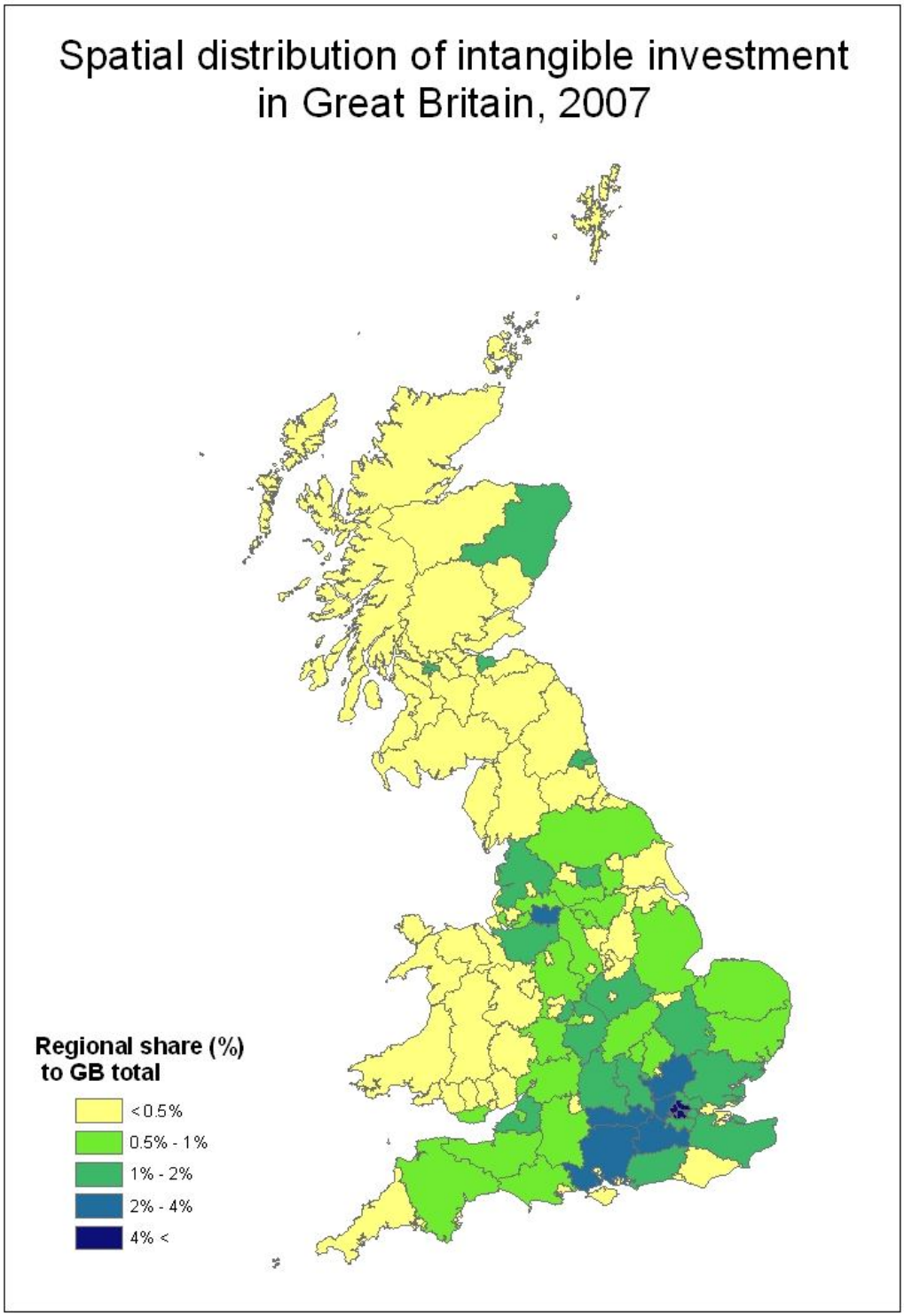

Figure 3 Regional intangibles (as percentage of regional adjusted for intangibles GVA) in Great Britain, 1995

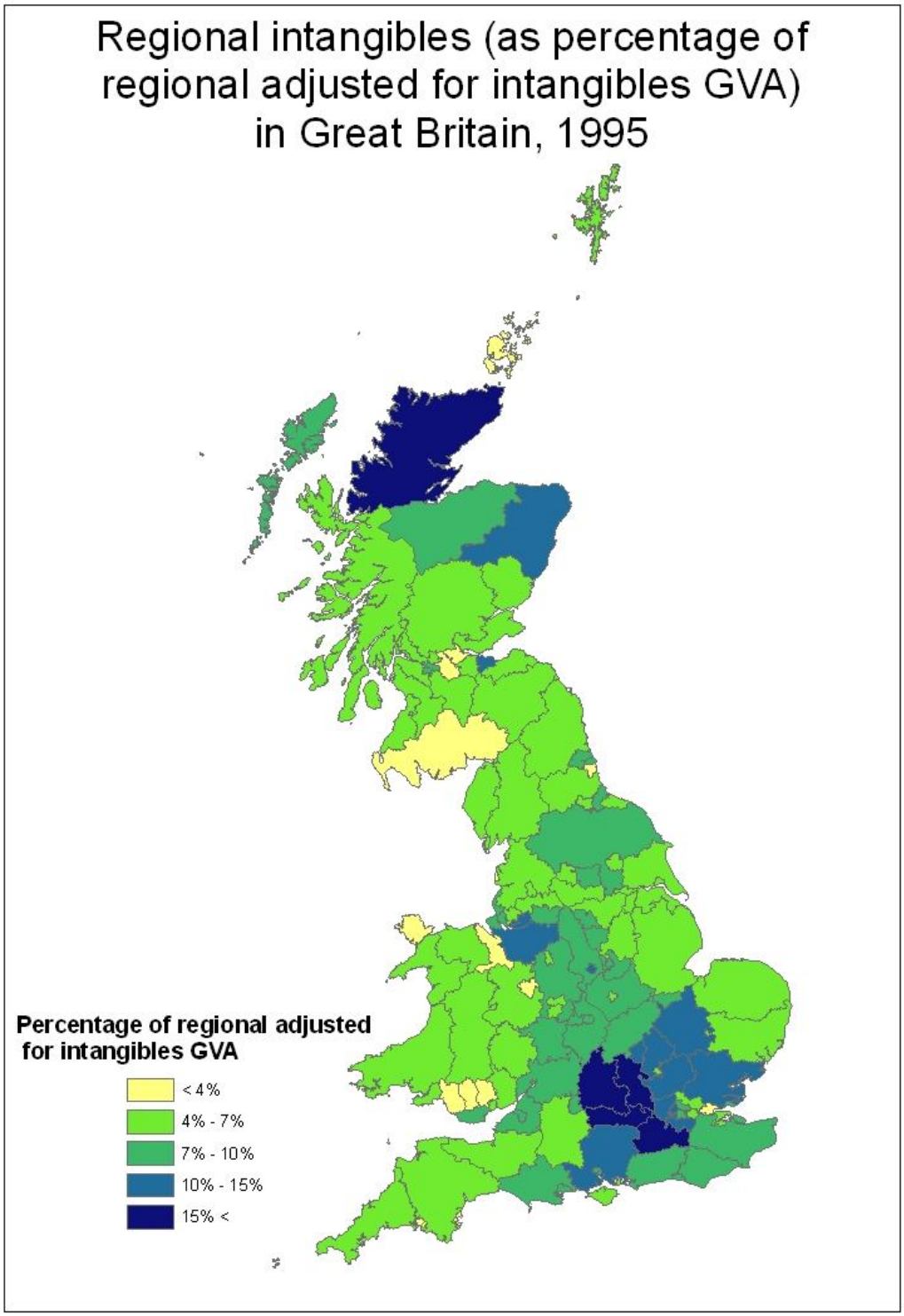

Figure 4 Regional intangibles (as percentage of regional adjusted for intangibles GVA) in Great Britain, 2007

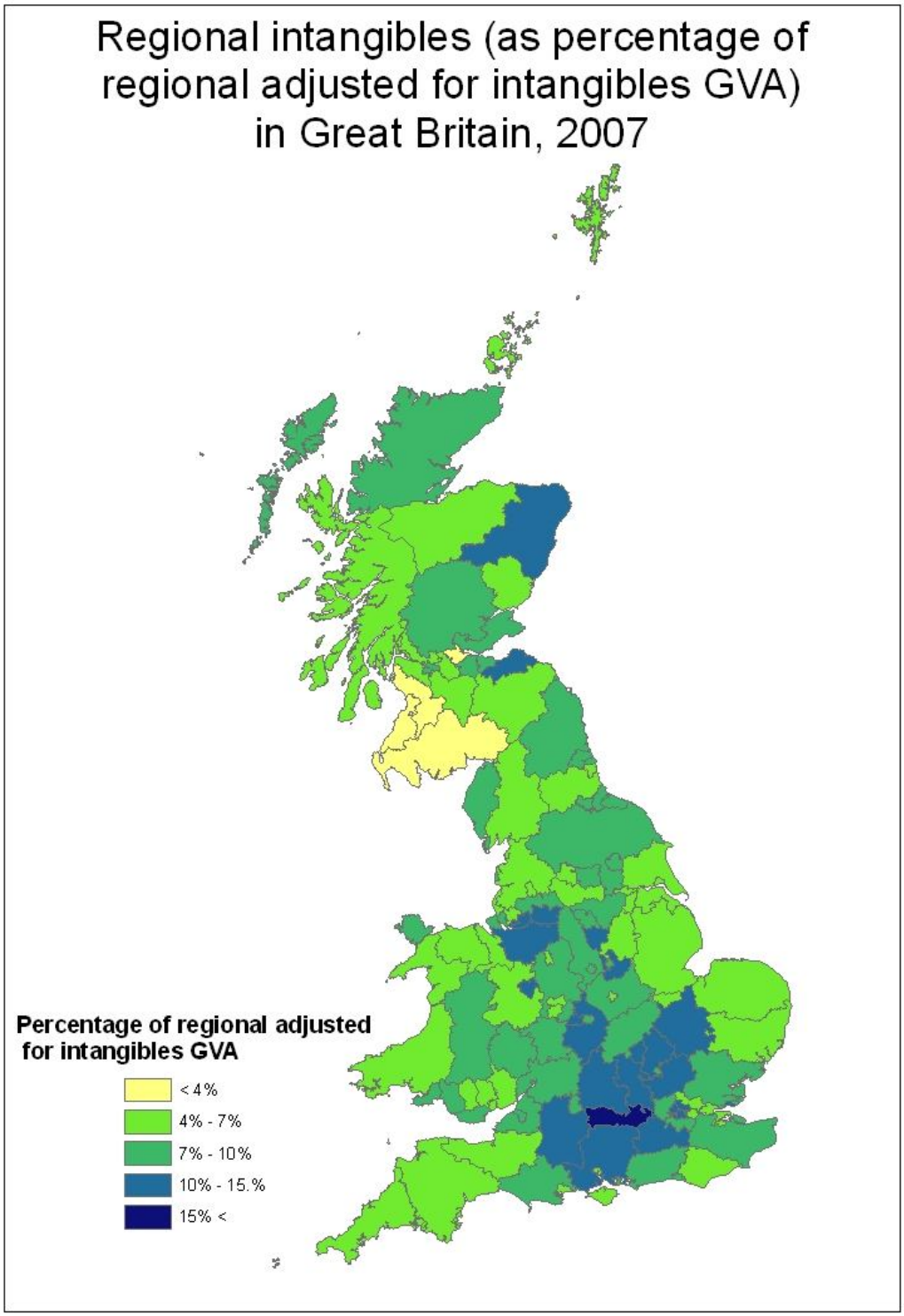

Figure 5 Great Britain regional GVA per employee indices (GB = 100), 1995

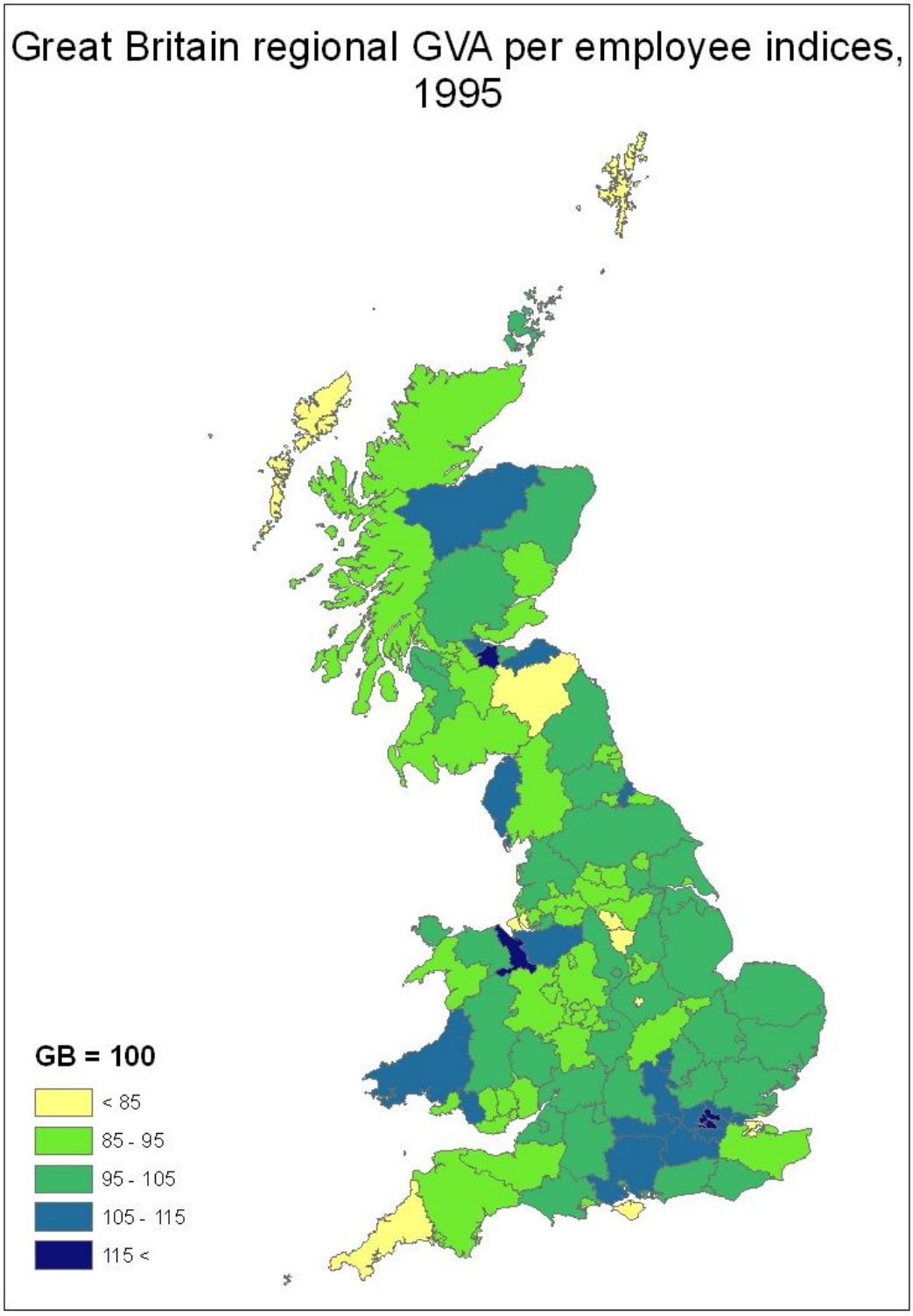

Figure 6 Great Britain regional GVA per employee indices (GB = 100), 2007

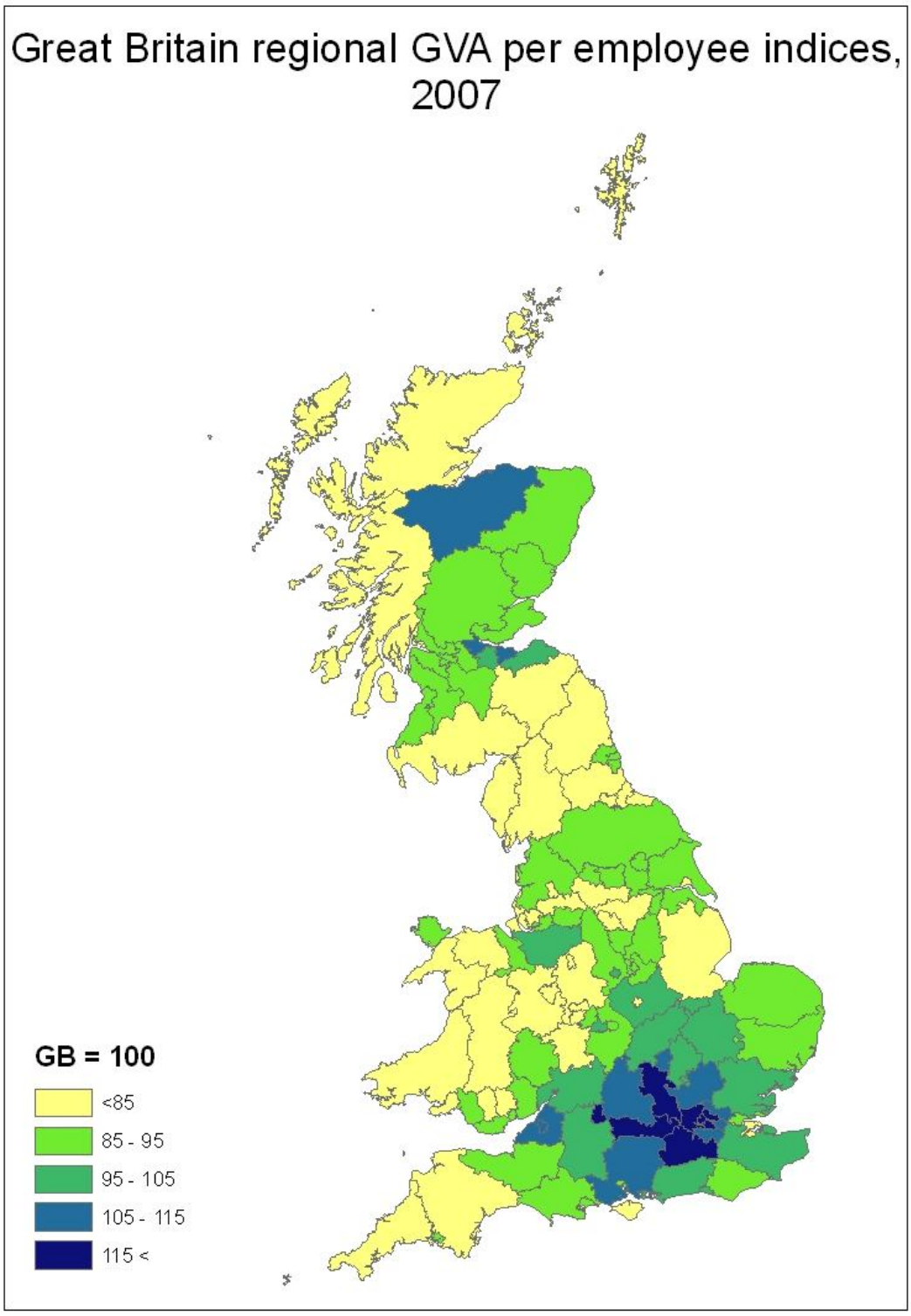

Figure 7 Great Britain regional intangibles GVA per employee indices (GB = 100), 1995

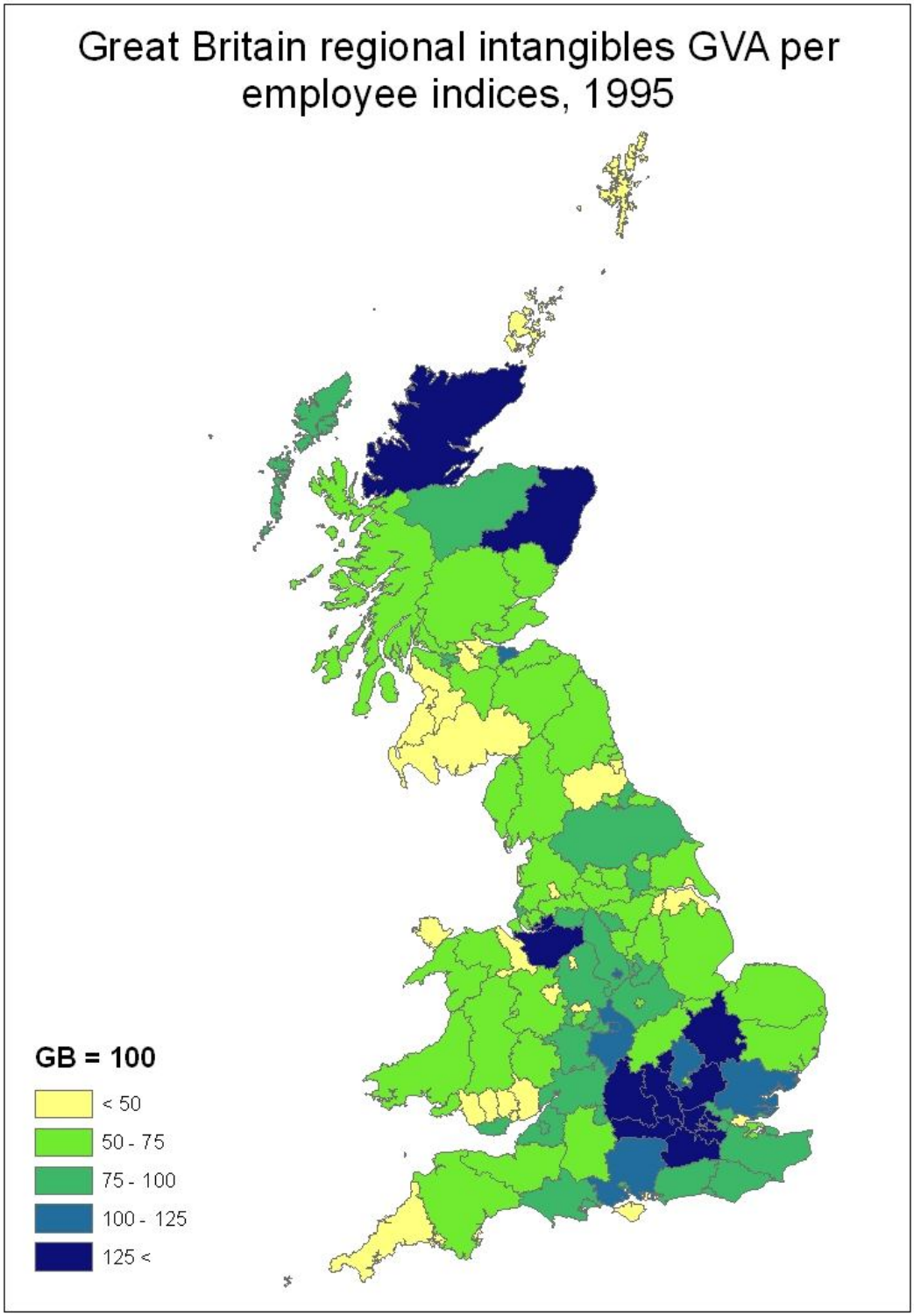

Figure 8 Great Britain regional intangibles GVA per employee indices (GB = 100), 2007

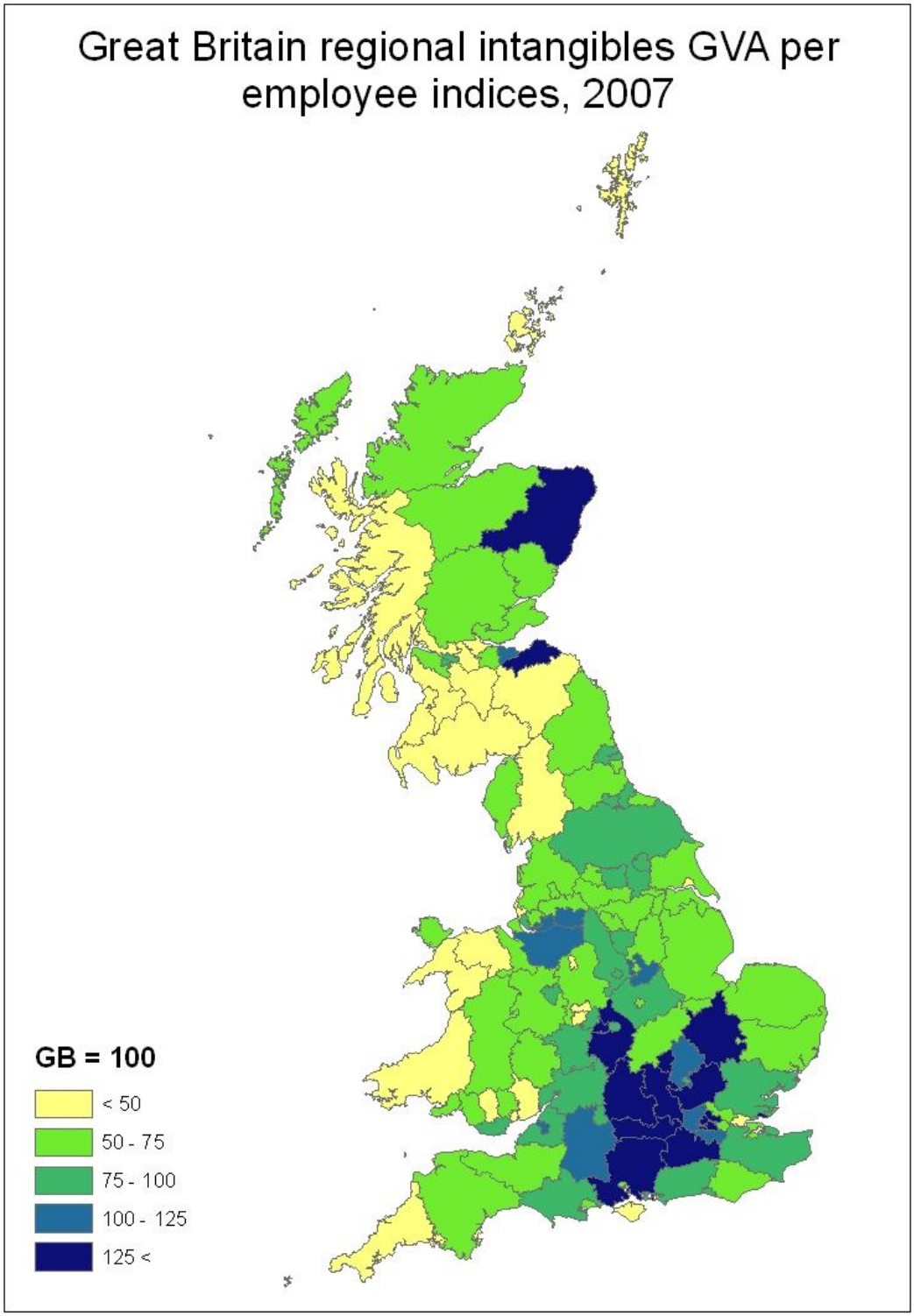

Figure 9 Great Britain regional GVA adjusted for intangibles per employee indices (GB = 100), 1995

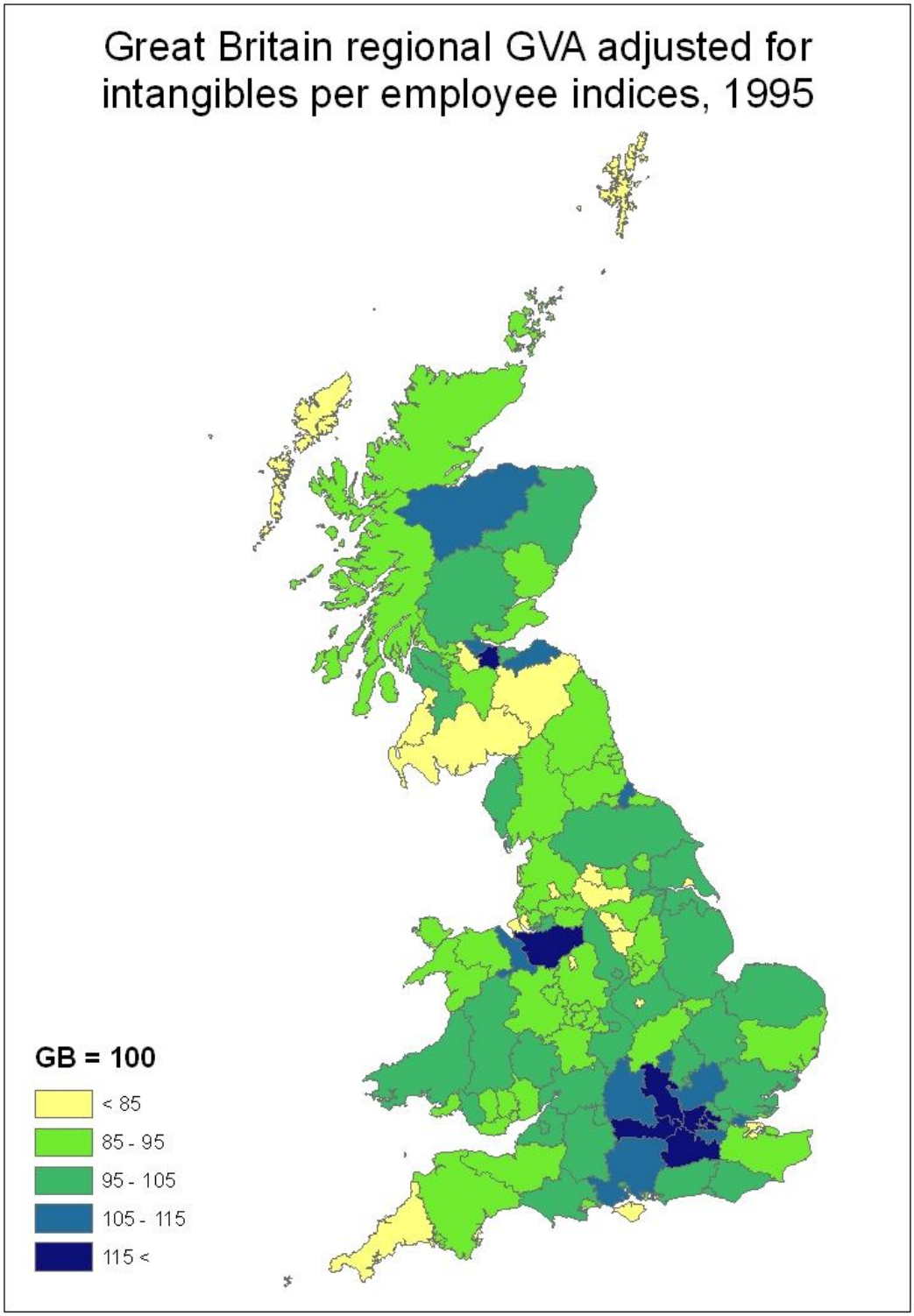

Figure 10 Great Britain regional GVA adjusted for intangibles per employee indices (GB = 100), 2007

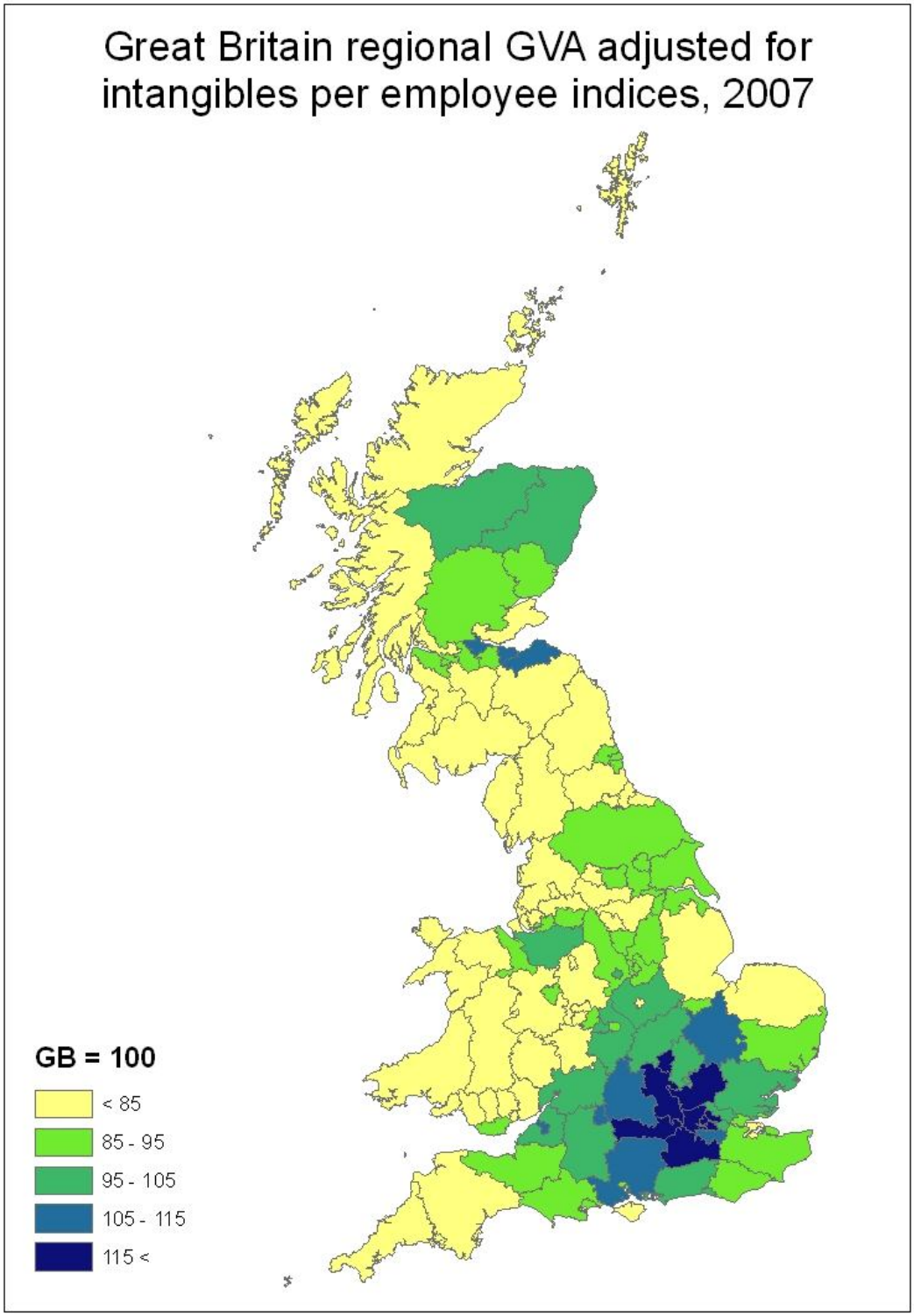

Table 4 Sigma convergence 1995 to 2007: regional (NUTS3) GVA, intangibles GVA and adjusted GVA for intangibles GVA per employee indices (GB = 100)

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Regional (NUTS3) GVA unadjusted per employee													
Coefficient of variation	0.10	0.10	0.11	0.11	0.14	0.14	0.13	0.13	0.14	0.14	0.14	0.15	0.16
Standard deviation	9.7	9.7	10.3	10.6	12.8	13.4	11.9	12.0	12.9	12.7	13.3	13.5	14.4
Mean	96.5	96.1	95.7	94.9	93.3	92.9	94.0	93.0	92.9	92.3	92.1	91.7	90.9
Regional (NUTS3) intangibles GVA per employee													
Coefficient of variation	0.54	0.55	0.54	0.55	0.62	0.61	0.55	0.55	0.51	0.52	0.50	0.50	0.50
Standard deviation	42.2	42.5	41.9	42.5	47.3	45.9	42.4	42.3	40.5	40.1	39.3	39.2	38.8
Mean	78.0	77.3	77.8	76.9	76.8	75.1	76.9	77.2	78.9	77.4	78.5	78.4	78.1
Regional (NUTS3) adjusted for intangibles GVA per employee													
Coefficient of variation	0.12	0.12	0.13	0.13	0.16	0.17	0.15	0.16	0.16	0.16	0.17	0.17	0.18
Standard deviation	11.1	11.2	11.8	12.3	15.0	15.8	14.1	14.3	14.8	14.5	15.1	15.2	16.0
Mean	94.8	94.4	94.0	93.2	91.6	91.1	92.2	91.4	91.5	90.9	90.7	90.4	89.7

Table 5 Beta convergence 1995-2007: regional (NUTS3) GVA, intangibles GVA and adjusted GVA per employee (natural logarithms) at constant 2003 prices

Period	1995-2000	2000-2004	2004-2007	2000-2007	1995-2007
Regional GVA unadjusted per employee (ln)					
Beta coefficients	0.0026	-0.0479***	0.0243**	-0.0175**	0.0024
R^2	0.00	0.16	0.04	0.05	0.00
Convergence rates	-0.26%	4.39%	-2.52%	1.65%	-0.24%
Standard error of convergence rates	0.0178	0.0116	0.0097	0.0079	0.0077
Half life	-269.8	15.8	-27.5	42.0	-285.2
Regional intangibles GVA per employee (ln)					
Beta coefficients	-0.0260**	-0.0523***	-0.0325***	-0.0345***	-0.0201***
R^2	0.04	0.20	0.06	0.23	0.17
Convergence rates	2.44%	4.74%	3.10%	3.09%	1.80%
Standard error of convergence rates	0.0123	0.0111	0.0127	0.0069	0.0050
Half life	28.4	14.6	22.3	22.4	38.4
Regional GVA adjusted for intangibles per employee (ln)					
Beta coefficients	0.0286*	-0.0459***	0.0193**	-0.0180***	0.0115*
R^2	0.03	0.19	0.03	0.07	0.02
Convergence rates	-3.09%	4.21%	-1.98%	1.70%	-1.23%
Standard error of convergence rates	0.0135	0.0101	0.0088	0.0068	0.0056
Half life	-22.4	16.5	-35.0	40.9	-56.2

* Statistically significant at 10% level
** Statistically significant at 5% level
*** Statistically significant at 1% level

Table 6 Intra-regional sigma convergence 1995 to 2007 within selected groups of NUTS3 regions: GVA, intangibles GVA and adjusted GVA for intangibles GVA per employee indices (GB = 100)

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Coefficient of variation within selected groups of NUTS3 regions GVA unadjusted per employee													
London & South East	0.11	0.13	0.14	0.14	0.16	0.16	0.14	0.15	0.17	0.16	0.17	0.18	0.19
Rest of Great Britain	0.09	0.08	0.09	0.09	0.11	0.11	0.11	0.10	0.10	0.10	0.11	0.11	0.11
South	0.10	0.11	0.13	0.13	0.14	0.14	0.13	0.14	0.16	0.15	0.15	0.16	0.17
Midlands & Wales	0.08	0.07	0.07	0.07	0.09	0.09	0.10	0.08	0.09	0.08	0.08	0.08	0.09
North	0.10	0.09	0.10	0.10	0.11	0.12	0.11	0.09	0.09	0.09	0.11	0.11	0.11
Coefficient of variation within selected groups of NUTS3 regions intangibles GVA per employee													
London & South East	0.50	0.46	0.49	0.50	0.56	0.55	0.51	0.49	0.48	0.47	0.46	0.46	0.46
Rest of Great Britain	0.42	0.44	0.44	0.46	0.48	0.44	0.43	0.43	0.41	0.40	0.41	0.41	0.40
South	0.54	0.52	0.53	0.53	0.62	0.61	0.56	0.54	0.51	0.51	0.48	0.47	0.49
Midlands & Wales	0.35	0.45	0.48	0.47	0.50	0.34	0.37	0.43	0.42	0.39	0.39	0.41	0.38
North	0.44	0.44	0.40	0.46	0.47	0.45	0.42	0.41	0.39	0.39	0.38	0.39	0.40
Coefficient of variation within selected groups of NUTS3 regions adjusted for intangibles GVA per employee													
London & South East	0.14	0.15	0.17	0.17	0.19	0.20	0.18	0.18	0.20	0.19	0.19	0.21	0.22
Rest of Great Britain	0.09	0.09	0.10	0.10	0.12	0.12	0.12	0.11	0.11	0.11	0.12	0.12	0.13
South	0.13	0.13	0.15	0.15	0.18	0.18	0.16	0.17	0.18	0.17	0.18	0.18	0.20
Midlands & Wales	0.07	0.07	0.08	0.08	0.10	0.10	0.11	0.10	0.11	0.09	0.10	0.10	0.10
North	0.10	0.10	0.10	0.11	0.12	0.13	0.12	0.10	0.10	0.10	0.11	0.11	0.12

Table 7 Beta convergence 1995-2007 within selected groups of NUTS3 regions: GVA, intangibles GVA and adjusted GVA per employee (natural logarithms) at constant 2003 prices

Period	London & South East	Rest of Great Britain	South	Midlands & Wales	North
Regional GVA unadjusted per employee (ln)					
Beta coefficients	0.0406***	-0.0267***	0.0326***	-0.0696***	-0.0240**
R^2	0.50	0.08	0.22	0.34	0.09
Convergence rates	-5.56%	2.32%	-4.13%	5.06%	2.11%
Standard error of convergence rates	0.0051	0.0077	0.0060	0.0194	0.0075
Half life	-12.5	29.9	-16.8	13.7	32.9
Regional intangibles GVA per employee (ln)					
Beta coefficients	-0.0193**	-0.0244***	-0.0172***	-0.0364***	-0.0224***
R^2	0.21	0.18	0.22	0.25	0.15
Convergence rates	1.74%	2.14%	1.56%	3.02%	1.99%
Standard error of convergence rates	0.0111	0.0080	0.0070	0.0194	0.0106
Half life	39.9	32.4	44.3	23.0	34.9
Regional GVA adjusted for intangibles per employee (ln)					
Beta coefficients	0.0285***	-0.0120	0.0260***	-0.0485**	-0.0170
R^2	0.43	0.02	0.27	0.16	0.05
Convergence rates	-3.49%	1.12%	-3.12%	3.82%	1.55%
Standard error of convergence rates	0.0052	0.0072	0.0049	0.0203	0.0067
Half life	-19.8	62.0	-22.2	18.1	44.7
Observations	19	109	41	34	53

* Statistically significant at 10% level
** Statistically significant at 5% level
*** Statistically significant at 1% level

Table 8 Harris-Tzavalis unit-root test for Great Britain plus selected groups of NUTS 3 regions 1995-2007: GVA, intangibles GVA and adjusted GVA per employee (natural logarithms) at constant 2003 prices

	Great Britain	London & South East	Rest of Great Britain	South	Midlands & Wales	North
Regional GVA unadjusted per employee (ln)						
ρ-statistic	0.3112	0.2784	0.3193	0.2532	0.3225	0.3184
z	-5.5141	-2.5796	-4.8201	-4.3034	-2.6326	-3.3827
p-value	(0.0000)	(0.0049)	(0.0000)	(0.0000)	(0.0042)	(0.0004)
Regional intangibles GVA per employee (ln)						
ρ-statistic	0.1431	0.1462	0.1453	0.2125	0.1354	0.1229
z	-11.5712	-4.4153	-10.6046	-5.1339	-6.1066	-7.9158
p-value	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Regional GVA adjusted for intangibles per employee (ln)						
ρ-statistic	0.2960	0.2677	0.3002	0.2591	0.3296	0.2809
z	-6.0631	-2.7290	-5.4564	-4.1846	-2.5012	-4.2523
p-value	(0.0000)	(0.0032)	(0.0000)	(0.0000)	(0.0062)	(0.0000)

Note: Variables are demeaned. For all variables, the trend is included.

Table 9 Arellano-Bond dynamic panel-data estimation of convergence 1995-2007

	Great Britain	London & South East	Rest of Great Britain	South	Midlands & Wales	North
Regional GVA unadjusted per employee (ln)						
Coefficient ρ	0.8140	0.8469	0.7037	0.8641	0.7799	0.2193
p-value	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0050)
Beta coefficient	-0.1860	-0.1531	-0.2963	-0.1359	-0.2201	-0.7807
Convergence rates	17.06%	14.25%	25.95%	12.74%	19.89%	57.70%
AR(2)	-0.5497	-2.8802	0.3804	-2.7267	0.5199	-0.6665
p-value	(0.5825)	(0.0040)	(0.7036)	(0.0064)	(0.6031)	(0.5051)
Sargan	101.6306	17.8340	86.5771	32.7688	25.2843	44.3563
p-value	(0.0000)	(0.0578)	(0.0000)	(0.0003)	(0.0048)	(0.0000)
Regional intangibles GVA per employee (ln)						
Coefficient ρ	0.8155	0.7769	0.8165	0.8217	0.7642	0.7728
p-value	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Beta coefficient	-0.1845	-0.2231	-0.1835	-0.1783	-0.2358	-0.2272
Convergence rates	16.93%	20.14%	16.85%	16.41%	21.17%	20.47%
AR(2)	2.3414	-2.4375	2.7284	-0.0947	1.5012	1.9993
p-value	(0.0192)	(0.0148)	(0.0064)	(0.9246)	(0.1333)	(0.0456)
Sargan	50.7479	16.9885	45.1601	24.1890	21.0284	28.1535
p-value	(0.0000)	(0.0746)	(0.0000)	(0.0071)	(0.0209)	(0.0017)
Regional GVA adjusted for intangibles per employee (ln)						
Coefficient ρ	0.7899	0.8099	0.7339	0.8461	0.7956	0.3864
p-value	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Beta coefficient	-0.2101	-0.1901	-0.2661	-0.1539	-0.2044	-0.6136
Convergence rates	19.07%	17.40%	23.59%	14.31%	18.60%	47.85%
AR(2)	0.2443	-2.7895	1.1399	-2.0647	0.7932	(0.4334)
p-value	(0.8070)	(0.0053)	(0.2543)	(0.0390)	(0.4276)	(0.6647)
Sargan	87.0748	16.8697	73.8277	31.2952	23.1914	41.2083
p-value	(0.0000)	(0.0773)	(0.0000)	(0.0005)	(0.0101)	(0.0000)