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Sectoral Trends and British Regional Economic Growth – A Spatial Econometric Perspective[1]

Declan Curran

Abstract

This paper aims to look beneath the surface of British sub-regional aggregate GVA growth over the period 1995-2004, by examining how the differing growth dynamics of the secondary and services sectors have influenced the overall regional growth process. A spatial econometric analysis is undertaken which tests regional secondary, services and aggregate real GVA *per capita* for absolute and conditional convergence at the NUTS 3 level as well as on a set of functional economic areas, constructed using NUTS 3 level commuter flow data. A number of explanatory factors influencing secondary, services, and aggregate regional economic growth are also identified.

Keywords: Regional Economic Growth, Britain, Spatial Econometrics
JEL-Classification: R11, R12

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[1] This paper is an extract from the PhD thesis "Regional Growth across Space and Time" published by the University of Hamburg in June 2008.

1. Introduction

The emergence of an impressive array of spatial econometric techniques in recent years has helped give geographic factors a more realistic characterisation in regional economic analysis. The importance of this spatial dimension has never been in doubt, but the tools are only now available to provide a more vivid depiction of how the regional growth process is impacted by core or peripheral location, proximity to natural resources, and spillover effects from neighbouring regions. This paper builds upon the work of Henley (2005) and Monastiriotis (2006) and employs these spatial techniques to shed light on the regional growth process occurring in Britain over the period 1995-2004. Regional disparities have been synonymous with modern day British economic development and their influence can still be seen in current regional growth trends. In 2005 the gross value added (GVA) per head of population for the UK was £17,700, with London having the highest regional GVA per head of population (£24,100), and the South East following with £20,400.[2] The East of England (£18,900) was the only other region to have a GVA per head of population higher than the national average.[3] Wales had the lowest GVA per head of population at £13,800.[4] That said, there have been signs recently that these disparities may be lessening: in 2005 the North East enjoyed, along with the East Midlands and London, the strongest GVA per head growth (4.4 per cent), while the lowest growth rate (3.5 per cent) was experienced in the South East. [5]

This analysis of British regional economic development focuses on NUTS 3 real GVA *per capita* data spanning the period 1995-2004, not just for aggregate British GVA *per capita* but also for the secondary and services sectors. In this way, it is possible to look beneath the surface of the British sub-regional aggregate GVA growth process experienced over the period 1995-2004, by examining to what extent this process may have been driven by the differing growth dynamics of the secondary and services sectors. This approach also finds support in the work of Boddy *et al*. (2005) who, in their study of productivity differentials based on individual business units, find that “the scale of difference in productivity between particular sectors is very considerable”. Two problems often emerge in studies utilising highly disaggregated regional data: (i) neglect of the impact of commuter flows and (ii) the administrative delineation of regions may not reflect self-contained economic areas.[6] This paper attempts to address these two issues by constructing a set of functional economic regions for Britain, where the 128 NUTS 3 regions are aggregated together using a method based on commuter flow data. These functional economic areas provide a means for checking the robustness of results emanating from the econometric analysis carried out on the NUTS 3 level data. While the time-span (1995-2004) considered in this paper is dictated by data availability, this decade is nonetheless an important one. It captures a period of time where regional growth in many developed countries has been impacted by the move towards the outsourcing of manufacturing and the absorption of phenomenal technological advances.

[2] Throughout this paper, the term “regions” denotes British NUTS 1 level disaggregation, “counties” denote British NUTS 2 disaggregation, and “sub-regions” denote British NUTS 3 level disaggregation. The term “regional economic growth” is used in a general sense to refer to the field of literature to which this paper belongs.

[3] GVA is defined as follows: Under European System of Accounts 95 (ESA95), the term GVA is used to denote estimates that were previously known as Gross Domestic Product (GDP) at basic prices. Under ESA95 the term GDP denotes GVA plus taxes (less subsidies) on products, i.e. at market prices.

[4] Data available from the Office of National Statistics (ONS) at: http://www.statistics.gov.uk/CCI/nugget.asp?ID=420&Pos=&ColRank=1&Rank=374.

[5] The quantity of real GVA generated by each geographic unit, scaled by that unit’s population, is a standard proxy for the productivity in the face of data constraints at high levels of disaggregation. It is not intended to represent income *per capita*. For a treatment of regional productivity differentials based on individual business units, see Boddy *et al* (2005).

[6] In the British context, Fingleton (2003) has found that commuting exerts a significant effect on wages and productivity in central cities.

Britain is no exception to this trend: in 2004 primary, secondary, and services as defined in Section 2, below, accounted for approximately 1%, 22% and 75% of British GVA, while the equivalent shares in 1995 were 2%, 30% and 66%, respectively.[7] This surge in services sector output, accompanied by a falling off of secondary output, justifies a more disaggregated approach to the convergence/divergence debate.

This paper is organised as follows: Section 2 provides a description of the data used in this paper, as well as a brief review of the literature on British regional growth in the years prior to 1995. The spatial dispersion of British real GVA *per capita* is also discussed, with a set of colour-coded maps provided. A description of how β-convergence analysis has been augmented to include a number of spatial econometric methods is provided in Section 3. The section concludes with an outline of the approach adopted in this paper for allocating British NUTS 3 regions to functional economic regions. The results of the spatial econometric analysis testing for absolute and conditional convergence are reported in Section 4. Conclusions are then presented in Section 5.

2. Data Issues and Background

This paper is primarily focused on NUTS 3 level gross value added (GVA) *per capita* data. Unadjusted (constrained to headline NUTS2) aggregate GVA by NUTS3 area at current basic prices for the years 1995 to 2004 is available from the Office of National Statistics (www.statistics.gov.uk), as well as being disaggregated for 1) agriculture, hunting and forestry 2) Industry, including energy and construction and 3) service activities, including Financial Intermediation Services Indirectly Measured (FISIM). These three categories are henceforth referred to as “primary”, “secondary”, and “services”, respectively. Estimates of workplace-based GVA allocate income to the region in which commuters work. *Per capita* estimates can then be constructed using NUTS 3 level population data available from Nomis Labour Market Statistics (www.nomisweb.co.uk). Unfortunately, regional deflators such as the Retail Price Index (RPI) are only available for the UK for the years 2000, 2003, and 2004, and the methodology for this index is still at a formative stage. One could merely use the yearly national deflator for each NUTS 3 region. However, this would be unsatisfactory as it would make no allowance whatsoever for regional price differences – particularly problematic in the British case as secondary, services, and aggregate GVA *per capita* exhibit clear regional trends, as illustrated in Figures 1-3. In this study, regional deflators for each year have been constructed by weighting the 1995-99 national RPI figure by the 2000 regional RPI weights. Similarly for 2001-2002 regional RPI the 2003 regional RPI figures are used as weights. The basket used to calculate the RPI figures include both consumer goods and services such as household services, personal services, and leisure services.[8]

By way of background, it should be noted that studies of British regional growth patterns over the 1977-1995 period, based on National Accounts GDP *per capita* data for the 62 British counties and New Earnings Survey data, have identified a number of prominent features.[9]

Chatterji and Dewhurst (1996) conclude that Regional GDP *per capita* data yields no evidence of convergence over this time period, though they do identify some sub-periods that exhibit convergence (in periods where the economy as a whole was experiencing slow growth). Bishop and Gripaios (2004) find no signs of convergence over the period 1977-1995, regardless of whether one uses National Accounts or New Earnings Survey data. A further

[7] Calculations based on National Accounts GVA data available from Office of National Statistics, as discussed in Section 2.

[8] For further details of the composition of the RPI series, see the ONS publication *Economic Trends 615*, February 2005.

[9] For the purposes of this study, only Great Britain is considered, i.e. Northern Ireland is not included.

insight to emerge from this line of research has been the influence of geographic location and spatial factors on British regional growth. Dewhurst (1998) finds evidence of the influence of the “north-south divide” on British regional growth patterns while Bishop and Gripaios (2004) also find a significant “north-south divide” effect, which acts to the detriment of the northern areas. More recently a whole range of spatial economic techniques have become available, allowing for a more refined characterisation of the spatial dimension in the regional growth process. When this spatial component is controlled for in convergence analysis, there are signs that not only has Britain not experienced regional convergence in recent decades, but there may even have been a process of divergence in action. Monastiriotis (2006), using wage data from the New Earnings Survey, points to widening aggregate wage disparities throughout the 1980s and 1990s when the issue of spatial dependence is taken into account. Henley (2006) has undertaken a spatial econometric analysis of NUTS 3 level aggregate GVA data for the period 1995-2001 and concludes that British NUTS 3 sub-regions experienced divergence over this time period.

In order to provide a visual impression of the spatial dispersion of real GVA *per capita* across British NUTS 3 sub-regions, a set of maps are presented (Figures 1-3). Each map is colour coded, with the light shading denoting 0-100% of median real GVA *per capita*, medium shading denoting 100-125%, and dark shading denoting over 125% of median real GVA *per capita*. Each sub-region is shown relative to the median rather than the mean to mitigate the impact of outliers such as the services GVA of London’s financial district located in the Inner London West NUTS 3 sub-region. Figure 1 presents aggregate real GVA *per capita* for 1995 and 2004. Salient features include the apparent spatial clustering of high GVA *per capita* in greater London, Manchester, Liverpool, Edinburgh, Glasgow, and Aberdeen (near the North Sea oil fields); a clear expansion of the greater London high-GVA area over the period in question; and the noticeable improvement of the Midlands but no consistent GVA *per capita* increase in Northern England and Scotland. One might wonder whether these impressions are reflected in the development of the secondary and services sectors over the period 1995-2004. As illustrated in Figure 2, the secondary industry presents a mixed picture: the North of England NUTS 3 sub-regions appear to have experienced mixed fortunes; a belt of increased GVA *per capita* is apparent in the Midlands, while the South West and South East exhibit some shuffling of regions between the three categories, but no clear pattern. The services sector (Figure 3) highlights the strength of the high-GVA greater London area, increases in Liverpool and Manchester, but continued sluggishness in Northern England and Scotland. In all it would appear that it is the services industry which drives the expansion of the southern high GVA *per capita* in the aggregate map. While the secondary sector does appear to be the more dispersed in terms of the highest GVA *per capita* category; this trend seems to be eclipsed in the aggregate GVA *per capita* map by the strong services performance.

Further descriptive evidence of sub-regional GVA *per capita* trends can be gleaned from the summary statistics presented in Table 1.

Table 1: Summary Statistics for Secondary and Services real GVA *per capita*, 1995 and 2004

Secondary Sector GVA *per capita* (2002 UK£)			Services Sector GVA *per capita* (2002 UK£)		
	1995	**2004**		**1995**	**2004**
Mean	3,517.29	4,031.72	Mean	6,422.84	11,261.36
Median	3,343.53	3,964.37	Median	5,828.70	9,708.08
Maximum	7,068.65	8,383.50	Maximum	41,398.86	64,654.04
Minimum	1,634.15	1,648.84	Minimum	3,050.08	5,766.21
Std. Dev.	1,162.03	1,168.17	Std. Dev.	3,574.93	6,023.20

The contrast between secondary and services sector GVA *per capita* developments over the period 1995-2004 is stark. The virtually unchanged mean, median, and standard deviation of secondary GVA *per capita* over the 10 year period, together with slight increases in the minimum and maximum GVA *per capita* figures, suggest that any convergence experienced in the secondary sector has not been a buoyant one. Services GVA *per capita*, on the other hand, bears all the hallmarks of a sector on the move, with its mean and median showing marked increases over the 10 years and its widening standard deviation indicative of the absolute divergence.[10]

[10] Measuring the dispersion of real GVA *per capita* between regions based on the standard deviation of the cross-section series is referred to as "sigma convergence"; see Barro and Sala-I-Martin (1992). An alternative way of measuring sigma convergence is to use the coefficient of variation, which is obtained by dividing the standard deviation of the series by the mean of the sample. From Table 1 the coefficient of variation for services appears to fall from 0.56 to 0.53 over the period 1995-2004. This decrease over time would suggest convergence rather than divergence of real GVA *per capita*. However, as noted above, the services GVA data contains one notable outlier - the Inner London West financial district - which greatly influences the mean and the standard deviation. Omitting this NUTS 3 region from the coefficient of variation calculation yields figures of 0.29 and 0.34 for 1995 and 2004 respectively and is indicative of a divergence process.

Figure 1: Aggregate Real GVA *Per Capita*, 1995 (left) and 2004 (right)

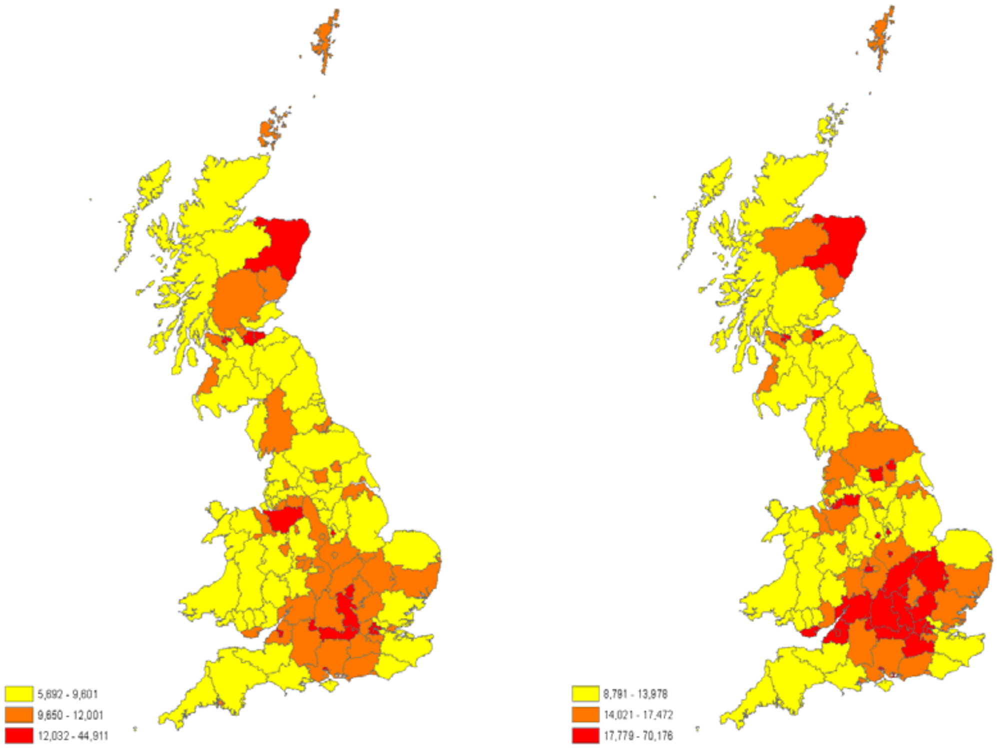


Figure 2: Secondary Sector Real GVA *Per Capita*, 1995 (left) and 2004 (right)

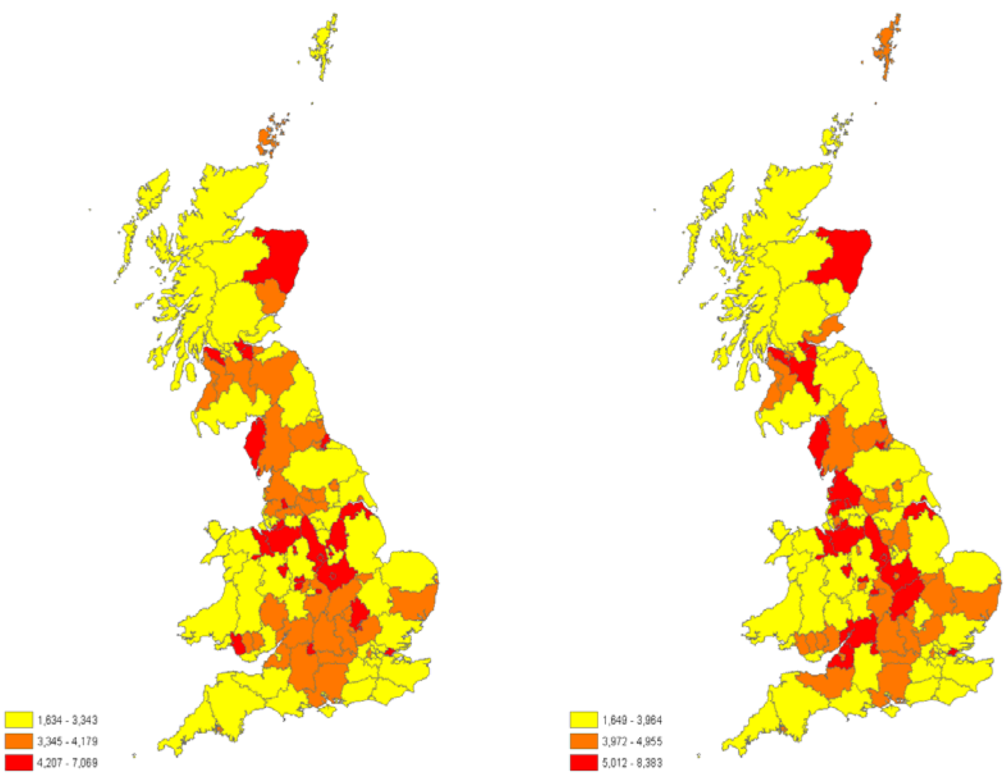
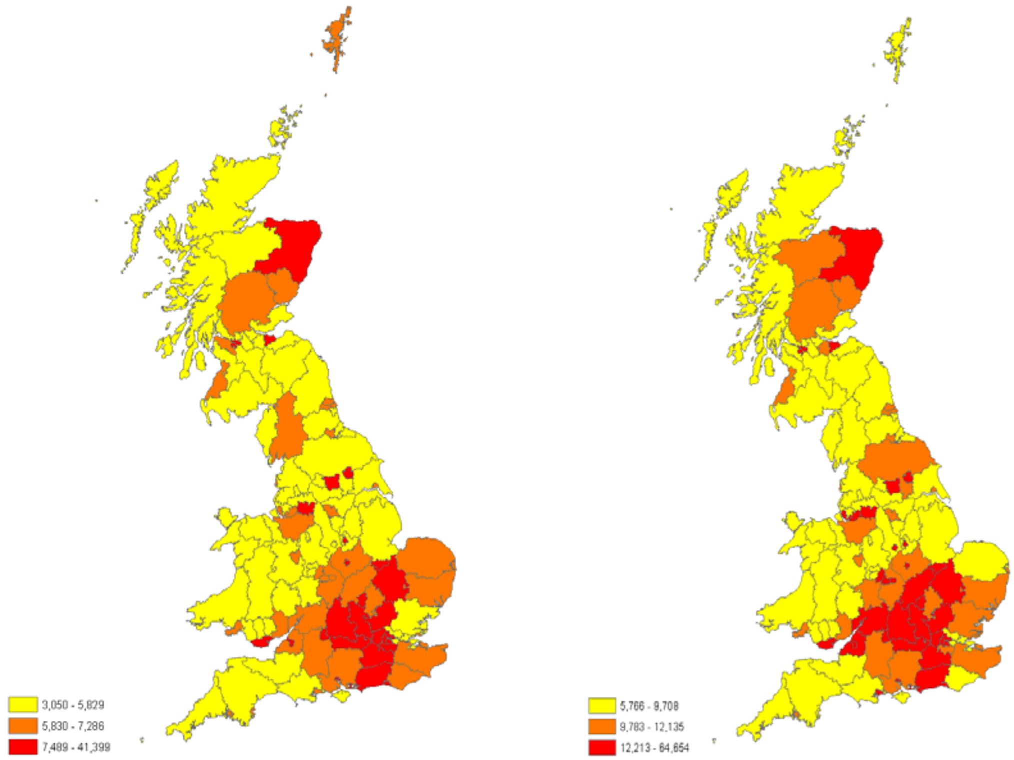


Figure 3: Services Sector Real GVA *Per Capita*, 1995 (left) and 2004 (right)



In Sections 3 and 4 a number of additional data sources are drawn upon. NUTS 3 level commuter flow data used in the construction of British functional economic areas is available from the Labour Force Survey Data Service (lfs.dataservice@ons.gov.uk). The explanatory variables introduced in the conditional convergence analysis of Section 4 include the average primary school pupil-teacher ratio per county and the average A-level pass rate achieved by pupils in each county, both of which are available from the ONS publication *Regional Trends*. The number of businesses registered for Value Added Tax and female employment expressed as a proportion of people aged 16+ are both available from Nomis Labour Market Statistics (www.nomisweb.co.uk). Net capital expenditure data for British sub-regions is available from the ONS series *Regions in Figures*.[11]

3. Regional Convergence and the Spatial Dimension

This section begins with a brief description of how β-convergence analysis, as developed by Baumol (1986), Barro and Sala-I-Martin (1992), and Mankiw *et al*. (1992), has been augmented to include a number of spatial econometric methods. When considering regional convergence, various empirical approaches have been implemented in the literature: from simple plots of measures of dispersion over time to intra-distributional dynamics using Markov chains applied to GDP *per capita*. It is β-convergence analysis however that has lent itself most easily to spatial econometric analysis. This section discusses methods for constructing functional economic areas from administrative regions. The section concludes with an outline of the approach adopted in this paper for allocating British NUTS 3 regions to functional economic regions.

[11] *Region in Figures* has now been discontinued. The final edition was Winter 2004/05 (volume 9). It has now been replaced by a new publication, *Regional Snapshot*.

3.1 Spatial Convergence and the Modelling of Regional Growth

While a variety of distinct convergence concepts have emanated from the economic growth literature, one form of convergence which has received particular attention over the last two decades has been that of *β*-convergence. This form of convergence occurs when poor regions grow faster than richer regions, resulting in a catching-up process where the poor regions close the economic gap that exists between their richer counterparts. The now-standard specification of *β*-convergence can be expressed in vector form as follows:

$$(1) \qquad \ln\left(\frac{y_{t+k}}{y_t}\right) = \alpha + (1 - e^{-\lambda k})\ln(y_t) + \varepsilon_t$$

where $\boldsymbol{y}_t$ denotes the vector of *per capita* income of each state i in year t; α represents the intercept term, and $(1\text{-}e^{-\lambda k})$ is the convergence coefficient, which is usually reparameterized as $\beta = (1\text{-}e^{-\lambda k})$. The β coefficient is then estimated using Ordinary Least Squares (OLS), and the speed of convergence, λ, can then be calculated. A negative estimate for β indicates that growth rates of *per capita* income over the k years is negatively correlated with initial incomes – a finding which is interpreted as support for the hypothesis of convergence. It is assumed that the error terms from different regions are independent:

$$(2) \qquad E[\varepsilon_t \varepsilon_t'] = \sigma_t^2 I \; .$$

This unconditional *β*-convergence specification can then be augmented, as per Barro and Sala-I-Martin (1992), to include a range of control variables (such as differences in human capital accumulation, infrastructure disparities, industrial structure, as well as dummy variables reflecting different regional characteristics) which may capture differences in the paths of steady-state GVA *per capita*.

Equations (1) and (2) can be augmented to capture interactions across space, a refinement which reflects more accurately the realities of the growth process across regions. As Henley (2006) notes, this spatial dimension can exert its influence on regional growth through numerous channels: adjustment costs and barriers to labour and capital mobility, spatial patterns in technological diffusion, the ability of regions to pursue independent regional growth policies, and the extent to which neighbouring regions interact and benefit from spillover effects. Any analysis which ignores the influence of spatial location on the growth process runs the risk of producing biased results. Following Anselin (1988), spatial dependence has been incorporated into the *β*-convergence specification in two ways: it can be included as an explanatory variable in the specification or it can be modelled as operating through the error process.[12] The former, known as a Spatial Autoregressive Model (SAR), depicts a region's growth as being directly affected by growth in neighbouring regions. This direct spatial effect is independent of the exogenous variables and is captured by including a spatial autoregressive parameter, *ρ*, and a spatial weight matrix, *W*, in the specification:

$$(3) \qquad \ln\left(\frac{y_{i,t+k}}{y_{i,t}}\right) = \alpha + (1 - e^{-\lambda k})\ln(y_{i,t}) + \rho W \ln\left(\frac{y_{j,t+k}}{y_{j,t}}\right) + \varepsilon_{i,t}$$

[12] For more detailed treatment of spatial autoregressive and spatial error models, see Bernat (1996), Rey and Montouri (1999), and Fingleton and Lopez-Bazo (2006).

In equation (3), the growth of a given region is influenced by the growth rate of adjacent regions. This "spatial lag" approach can also be utilised where a region's growth rate is thought to be influenced by the initial income level of adjacent regions, a specification which Rey and Montouri (1999) refer to as a spatial cross-regressive model:

(4) $$\ln\left(\frac{y_{i,t+k}}{y_{i,t}}\right) = \alpha + (1-e^{-\lambda k})\ln(y_{i,t}) + \tau W \ln(y_{j,t}) + \varepsilon_{i,t}\,.$$

It may be the case that, rather being directly affected by the growth rate of its neighbours, a region's growth rate may be influenced by a complex set of random, unexpected shocks transmitted across space. Such unexpected shocks take the form of spillovers associated with technology or consumer tastes. In this Spatial Error Model (SEM) case, the spatial influence does not enter the systematic component of the specification. Instead, it is captured in an error term which contains a spatial error coefficient, ζ, and an idiosyncratic component, *u*, where $u \sim N(0, \sigma^2 I)$.

(5) $$\ln\left(\frac{y_{i,t+k}}{y_{i,t}}\right) = \alpha + (1-e^{-\lambda k})\ln(y_{i,t}) + \varepsilon_{i,t} \qquad \text{where} \quad \varepsilon_{i,t} = \zeta W \varepsilon_{j,t} + u_{i,t}$$

Section 4 reports on the results for cross-sectional growth equation regressions which test for absolute and conditional convergence using the SAR and SEM specifications.

3.2 Functional Economic Areas

It is entirely possible that the administrative areas into which a country is divided may not coincide with patterns of economic activity on the ground. Administrative areas may differ from areas of economic activity due to factors such as local democracy or local customs, and these differences may be perpetuated over time. These areas of economic activity have been termed *functional economic areas* (or *local labour market areas*, or *commuting areas*, or *travel to-work-areas*) and have been the focus of much research, as illustrated by Coombes *et al*. (1986), Casado-Diaz (2000), and Andersen (2002), to name but a few. A functional economic area can be characterised by a high frequency of intra-regional interaction, for example, intra-regional trade in goods and services or labour commuting As Andersen(2002) notes, the divergence between administrative and functional economic areas may lead to tensions between administrative authorities, inefficient planning of infrastructure, or sub-optimal labour market policies. This mismatch between administrative and functional economic areas may also have repercussions for those interested in studying the regional economic growth process: findings based on data disaggregated along administrative lines may not fully reflect the economic realities at the regional level. It is understandable then that some effort should be invested in checking whether findings based on administrative-area data are consistent with those that would emerge if a functional economic delineation were used.[13]

[13] The broader issue is that of the Modifiable Areal Unit Problem (MAUP), which occurs whenever arbitrarily defined boundaries are used for measurement and reporting of spatial phenomena. This problem may be alleviated by analysing data at various levels of disaggregation or by taking highly disaggregated spatial units and aggregating them in a context driven by an economic or demographic factor that is not arbitrary. In recent times a number of GIS computational methods have been developed in order to provide a consistent, uniform method for addressing Modifiable Areal Unit Problem (MAUP). For a more detailed treatment of MAUP, see Openshaw (1984). Efforts to address MAUP using GIS technology are discussed in Openshaw and Alvanides (1999).

The problem, of course, is how to identify functional economic areas and delineate them in a meaningful, consistent way. Karlsson and Olsson (2006) outline three theoretical approaches to delineating functional economic areas: (i) the local labour market approach, where one-way commuting data can be used to indicate the existence of wage differentials between areas. Focal regions are identified which are self-contained in terms of commuter flow and then the remaining areas are assigned to these cores, based on commuter flows. The borders are found when areas have equal attraction to both of the closest *foci*; (ii) the commuting zone approach, which is similar to (i), but hinges less on urban *foci* and instead considers the existing mutual dependencies of regions. The interaction between regions is calculated using commuter flows in both directions. Examples of this approach include Masser and Scheurwater (1980), Killian and Tolbert (1993), and Cörvers *et al.* (2008); (iii) the accessibility approach, which uses commuting time to proxy the potential interaction between areas. The approach used to delineate the British functional economic areas constructed in this paper augments (i) above with the two-way commuter flow aspect of (ii): commuter flows in both directions are initially used to identify *foci* to which all other regions are assigned, and subsequently used as a means of approximating the interaction between administrative areas. This method is now described in more detail.

The method used here for delineating functional economic regions owes its origins to Coombes *et al.* (1986), who use micro-level data to divide Britain up into Travel-to-Work Areas (TTWAs). These TTWAs incorporate commuting data in their definition and utilise census data in the delineation process. The algorithm discussed presently, originally constructed in Coombes *et al.* (1986), consists of three phases: i) possible *foci* are identified; ii) unallocated units are assigned to these *foci;* iii) the process is iterated until all regions are deemed self-contained or “closed” in an economic sense, as defined in the methodology. As outlined presently, this methodology has been further refined by Eurostat (1992), Casado-Diaz (2000), and Andersen (2002).

The three phases of the methodology are undertaken in the following manner:
(i) Identification of possible *foci*: at least one area or “couple” constitutes a focus to which all other areas will be assigned. A “couple” occurs where two areas have the highest total of in-commuting and out-commuting with each other. As per Coombes *et al.* (1986) and Casado-Diaz (2000), *foci* are identified using a supply-side and a demand-side self-containment condition. The supply-side self-containment condition captures the extent to which the resident working population work in their area of residence, while the demand-side self-containment condition captures the extent to which jobs in a given area were filled by residents of that area.

The supply-side self-containment condition expresses the number of residents who live and work in area *i* as a proportion of the total number of workers in area *i* (residents who live and work in area *i* plus inward commuters). Let C_{ji} denote the number of commuters travelling from area *j* to area *i*, and C_{ij} denoting those commuting in the opposite direction. The total number of inward commuters to area *i* can then be represented as $\Sigma_{j=1}C_{ji}$ and outward commuters from area *i* can be represented as $\Sigma_{j=1}C_{ij}$. The total number of residents who live and work in area *i* is denoted as TR, or in keeping with the notation above, TR = C_{ii}. The supply-side containment condition can be stated as follows:

(6) $$\frac{TR}{TR + \sum_{j=1} C_{ij}},$$

and the demand-side self-containment condition, which expresses the number of residents who live and work in area *i* as a proportion of the total number of jobs in area *i*, can be stated as:

$$(7) \qquad \frac{TR}{TR + \sum_{j=1} C_{ji}}.$$

In keeping with Eurostat (1992), a self-containment level of 70% or over for both conditions is required for an area to qualify as a focus and areas must have a population of over 50,000.

(ii) Assignment of the remaining areas to the focus with which they exhibit the highest interaction. The interaction of area *i* with area *j* (or any potential focus) is approximated by the sum of commuter flows in both direction between areas *i* and *j* expressed as a proportion of total commuter flows to and from area *i*:

$$(8) \qquad \frac{C_{ij} + C_{ji}}{\sum_{j=1} C_{ij} + \sum_{j=1} C_{ji}}$$

(iii) Having assigned all areas to potential *foci*, it now remains to be seen if each newly constructed functional economic area is sufficiently "closed". Andersen (2002) has developed a measure of how closed a functional economic area is. The number of residents who live and work in this newly constructed functional economic area (TR_{FEA}) is expressed as a proportion of that functional economic area's total commuter inflow and outflows. This ratio, denoted in equation (9) as κ must then exceed a certain threshold value for the functional economic area to be deemed "closed".

$$(9) \qquad \kappa = \frac{TR_{FEA}}{\sum_{j=1} C_{ij} + \sum_{j=1} C_{ji}}$$

The choice of the threshold value, κ, is exogenous and is ultimately data-driven – clearly an unsatisfactory situation. However, as Andersen (2002) notes, it seems reasonable to argue that this threshold should not be less than 1, because a value less than 1 would suggest that commuter flows into and out of the functional economic area were greater than the number of residents living and working in the functional economic area. In light of this, the rather lax but intuitively understandable lower bound threshold value, $\kappa=1$, is used in this paper to determine whether the functional economic areas are "closed". Examination of the data used in this paper, Great Britain's 128 NUTS 3 sub-regions, also supports using this threshold value as it ensures that the number of functional economic areas obtained is not at the extremely low or high end of the 128 NUTS 3 sub-region total. Where functional economic areas are not deemed to be sufficiently "closed", the procedure is iterated until all these "not closed" areas are assigned to another focus and the threshold is attained. In the case of remote areas which may not have any interaction with the *foci*, these remote areas are assigned to the area with which they share the highest interaction. The final delineation of the 64 British functional economic areas, constructed using NUTS 3 level commuter flow data for the year 2000, is displayed in Figure 4, and a complete list of the functional economic areas is provided in Appendix 1.

Figure 4: Functional Economic Areas for Britain Based on Commuter Flow Data

Having illustrated the 64 functional economic areas in Figure 4, it is natural to wonder how satisfactory these constructed areas are in capturing the reality of British regional patterns "on the ground". An intuitive indication might be gained from comparing the functional economic areas (and their underlying NUTS 3 sub-region components) with existing urban conurbations. Here, the six English metropolitan counties and Greater London are used to give an impression of the performance of the functional economic areas.[14] As outlined in Table 2, these metropolitan counties (and Greater London) envelope a number of NUTS 3 sub-regions. How do the functional economic areas handle these NUTS 3 regions? One would expect that sensible functional economic areas should not separate the NUTS 3 regions that the metropolitan counties suggest should be grouped together. As illustrated in Table 2, the functional economic areas are broadly in line with the amalgamation of metropolitan counties (and Greater London) NUTS 3 regions, with a number of neighbouring sub-regions added to these metropolitan counties where the commuter flow data deemed appropriate.

[14] The English metropolitan county sub-division was created by the Local Government Act, 1972. The administrative area of Greater London is not a Metropolitan county, as it was created earlier (Local Government Act, 1963). For completeness, Edinburgh (ED) and Glasgow (GL) are also indicated in Figure 4.

Table 2: Comparison of Metropolitan Counties and Functional Economic Areas

Metropolitan county	Constituent NUTS 3 Sub-regions	Comparable Functional Economic Area(s)
Greater Manchester (MN)	1.Greater Manchester North 2. Greater Manchester South	• North Manchester, South Manchester, and Cheshire
Merseyside (LV)	1. Liverpool, 2. Sefton, 3. East Merseyside, 4. Wirral	• Liverpool, Sefton, East Merseyside, Wirral, Halton and Warrington
South Yorkshire (SW)	1. Sheffield, 2. Barnsley, Doncaster, Rotherham	• Barnsley Doncaster and Rotherham, Sheffield, East Derbyshire
West Yorkshire (WY)	1. Leeds, 2. Bradford, 3. Wakefield, Calderdale, and Kirklees	• Leeds and Calderdale, Kirklees, and Wakefield • Bradford
Tyne and Wear (TN)	1. Sunderland, 2.Tyneside	• Northumberland and Tyneside • Sunderland
West Midlands (W)	1. Birmingham, 2. Coventry, 3. Wolverhampton, Walsall 4. Dudley, Sandwell, 5. Solihull,	• Birmingham, Solihull, Dudley, Sandwell, Wolverhampton and Walsall • Warwickshire, Coventry
Greater London (LN)	1. Inner London West 2. Inner London East 3. Outer London East and North East 4. Outer London South 5. Outer London West and North West	• Inner London West ,Inner London East Outer London East and North East, Outer London South, Outer London West and North West, Hertfordshire, Buckinghamshire, Surrey

Note: Abbreviations in brackets identify the metropolitan counties in Figure 4.

One curious functional economic area in Table 2 is the city of Bradford. This raises the issue of the plausibility of the smaller functional economic areas visible in Figure 4. An inspection of the supply-side and demand-side self containment criteria derived from commuter flows (equations (6) and (7) above) and the measure of self containment (equation (9)) for the smallest, in geographical terms, of these areas suggests that as Bradford, Swindon, Plymouth, and Swansea do appear to be quite self-contained, though Sunderland and York are more debatable.[15]

[15] The full version of the data given in Table 3 for all 64 functional economic areas constructed in this paper is available from the author on request.

Table 3: Self-Containment of Smallest Functional Economic Areas

Functional Economic Area	Supply–Side Condition (70% Threshold)	Demand–Side Condition (70% Threshold)	Measure of Self-containment (κ=1)
Bradford	0.77	0.79	1.79
Swindon	0.79	0.77	1.74
Plymouth	0.93	0.79	2.96
Swansea	0.84	0.80	2.28
Sunderland	0.73	0.71	1.29
York	0.71	0.72	1.26

In all, the functional economic areas constructed in this paper appear to serve as a useful basis for checking the robustness of regional econometric analysis undertaken in Section 4, based on administrative NUTS 3 level units.

4. Spatial Analysis of β-convergence

The focus now turns to establishing the empirics of regional growth and β-convergence across British sub-regions, in the presence of possible spatial dependence. The first step is to statistically test for the presence of spatial autocorrelation in sub-regional secondary, services and aggregate real GVA *per capita* data. From Figures 1-3 it appears that clear spatial patterns exist in the geographic dispersion of secondary, services and aggregate real GVA *per capita* across British sub-regions. In order to confirm this, the well-known diagnostic for global spatial autocorrelation, Moran's *I* statistic, is utilised. Once the presence of spatial autocorrelation has been established, the issue of convergence across sub-regions is then considered. As outlined in Section 3, the cross-sectional growth equations which test the hypotheses of absolute conditional convergence are easily augmented to incorporate spatial autoregressive (SAR) components and spatial error (SEM) components. What is more, the inclusion of a set of explanatory variables in the conditional convergence growth equation allows one to identify those factors which may explain the trends observed in British sub-regional growth over the period 1995-2004.

4.1. Diagnostic Test for Spatial Autocorrelation

The Moran's *I* statistic for spatial autocorrelation yields a test statistic which can be defined as follows:

(10) $$I_t = \left(\frac{n}{s}\right)\frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\, y_{it}\, y_{jt}}{\sum_{i=1}^{n}\sum_{j=1}^{n} y_{ij}\, y_{jt}}$$

where w_{ij} represents the elements of the spatial weighting matrix W, n and s denote the total number of sub-regions and the summation of w_{ij} respectively. The results of this diagnostic test for spatial autocorrelation on secondary, services and aggregate log real GVA *per capita* for 1995 and 2004, as well as for real GVA *per capita* growth over the period 1995-2004, are reported in Table 4. The test has been carried out using two different types of spatial weighting matrix: i) a binary contiguity matrix, where w_{ij} = 1 if sub-regions are geographically adjacent, and w_{ij} = 0; ii) an inverse distance spatial weighting matrix, where w_{ij} denotes the row standardised reciprocal distance between sub-regions *i* and *j*.

Table 4: Moran's *I* Global Spatial Autocorrelation Statistic

	Secondary		Services		Aggregate	
	Binary *W*	Distance *W*	Binary *W*	Distance *W*	Binary *W*	Distance *W*
Log real GVA *per capita* 1995	0.115**	0.079***	0.200**	0.179***	0.114**	0.102***
Log real GVA *per capita* 2004	0.156**	0.097**	0.238***	0.207***	0.197**	0.176***
GVA *per capita* Growth 1995-2004	0.017	-0.017	0.198***	0.108***	0.123**	0.093***

Note: Significance at ***1%, **5%, and *10% level.

It is clear from Table 4 that secondary, services, and aggregate real GVA *per capita* do indeed exhibit strong spatial autocorrelation across sub-regions in both 1995 and 2004, the start- and end-point of the dataset used in this paper. However, when one considers growth rates over the period 1995-2004, it is just services and aggregate GVA *per capita* growth that exhibit spatial autocorrelation, which suggests that aggregate GVA growth spatial autocorrelation over the period 1995-2004 has been influenced by that of the services sector. These findings appear to be robust to the type of spatial weighting matrix used in the Moran's *I* statistic.

4.2. Absolute β-convergence

Tables 5 and 6 below present spatial autoregressive (SAR) and spatial error and (SEM) cross-sectional regressions of secondary, services, and aggregate GVA *per capita* growth on initial, 1995, log GVA *per capita* ($lnGVA_{1995}$) – as outlined in Section 3. This is the standard test for absolute β-convergence (augmented to capture two distinct types of spatial influence), where a negative significant coefficient on initial log GVA *per capita* indicates convergence and a positive significant coefficient indicates divergence. GVA *per capita* data for 125 of the 128 NUT 3 sub-regions are used in the specifications in Table 5.[16] The results reported in Table 6 relate to the 64 functional economic areas constructed in Section 3.3. For this purpose NUTS 3 level real GVA data has been allocated into functional economic areas and then divided by the relevant population figure. In keeping with the notation of Section 3, ρ and τ represent the spatial autocorrelation coefficient and spatial error coefficient, respectively. The spatial weighting matrix used in throughout this section is the row standardised inverse distance matrix.[17]

[16] In order to ensure consistency with the explanatory variables included in Table 7, the NUTS 3 sub-regions of East and West Cumbria have been amalgamated into one region: Cumbria. Similarly, East Derbyshire and South and West Derbyshire have been combined to form Derbyshire, while North and South Nottinghamshire have been combined to form Nottinghamshire.

[17] The regression specifications of Tables 5 and 6 have also been run using the binary contiguity spatial weighting matrix. The results are qualitatively similar to those reported in Tables 4 and 5 and are available from the author on request. Higher R^2 values and lower log-likelihood values suggest that the specifications using inverse distance spatial weighting matrix are superior to those using the binary contiguity weighting matrix.

Table 5: Absolute Convergence Regressions for British NUTS 3 Sub-regions, 1995-2004

Dependent variable: Average GVA Growth per Capita (1995-2004)						
	Spatial Autoregressive Model (SAR)			**Spatial Error Model (SEM)**		
	Secondary	Services	Aggregate	Secondary	Services	Aggregate
Constant	0.202 (0.037)***	-0.005 (0.027)	-0.035 (0.037)	0.185 (0.035)***	0.013 (0.025)	-0.009 (0.037)
$\ln GVA_{1995}$	-0.022 (0.0.7)***	0.005 (0.003)*	0.006 (0.004)	-0.021 (0.004)***	0.005 (0.03)*	0.006 (0.004)
ρ (SAR)	-0.524 (0.313)*	0.314 (0.253)	0.433 (0.225)*			
τ (SEM)				-0.553 (0.332)*	0.313 (0.257)	0.423 (0.229)*
R^2	0.20	0.05	0.07	0.19	0.05	0.06
Log Likelihood	339.138	399.38	388.02	338.75	399.24	387.64
Number of Obs	125	125	125	125	125	125

Note: Standard errors are given in parenthesis. Significance at ***1%, **5%, and *10% level

Table 6: Absolute Convergence Regressions for Functional Economic Areas, 1995-2004

Dependent variable: Average GVA Growth per Capita (1995-2004)						
	Spatial Autoregressive Model (SAR)			**Spatial Error Model (SEM)**		
	Secondary	Services	Aggregate	Secondary	Services	Aggregate
Constant	0.225 (0.048)***	-0.089 (0.033)***	-0.161 (0.067)**	0.257 (0.047)***	-0.079 (0.034)**	-0.151 (0.068)**
$\ln GVA_{1995}$	-0.026 (0.006)***	0.015 (0.004)***	0.021 (0.007)***	-0.030 (0.006)***	0.015 (0.004)***	0.021 (0.007)***
ρ (SAR)	0.266 (0.217)	0.289 (0.201)	0.268 (0.220)			
τ (SEM)				0.503 (0.182)**	0.339 (0.218)	0.188 (0.244)
R^2	0.24	0.24	0.16	0.29	0.25	0.15
Log Likelihood	194.37	223.88	204.21	195.72	224.12	203.74
Number of Obs	64	64	64	64	64	64

Note: Standard errors are given in parenthesis. Significance at ***1%, **5%, and *10% level

With regard to regional growth convergence, a number of findings emerge from Tables 5 and 6. First, it is clear that there is no absolute convergence in aggregate real GVA *per capita* growth over the period 1995-2004. In fact, the functional economic area SEM and SAR specifications indicate divergence in aggregate real GVA *per capita* growth – a finding supported by Henley (2005) and Monastiriotis (2006). Second, services sector GVA *per capita* growth does not show signs of convergence. As with the aggregate data, it actually appears be experiencing a process of divergence. Finally, secondary sector GVA *per capita* growth exhibits strong convergence across all specifications, with an estimated annual speed of convergence of ranging from 2.3-2.8%. This, as suggested in Section 2, may reflect a process of sub-regional secondary GVA *per capita* being sucked towards the average, due to that sector's near stagnant growth performance over the period 1995-2004. As for the competing spatial specifications, both yield similar findings in terms of R^2 values and log-likelihood values.

4.3. Conditional β-convergence

The cross-sectional specifications used to test for absolute convergence are now augmented with a set of explanatory variables, which may capture differences in the paths of steady-state GVA *per capita*. The explanatory variables introduced to the analysis address a number of key features which have emerged from the literature as being influential in the economic growth process. Foremost among these are initial education levels and human capital formation, which are necessary to raise productivity.[18] Regarding human capital, this paper follows the approach of Henley (2005) which includes two variables, each capturing distinct aspects of the human capital accumulation process: (i) the county average primary school pupil-teacher ratio (*Pupil_Teacher*) and (ii) the average A-level pass rate (*grades*) achieved by pupils in each county. This is this exam which enables pupils to enter university. As 1995 data is unavailable for both of these variables, data dating from 1993 is used instead. As these variables are unavailable at sub-regional level, the data for each county is applied to the sub-region residing in that county. As discussed in Section 2, location and geographic proximity have been identified as key drivers of the British regional growth process – a feature which has been typified by the oft-cited "north-south divide". In order to capture this, a set of dummy variables for the eleven NUTS 1 regions has been constructed. Furthermore, the rural/urban orientation of each sub-region is captured through the inclusion of a variable representing each sub-region's 1995 agricultural real GVA as a proportion of aggregate real GVA *(Agri)*. However, *Agri* is not included in the services GVA specifications as it exhibits strong negative correlation with the dependent variable.[19] Data on the capital stock residing in each sub-region at the start of the period 1995-2004 is unavailable. That said, data on the number of businesses registered for Value Added Tax (VAT) is available and is disaggregated for secondary and services sectors.

A similar approach is taken by Hart and McGuinness (2003), where the stock of enterprises is used as a proxy for capital utilization. These variables are expressed in *per capita* terms with respect to their relevant sub-region and included in the conditional convergence specifications *(No. of Businesses)*. In order to control for capital investment, net capital expenditure as a proportion of aggregate real GVA for each sub-region *(Capital Expenditure)* in 1997, deflated as described in Section 2, is also included in the specifications.[20] A further control variable, females in employment in 1995 expressed as a proportion of people aged 16+ (*Fem Emp'ment*) is included in order capture differences in local labour market conditions (such as the tightness of the labour market) at the beginning of the 1995-2004 period. This is in keeping with Perugini and Signorelli (2004) who also use female employment as a proxy for labour market performance. From a methodological perspective, one weakness of cross-region regressions is that of reverse causality and endogeneity. With the exception of *Capital Expenditure*, all the explanatory variables used in the conditional convergence specifications refer to 1995 or earlier – and are thereby not susceptible to such reverse causality. *Capital*

[18] See Mankiw *et al*. (1992) and Barro and Sala-I-Martin (1995, pp. 420-445) for a detailed discussion of the inclusion of control and environmental variables in conditional convergence regressions.

[19] As *Agri* does not exhibit a strong correlation with Total GVA *per capita* growth, it is included in the Total GVA *per capita* growth regressions.

[20] Capital expenditure data for the 11 NUTS 3 regions of Wales was unavailable for 1997. As a proxy, the capital expenditure per worker figure for the NUTS 1 region, Wales, is weighted by the real GVA of NUTS 3 region.

Expenditure is assumed to be weakly exogenous, and instrumental variable techniques have not been applied to it.

As in Sub-section 4.2, ρ and τ represent the spatial autocorrelation coefficient and spatial error coefficient, respectively, and the spatial weighting matrix used is the binary contiguity matrix. Table 7 reports results for 125 NUTS 3 level sub-regions and Table 8 reports results for the 64 functional economic regions constructed in this paper. The set of NUTS 1 regional dummies are omitted from the specifications in Table 8 as the sub-regions which form functional economic regions do not necessarily all belong to the same NUTS 1 region.

Table 7: Conditional Convergence Regressions for British NUTS 3 Sub-regions, 1995-2004

Dependent variable: Average GVA Growth per Capita (1995-2004)						
	Spatial Autoregressive Model (SAR)			**Spatial Error Model (SEM)**		
	Secondary	Services	Aggregate	Secondary	Services	Aggregate
constant	0.177	-0.009	0.008	0.172	-0.033	0.009
	(0.045)***	(0.035)	(0.042)	(0.040)***	(0.031)	(0.040)
$\ln GVA_{1995}$	-0.029	0.011	0.003	-0.030	0.010	0.002
	(0.005)***	(0.003)***	(0.004)	(0.005)***	(0.003)***	(0.004)
Grades	0.0002	0.0001	0.0001	0.0003	0.0003	0.0001
	(0.001)	(0.0004)	(0.0004)	(0.0006)	(0.0004)	(0.0004)
Pupil_Teacher	0.002	0.0004	0.001	0.001	0.0001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Agri	-0.047	-	-0.00002	-0.046	-	-0.183
	(0.114)	-	(0.00001)***	(0.110)	-	(0.084)**
No. of Businesses	0.286	-0.396	0.015	0.280	-0.334	0.015
	(0.903)	(0.169)**	(0.092)	(0.900)	(0.171)**	0.092
Capital Expenditure	0.179	0.099	0.029	0.178	0.095	0.018
	(0.165)	(0.099)	(0.112)	(0.165)	(0.10)	(0.114)
Female Emp'ment	0.002	0.0002	0.000	0.002	0.0002	0.000
	(0.001)**	(0.0004)	(0.001)	(0.0006)**	(0.0004)	(0.001)
NE	0.001	-0.011	-0.015	0.001	-0.008	-0.014
	(0.008)	(0.005)**	(0.006)***	(0.001)	(0.004)*	(0.005)***
NW	-0.009	-0.004	-0.009	-0.007	-0.002	-0.009
	(0.006)	(0.004)	(0.005)**	(0.006)	(0.004)	(0.004)**
YH	0.003	-0.003	-0.007	0.006	-0.002	-0.006
	(0.007)	(0.004)	(0.005)	(0.006)	(0.004)	(0.004)
EM	0.008	0.005	-0.002	0.012	0.006	-0.001
	(0.007)	(0.004)	(0.005)	(0.007)*	(0.004)	(0.005)
WM	0.001	0.001	-0.008	0.004	0.003	-0.007
	(0.006)	(0.004)	(0.004)*	(0.006)	(0.004)	(0.004)*
EE	-0.0003	0.001	-0.004	0.000	0.0004	-0.003
	(0.006)	(0.004)	(0.006)	(0.006)	(0.004)	(0.004)
L	-0.006	-0.005	-0.004	-0.005	-0.006	-0.003
	(0.008)	(0.006)	(0.006)	(0.009)	(0.008)	(0.006)
SW	0.005	-0.001	-0.003	0.005	-0.001	-0.002
	(0.006)	(0.004)	(0.004)	(0.005)	(0.003)	(0.004)
W	-0.008	-0.0004	-0.013	-0.001	-0.007	-0.012
	(0.007)	(0.004)	(0.005)***	(0.001)	(0.006)	(0.005)***
S	0.004	-0.008	-0.010	0.004	0.0034	-0.009
	(0.007)	(0.004)*	(0.005)*	(0.005)	(0.005)	(0.004)**
ρ (SAR)	-0.585	-0.631	-0.171			
	(0.276)**	(0.297)**	(0.324)			
τ (SEM)				-0.849	-0.734	-0.204
				(0.257)***	(0.295)**	(0.340)
R^2	0.34	0.21	0.20	0.36	0.21	0.20
Log Likelihood	351.48	410.26	398.06	351.96	410.03	397.73
Number of Obs	125	125	125	125	125	125

Note: Standard errors are given in parenthesis. Significance at ***1%, **5%, and *10% level. The NUTS 1 level regional dummy variables included are North East (NE), North West (NW), Yorkshire and the Humber (YH), East Midlands (EM), West Midlands (WM), East England (EE), London (L), South West (SW), Wales (W), and Scotland (S). South East is the base region.

Table 8: Conditional Convergence Regressions for Functional Economic Areas, 1995-2004

Dependent variable: Average GVA Growth per Capita (1995-2004)						
	Spatial Autoregressive Model (SAR)			**Spatial Error Model (SEM)**		
	Secondary	Services	Aggregate	Secondary	Services	Aggregate
constant	0.238	-0.120	-0.168	0.238	-0.114	-0.171
	(0.058)***	(0.038)***	(0.218)**	(0.058)***	(0.038)***	(0.073)**
$\ln GVA_{1995}$	-0.035	0.015	0.022	-0.035	0.016	0.022
	(0.006)***	(0.005)***	(0.008)***	(0.006)***	(0.004)***	(0.008)***
Grades	-0.0005	0.0004	-0.0004	-0.001	0.0001	-0.0004
	(0.0004)	(0.0003)	(0.0003)	(0.0004)	(0.0003)	(0.0003)
Pupil_Teacher	0.001	0.001	0.001	0.001	0.001	0.001
	(0.001)	(0.0006)*	(0.001)	(0.001)	(0.001)	(0.001)
Agri	0.003	-	-0.121	0.001	-	-0.120
	(0.045)	-	(0.033)***	(0.046)	-	(0.033)***
No. of Businesses	-0.578	-0.328	-6.125	-0.464	-0.327	-5.907
	(1.145)	(0.293)	(1.361)***	(1.234)	(0.298)	(1.315)***
Capital Expenditure	0.152	-0.009	-0.127	0.150	0.033	-0.146
	(0.149)	(0.101)	(0.119)	(0.147)	(0.010)	(0.118)
Female Emp'ment	0.002	0.0004	0.001	0.002	0.0004	0.001
	(0.001)***	(0.0005)	(0.0006)**	(0.001)***	(0.0005)	(0.0006)**
ρ (SAR)	0.135	0.234	-0.065			
	(0.223)	(0.217)	(0.218)			
τ (SEM)				0.185	0.298	-0.141
				(0.244)	(0.225)	(0.617)
R^2	0.39	0.31	0.46	0.39	0.31	0.46
Log Likelihood	201.56	226.74	218.31	201.54	226.94	218.38
Number of Obs	64	64	64	64	64	64

Note: Standard errors are given in parenthesis. Significance at ***1%, **5%, and *10% level

Similar to the absolute convergence case, the results reported in Tables 7 and 8 clearly show that there is no evidence of convergence of aggregate real GVA growth *per capita* over the 1995-2004 period. The functional economic area regressions of Table 8 even point to divergence in the aggregate data over this time period – just as they did in the absolute convergence case. In the case of the services sector, across the specifications there appears to be support for the hypothesis that the services sector has also experienced divergence over the 1995-2004 period. A further feature that the conditional convergence results have in common with their absolute counterparts is the clear secondary sector convergence, but this time with the estimated annual speed of convergence residing within a 3.0-4.0% range. In all, these findings along with those of the absolute convergence specifications point to a situation where aggregate real GVA *per capita* growth has been influenced by the conflicting tendencies towards divergence and convergence emanating from the services and secondary sectors, respectively.

The conditional convergence regressions also provide some insights into the factors which have driven these growth trends over the period 1995-2004. Reflecting its lack of convergence in Tables 5-8, aggregate real GVA growth *per capita* appears to have been negatively associated with sub-regions whose GVA contains a relatively large agricultural content (as indicated by the *Agri* variable) and peripheral location (such as the North East, North West, Wales, and Scotland). The functional economic area regressions of Table 8 also suggests that sub-regions with a higher proportion of female employment enjoyed aggregate GVA growth – indicative of GVA *per capita* growth becoming increasingly concentrated in those functional economic areas with tighter labour markets. The negative significant coefficient on the number of VAT-registered businesses in Table 8 may reflect the substantial contribution of a relatively small number of large firms to functional economic area GVA *per capita* growth. The spatial autocorrelation coefficient does not appear to be significant for aggregate GVA growth within the functional economic zone – an indication, perhaps, that these areas are indeed relatively self-contained.

The explanatory variables in the services sector regressions also reflect the divergence trends evident in Tables 7 and 8. The Scotland and North East NUTS 1 region dummies turn out to be significant, displaying a negative relationship with services GVA growth. In the NUTS 3 level regression of Table 7, the spatial autocorrelation coefficient spatial error terms are both negatively significant, suggesting that bordering a NUTS 3 sub-region which enjoys strong services GVA growth does not enhance one's own prospects of services sector growth. In the secondary sector, the significant positive *Fem Emp'ment* coefficient indicates that the local labour market conditions prevailing in 1995 clearly influenced growth prospects over the period 1995-2004, both at the sub-regional and functional economic level.

5. Conclusions

The objective of this paper is to look beneath the surface of the British sub-regional aggregate GVA growth process experienced over the period 1995-2004, by examining to what extent this process may have been driven by the differing growth dynamics of the secondary (defined in Section 2 as "industry, including energy and construction") and services sectors. A clear pattern in the spatial dispersion of these sectors is apparent from the colour-coded maps of secondary, services, and aggregate real GVA *per capita* across Britain over the period 1995-2004: the secondary sector resides predominantly in the north, while the services sector is very much concentrated in the south –the "north-south divide". A statistical test for spatial autocorrelation (Moran's *I*) across the British NUTS 3 sub-regions confirms this spatial dependence. What is more, the trends observed in aggregate real GVA *per capita* appears to be influenced to a greater extent by the services sector than by the secondary sector.

The spatial econometric analysis undertaken in this paper serves a number of purposes: it allows one to (i) test for aggregate real GVA *per capita* convergence, as well as services and secondary convergence; (ii) characterise spatial influence as a "spatial lag" directly effecting neighbouring regions (SAR) or as an indirect, random spillover effect between regions (SEM); (iii) check the robustness of finding emanating from administrative NUTS 3 level data and with those arising from the use of functional economic areas; (iv) control for the impact of commuter flows, as the functional economic areas are constructed using commuter flow data; (v) test for the robustness of results to different types of spatial weighting matrices; and (vi) incorporate a set of explanatory variables into the analysis which shed light on influential factors in the sub-regional growth process.

The key findings of this paper are robust to the specification of spatial component, the choice of weight matrix, and the delineation of British sub-regions. Aggregate real GVA *per capita* growth over the 1995-2004 period exhibits no signs of convergence, either absolute or conditional. The services sector also exhibits no signs of either absolute or conditional convergence. Secondary sector real GVA *per capita* growth shows clear signs of both absolute and conditional convergence, with an estimated annual convergence rate of approximately 2-3% depending on the choice of specification. Regarding the services sectors, there is strong evidence across the various specifications that these sectors have actually experienced a process of divergence over the period 1995-2004, both in absolute and conditional terms. It is also clear across the specifications that the inclusion of a spatial term is justified and adds to the explanatory powers of those specifications. Furthermore, the insignificance of the spatial autocorrelation coefficient in the functional area specifications suggests that these constructed areas do serve their purpose of approximating self-contained economic areas.

The explanatory variables included in the tests for conditional convergence illustrate the differing forces at play in the various sectoral growth processes. The aggregate GVA *per capita* growth of sub-regions appears to be influenced negatively by high agricultural GVA content and peripheral location. The functional economic area approach adds to this in indicating the positive influence of a high proportion of female employment (used here to capture tight local labour markets), suggesting perhaps a demand-driven move by firms towards higher density market centres, and the negative influence of the presence of a large number of VAT-registered businesses (reflecting high levels of capital utilization). The secondary sector developments over the period 1995-2004 have been shown to consist largely of stagnation and the shrinkage of GVA *per capita* to its mean value. That said, one influential factor appears to be the labour market conditions prevailing at the beginning of the time period, as indicated the labour market proxy, *Fem Emp'ment*. The services sector developments over the 1995-2004 period reflects factors that are in keeping with its lack of convergence: the negative influence of peripheral regions, as illustrated by the Scotland and North East dummies, can be seen as signs of a services industry which is slow to move beyond its urban, predominantly southern, stronghold. That said, any such inferences should come with a caveat attached, as the services industry is known to be more heterogeneous in its composition than the secondary industry.

In all, it would appear that analysing aggregate GVA data alone is insufficient to identify the underlying trends in British sub-regional growth. Incorporating a sectoral breakdown of British GVA growth and characterising accurately its spatial dimension however offers the potential for richer insights into this growth process.

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Appendix 1 British Functional Economic Areas (64)

Hartlepool, Stockton-on-Tees, and South Teeside
Darlington and Durham
Northumberland and Tyneside
Sunderland
West Cumbria
East Cumbria
North and South Manchester, and Cheshire
Lancashire, Blackburn, and Blackpool
Greater Liverpool and Halton and Warrington
Kingston upon Hull and East Riding of Yorkshire
North and North East Lincolnshire
York
North Yorkshire CC
Barnsley Doncaster and Rotherham, Sheffield, East Derbyshire
Bradford
Leeds and Calderdale, Kirklees, and Wakefield
Derby, South West Derbyshire
Nottingham, NS Nottinghamshire
Leicester and Leicestershire
Northamptonshire
Lincolnshire
Herefordshire
Worcestershire
Shropshire CC, Telford and Wrekin
Staffordshire and Stoke
Warwickshire, Coventry
Birmingham, Solihull, Dudley, Sandwell, Wolverhampton and Walsall
Peterborough and Cambridgeshire
Norfolk and Suffolk
Bedfordshire and Luton
Essex, Thurrock, Southend
Greater London, Hertfordshire, Buckinghamshire, Surrey
Berkshire
Milton Keynes
Oxfordshire
East Sussex CC
West Sussex, Brighton and Hove
Hampshire, Portsmouth, Southampton, Isle of Wight
Kent and Medway
North East Somerset, S Gloucestershire, Bristol
Gloucestershire
Swindon
Wiltshire CC
Dorset, Bournemouth and Poole
Somerset
Cornwall and Isles of Scilly
Plymouth
Devon and Torbay
Isle of Angelsey, Gwynedd
South West Wales

Central Valleys
Gwent, Monmouthshire, Newport
Bridgend and Neath Port Talbot
Swansea
Cardiff and Vale of Glamorgan
Conwy, Denbighshire, Flintshire, Wrexham
Powys
Aberdeen, Aberdeenshire, and Angus
Clackmannanshire and Fife
Edinburgh, West Lothian, and Scottish Borders
Falkirk, Perth, Kinross, and Sterling
Dumfries and Galloway
Glasgow, East and West Dunbartonshire, Inverclyde, East Renfrewshire and Renfrew, North and South Lanarkshire
Highlands and Islands

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