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The UK *Intra*national Trade Cycle

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***Abstract*:** The paper uses annual data on real GDP for the UK regions and 12 manufacturing sectors to derive regional and regional/sectoral business cycles using an H-P filter. The cohesion of the cycles is examined via cross-correlations and comparisons made with the regional cycles for Japan, the United States and the EuroArea. The UK emerges as especially cohesive and efforts to explain the overall cross-correlations of regional GDP not very successful owing to the low variance of the explicand; when attention is turned to the sectoral/regional cycles, with their greater variance it is possible to demonstrate that economic variables such as distance, dissimilarity in structure and level of output play a significant role in explaining the variance in the cross-correlations. A significant feature of the cross-correlations in relation to those of EU countries is that whilst they continue to provide support for the "UK idiosyncrasy" they no longer do so as strongly as they did in earlier data samples.

Keywords: intranational business cycle; regional business cycles; income convergence; Hodrick-Prescott filter; Euro-sympathy

JEL: E32; E41; R11

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1. Introduction

This paper analyzes the business cycles that can be identified for the regions of the UK – the *intra*national business cycle of the UK, in short. An analysis of this type can benefit from the huge attention paid in recent years to the international business cycle in terms of the methodologies that can be used and some of the questions that can be examined. In particular in this paper we use the Hodrick-Prescott filtering techniques popularized in the RBC literature to identify the trend and make heavy use of the cross-correlations between the resultant series of cyclical deviates as measures of business cycle synchronicity. Explaining these, as in many of the studies stimulated by the real business cycle literature and the optimal currency area literature which use international data, is a particular aim of the paper.

Precursor studies of the *intra*national business cycle are relatively few: notable ones for the United States include papers by Wynne and Koo (2000); Hess and Shin (1997 and 2001), and most recently HM Treasury (2003). For Japan there is a paper by the present authors (Artis and Okubo, 2008) and for the UK a study by Barrios, *et al.* (2003). In most of these cases an optimal currency area (OCA) concern can be seen as a driver of the study, the United States sometimes being presented as a feasible if not formally "optimal" currency area and the coherence of its regional business cycles as some kind of benchmark for monetary union. We compare the convergence of UK regional business cycles with those in Japan, the United States and the EuroArea, finding it to be particularly high compared to what can be found for the last two of these entities. Current concerns about the optimality, for Scotland, of belonging to the UK currency area do not find any resonance in the cross correlation evidence presented here. There are other reasons for being concerned with regional business cycles, though. One of these is the issue of how far the regions demonstrate specialization or localization, and how spillovers distribute through time the effect of shocks attracted from one specific region to another. Because the data we have at our disposal are annual in frequency we cannot usefully date the cycles we detect nor explore in requisite detail the effect of monetary policy or external shocks upon the regions. However, the data come with an industrial breakdown and we are able to use sectorally disaggregated series; moreover we can examine in some detail the convergence of regional output trends and the (non-) convergence of per capita incomes across the regions.

The data we use for the greater part of this study are the annual series of real gross value added (GVA) (at 2002 prices) for NUTS1 regions that are provided by Cambridge Econometrics; here we use a sample that ranges from 1970 to 2004. This is a different data set than the one that was constructed for use in their own study of the UK's regional cycles by Barrios et al. (2003) – which spanned the period from 1966 to 1997. Barrios et al deploy a data set in which deflation of regional current price GDP to obtain a real GDP series is accomplished by using an estimated regional retail price index. Our data set is available for the 12 NUTS1 regions and has the advantage of coming with considerable industrial sector detail (12 manufacturing industrial sectors are distinguished for example). The original data for regional GVA come from the Office of National Statistics (ONS) in current price form; constant price GVA series for the regions are constructed by Cambridge Econometrics from the deflated national industrial sector series aggregated as appropriate for each region. **Table 1** identifies the regions and sectors by number, which will be a useful reference for what follows.

<< Table 1 >>

In the next section of the paper we explain how we identify the business cycle in the regions; we then move on to derive the regional business cycle cross-correlations that characterize the UK *intranational* cycle, making comparisons with cross-correlation evidence drawn from other countries and groupings (the United States, Japan and the EuroArea).

Subsequently we come to an econometric estimation of the variance in regional business cycle synchronization between regions and over time, using a GMM panel data estimation framework. In principle we should expect that the degree of business cycle synchronization would depend to some extent on (evolving) differences in industrial structure between the regions and as a preliminary to the estimation we devote a short section of the paper to a discussion of this issue. It is apparent that the sectoral developments are a lot less smooth than the evolution of GVA as a whole and we take advantage of the added variance in regional-sectoral GVA to revisit the explanation of the cross-correlations with more variance to bite on and more opportunity for revealing explanations to be identified In the remaining sections of the paper we revert to the cross-correlation evidence presented at the outset and extended to incorporate cross-correlations with EuroArea countries. This is done to confirm (or otherwise) the findings of Forni and Reichlin (2001), confirmed by Barrios, *et al.* (2003) on the "UK idiosyncrasy" – broadly, the finding that the UK economy possesses a high degree of internal cohesion with none of its regions displaying an outstanding affiliation with the business cycle of any EU country. Current discussion of further devolution for Scotland points up a particular dimension of this question. There are two appendices: the first of these discusses data and related issues whilst the other takes up the issue of per capita income convergence across the UK regions.

2. Identifying the Cycle.

Traditional business cycle analysis recognizes two types of cycle. There is the "classical" cycle, which can be recognized from the fact that it involves an *absolute* decline in economic activity from the peak and an *absolute* rise in activity from the trough. The NBER for the US and the CEPR for the EuroArea provide chronologies of such cycles. Clearly such cycles do not exist in growth economies and they are relatively rare for European economies and for Japan. The other type of cycle is a deviation or growth (occasionally growth *rate*) cycle where the underlying idea is that the business cycle can be identified as a cycle relative to a trend. Thus some kind of filter is required to provide a measure of the trend, and the cycle is identified as the deviation from this trend. In our case, where the original data are annual, there is a reasonable presumption that the high-frequency noise (seasonal and the like) is already filtered out by the annualization of the data. On this basis we use a Hodrick-Prescott filter with a lambda value (dampening factor) set at 6.25, following the suggestion of Ravn and Uhlig (2002): this corresponds to a maximum periodicity of the cycle of 10 years just as the popular lambda value of 1600 does for data at a quarterly frequency.[1] The filter has been

[1] There remains a degree of controversy about the procedure, as exemplified most recently in the paper by Meyers and Winker (2005), following earlier papers by Harvey and Jaeger (1993), Burnside (1998) and Canova

applied to the log of the GVA series for each region and subsequently for each industrial sector.

<<Figure 1>>

Figure 1 shows the business cycles for the individual regions identified by the numbers shown in **Table 1**. Because the data we are using are annual, dating the cycle is not undertaken here: a higher frequency series of economic activity is necessary for such an endeavour. The Economic Cycle Research Institute (ECRI) reckons to give a monthly dating of the growth rate cycle based on their coincident index. The turning points they give (which are largely similar to those identified by Artis (2002) on monthly GDP data using a non-parametric dating algorithm) are consistent with the peaks and trough apparent in Figure 1 given that the regions move fairly closely together. Indeed, the Figure gives the strong impression that the cycles are quite closely synchronized in general with only a few singular features: the cycle in the South West has a strikingly higher amplitude in the early years than do other regions' cycles; there is generally less synchronization in the first half of the sample; the second half of the period shows signs of "the great moderation" – since 1994 there has been much less volatility and synchronization appears more marked (our data series do not include 2008).

The second part of the figure shows the cycle identified on data for manufacturing industry, traditionally regarded as the more cyclical and volatile component of total output: this apprehension is borne out in the tabulation of standard deviations accompanying the Figure: the values for manufacturing industry are in the order of twice as much as those for overall GVA. The bilateral cross-correlations measured over the period as a whole between the regions' cycles and (in the bottom row) between those for each region and the national cycle are shown in **Table 2**.

<<Table 2>>

(1998) among others. However, an effective counter-criticism can be found in Kaiser and Maravall (2001, 2002).

<<Figure 2>>

There are no negative cross-correlations to be observed and very few that fall below 0.5; the main exception to this picture is for region 12 (i.e. Northern Ireland) which has the lowest correlation with the nation as a whole and quite a number of low correlations with other individual regions. The data are conveyed in the form of a histogram in **Figure 2**.

<<Figure 3>>

Figure 3 provides a plot of the 5-year moving averages of the variance and the unweighted mean of the bilateral regional cyclical cross-correlations of overall GVA over our sample period. A definition of a coherent *intra*national cycle would have a low variance and a high mean as components. As can be seen these are characteristic, most of the time, of the UK. How does the UK experience compare with the cross-correlations that can be observed for the regional cycles within other countries? Although the comparison depends in detail on the period concerned – and should also depend in principle on the relative size and sovereignty of the regions in the comparison[2] - the picture conveyed in **Figures 4-6** deserves comment. **Figure 4** shows the histogram for Japan computed for four separate sub-periods whilst **Figure 5** shows comparable information for the states of the United States in two separate periods (1990-1997 and 1997-2005). Finally, **Figure 6** shows the histogram of cross-correlations between EuroArea member countries over the period from 1975 to 1995.[3]

<<Figure 4>>

[2] Smaller-sized regions seem likely to show more specialization, hence lower cross-correlations than larger sized regions. On this basis the Japanese prefectures (of which there are 46 excluding Okinawa) might be expected to show the lowest cross-correlations *ceteris paribus* and those for the Euro-Area among the highest. Sovereignty may work towards less specialization as nations prefer a degree of all-round self-sufficiency.

[3] The countries concerned are those that made up the "Euro-12" after the accession of Greece to the monetary union and before that of Slovenia. The bulk of the data used here of course predates the operation of the monetary union itself.

<<Figure 5>>

<<Figure 6>>

The histogram of the bilateral cross-correlation coefficients for the EuroArea shows a concentration in the positive area, a little below the values where the values concentrate in the case of the UK (in the range 0.4 to 0.8 rather than 0.6 to 0.9), with a couple of negative values and a scattering of low values. The histogram for the United States has the bulk of its observations in the positive area, but there are many negative values to be found and – especially in the second period – the histogram shows less of a tendency to peak at very high values than does that for the UK. The Japanese experience, finally, offers for all periods the bulk of observations in a strongly positive area, with negative observations growing fewer through the periods shown and a strengthening tendency to demonstrate a concentration at the highest values. Of all these results the cohesion of the UK and (especially in later periods) the Japanese regions stands out in some contrast to the experience reported for the United States. That the latter should be exemplified as an "optimal" currency area is not something that these observations alone could support (the extent of labor mobility, the federal income tax and expenditure system and the degree of financial integration may be the more important features).

3. Industrial Trends

A significant ingredient in the cyclical experience of a region will depend from its industrial structure and changes in that structure may significantly alter the overall cyclical experience of a region and its relationship to the cycle in other regions. As in other countries there have been, in the UK, some very large changes in industrial structure in the past 25 or so years. A traditional signifier of this is the ratio of the manufacturing sector to the total economy – data for this are shown in **Figure 7**. There are some exceptions to the almost monotonic decline in the ratio shared by all the regions – with a prolonged revival in Wales for example and more resistance to decline in Northern Ireland. Some of the fluctuations are due to changes in trend and some to cyclical variation around that trend.

<<Figure 7>>

Figures 8-1 and **8-2** deploy data derived from the H-P filtering and show changes in the overall trends - notably these changes are relatively smooth for total GVA with relatively little movement between the regions whereas for individual sectors (four are chosen for illustration), some quite large movements and changes in relative position as between the regions are noticeable. This is consistent with our econometric findings, below, that reflect a relative success in explaining the high variance of the sector-regional cyclical cross-correlations compared with a disappointing inability to provide an interesting account of the overall GVA cross-correlations. It is to some econometric work that we now proceed.

<<Figure 8-1>>

<<Figure 8-2>>

4. Estimation

4.1. Estimation Strategy

In this section we address the issue of explaining the variance in the cross correlation coefficients over time and by region. A panel data estimation framework appears the most appropriate, with GMM estimation in view of the likely endogeneity of the variables deployed.[4] Because the set of bilateral cross-correlations is bounded by -1 to +1, Fisher's z-transform of the left hand side (LHS) variable is used: otherwise we would have to deal with limited dependent variable estimation as well. To anticipate our strategy, it is first to concentrate on overall measures of GVA and their cross correlation between pairs of regions; and, subsequently, to expand the set of observations and their variance by defining cycles in the same way as before, but for industrial sectors in the regions. Then the cross-correlations are defined for sector *k* in each pair of regions *i* and *j*. Then, suppressing time subscripts for convenience the general form of the estimation is as follows:

$$\frac{1}{2}\log\left(\frac{1+\rho_{ijk}}{1-\rho_{ijk}}\right)=\beta_t\left[X_{ijk}\ldots\right]+Dk+D_i+D_j+\varepsilon_{ijk} \qquad \textbf{(1)}$$

where the ρ_{ijk} are the cross-correlation coefficients between all pairs of regions *i, j*, for sector *k*, $Xijk$ are a set of explanatory variables, whilst the *D* represent region and sector fixed effect dummies. At first pass, we estimate this equation without reference to sector, so dropping the subscript *k* and the corresponding fixed effect dummies; then at a second stage we define the cross correlations for sector GVAs and the sector dummies become relevant. The selection of variables in the explanatory set *X* is relatively sparse compared with the long lists that appear in comparable exercises designed to explain the variance in international bilateral business cycle cross-correlations. This is for two reasons: first, the availability of data is less – in particular, data on trade between regions are not available; secondly, variables that register differences between nations in labor and product markets, fiscal systems and financial structure are not appropriate in interregional comparisons where all regions share the same fiscal systems and financial structure and participate in unified, national labor and product markets. The basic motivating ideas we can use are two-fold: first, although explicit trade data are not available the ideas behind the gravity model of trade appear relevant in this setting. This means that we can use variables that measure "mass" and geographical distance. In this case "mass" is represented as the sum of GVA in each of the two regions in the pair. Distance is measured in two alternative ways – either as physical distance between the principal cities or towns in each pair of regions or as the time taken to travel (by road transport) between these cities. That the one is not a simple transform of the other is due to

[4] Our estimations use two or three subsample periods (1971-1987 and 1988-2004 for two subsample case and 1971-1981, 1982-1992 and 1993-2004 for three subsample case). In our GMM estimations, independent variables before one period are used as instruments.

the presence of physical barriers between regions in some cases, notably where Northern Ireland is involved. The distance measures are supplemented by a contiguity dummy for shared borders. The second idea we use is based on the notion of a business cycle as the product of a shock and a propagation mechanism; differences in industrial structure between regions stand for a different vulnerability to shocks, so that a variable measuring dissimilarity of industrial structure should help to explain differences in the cross-correlations of the business cycle deviates for those regions. In fact, we employ two such measures, one which defines the difference in a region's industrial structure with respect to the national average, which we term *DISSIM* (and where in estimation we employ the difference between the values of this measure between each of the two regions in every pair), the other which, following Krugman (1991) measures directly the difference in industrial structure between each pair of regions, which we term *SPECIALIZATION*. The appendix gives more detail on the explanatory variables we use. Time is divided into two or three subsamples – 1971-1987 and 1988-2004 in the first case and 1971-1981, 1982-1992 and 1993-2004 in the second, all variables as appropriate being averaged over those periods. As the GMM estimation requires instruments it is convenient to nominate the values of the variables in the previous period as the instrument for the current one. Evidently this reduces the number of periods being examined from two and three to one and two.

4.2. Estimation Results

Before showing estimation results, we need to check the presence of spatial autocorrelation because our data are regional level and regions are spatially linked each other. Classical statistical inference would be invalidated in the presence of substantial spatial autocorrelation. We test for this by calculating Moran's *I* statistic. The values of Moran's *I* are low and insignificant in our case so that we can proceed with the estimation in the normal way. We present some of the calculations with an illustrative diagram in the first appendix to this paper (**Figure A-1** in Appendix A).

Table 3 shows a set of results for overall GVA; it is evident that it is not just the significance of the region dummies that is responsible for the poverty of significant estimates on the explanatory variables for these are insignificant even when the region dummies are suppressed (as in the top half of the table). With only regional fixed effects significant none of the variables suggested by economic theory has anything to contribute.[5] Much the same result was evident in Barrios et al. (2003). More interesting results were retrieved, in their case, by extending the sample to include correlations with a number of European countries. Both specialization and dissimilarity index are not significant at all. While overall GVA are closely correlated (**Figure 2**), cross-correlations of sectoral GVA are quite different across sectors (see Appendix C and **Figure C**). Overall GVA seems to absorb heterogeneous sectoral fluctuations as well as different location patterns across sectors, which results in poor estimation outcomes. We can say that overall GVA cannot capture heterogeneous sectoral behaviors. Thus we now turn to estimations using sector-GVA correlations.

<<Table 3>>

In our case, we find that extending the sample to examine sector-GVA cycles in the regions not only adds more observations, but increases the variance to be explained, whereupon the explanatory variables suggested by economic theory become significant (with the expected sign) in every case – even while fixed effects for both regions and industrial sectors are also highly significant. **Tables 4-7** show these results; it is also observable that when different time subsamples are used the coefficient estimates are not greatly disturbed. The extension of the analysis to examine sector-GVA cycles by region is in this sense highly successful.

<<Table 4>>

<<Table 5>>

<<Table 6>>

[5] We also tried estimations using 3-subsample period data. However, results cannot be improved at all. The paper omits the report of the results in 3-subsample overall-GVA case.

<<Table 7>>

By decomposing aggregate level analysis to sectoral level, our sector-GVA estimations can capture heterogeneous sector-GVA movements and geographical location patterns and can definitely improve estimation results: significantly positive average sector-GVA and significantly negative geographical distance and dissimilarity index. Sector-GVA cross-correlations are higher as two regions are closer in geographical distance and similar in industrial structure. By contrast to the overall-GVA results shown in Table 2 and evidences shown in previous studies (e.g. Barrios, et al. 2003), we have all significant and reasonable results.

4.3 The OCA criterion recalled

At this point we turn to a further consideration of the way in which the data we have collected reflect on the UK's suitability to join the Eurozone – and the possible suitability of a further devolved Scotland as a Euro-member. As we noted earlier in the paper cyclical cross-correlation evidence has been extensively used in the empirical counterpart of the optimal currency area discussion. In the case of the UK, the "five tests" promoted by the UK government as economic criteria which should be satisfied before the government could make a case, to be tested by referendum, for the UK to join the Eurozone, included an argument that could be translated as a requirement that the correlation of business cycles in the UK and the EuroArea should be highly correlated. In fact, HM Treasury (2003) includes an extensive consideration of this issue - with a negative flavour, "the UK business cycle idiosyncrasy" being at the time a well-recognized phenomenon. The idiosyncrasy embraces two aspects – first that the UK cycle as a whole is not in tune with the cycle that dominates in continental Europe and, second, that there is no region of the UK that is closely associated with that cycle. Barrios, *et al.* (2003) noted both these aspects of the UK case. They support the finding of Forni and Reichlin (1998) that the UK and Greece were the only two European countries not to contain at least one region that was prominently tied to the

European cycle. Today, in the light of the possibility of Scottish devolution paving the way for that country to secede from the sterling area and to join the EuroArea, the UK idiosyncrasy takes on an additional flavour. Our findings in fact suggest that with the passage of time the extent of the UK idiosyncrasy has diminished without having disappeared. **Figure 9** shows the histograms of the UK regional cross-correlations alongside those for the EuroArea countries and for the joint distribution of the two. Evidently, the UK histogram is tighter than either of the others and has a higher average; when the UK and the EuroArea are mixed the result is to reduce the average for the EuroArea.

<<Figure 9>>

However, when the data are interrogated on the question of possible regional affiliations with EuroArea countries – as in **Figure 10** – it emerges that many UK regions enjoy quite high cyclical correlations with individual EuroArea countries, with the prominent exception of Germany. It is not the case, though, that Scotland's affiliation is more notable than others'; if anything it is London and the South East which exhibit the highest cross-correlations.

<<Figure 10>>

5. Conclusions

The UK *intra*national cycle is a highly cohesive one, when judged by the size of the cross-correlations between its regional cycles and in comparison with similar evidence for the US and the EuroArea; Japan is a similarly cohesive economy when evaluated in the same way. Explaining the cross-correlations between the regions yields few results of interest, perhaps because the variance of the explicand is in fact quite small. The basic GVA data set does however contain considerable sectoral detail and, when attention is turned to explaining the sectoral/regional cycles, results can be obtained which are of greater economic interest.

GMM estimation discloses that variables measuring distance, GVA size and indicators of structural difference are significant in explaining the pattern of cross-correlations. The UK business cycle idiosyncrasy, whereby the UK cycle is found to stand apart from the continental European one and no individual regions are affiliated to continental European state cycles is confirmed on this data set, yet in weakened form. Whilst the UK regional cycles *en bloc* are not strongly affiliated to the cycles that can be measured for the EuroArea economies, most regions are quite well connected to most continental economies (with the principal exception of Germany). Current interest in Scottish devolution cannot be rationalized in a finding that the Scottish cycle is more closely synchronized than are other UK regions to EuroArea countries' cycles as there is in fact rather little difference between them - London and the South East might appear to be a better candidate.

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Data Appendix: Data sources and definitions

1. GDP and GVA data sets

GVA: GVA data are taken from Cambridge Econometrics (Regional Economic Prospects, February 2006). The data are all real GVA (£mn 2002 prices) from 1971 to 2004 for 12 UK regions. We use the data for total GVA, main sector GVA, total manufacturing GVA and 14 manufacturing sectoral GVAs.
The main sectors are agriculture, coal, "oil and natural gas, etc", other mining, "electricity, gas, water", construction, distribution, retailing, "hotel and catering", "transport and communications", "banking and finance", insurance, other business services, "public administration and defence", "education and health", "manufacturing" "other services".
In our estimations for manufacturing sectors, we single out 12 manufacturing sectors (as seen in **Table 1**) from 14: "motor vehicles", "textiles, clothing and leather", "food, drink and tobacco", "rubber and plastic products", "printing and publishing", "other transport equipment", "chemicals and man-made fibers", "electronics, electrical, inst.eng", "non-metallic mineral products", "basic metals and metal products", "mechanical engineering" and "wood and paper". We dropped two minor sectors: "manufacturing fuels" and "other manufacturing".

Our (NUTS 1) 12 regions are composed of London, South East, East of England, South West, West Midlands, East Midlands, Yorkshire and Humberside, North West, North East, Wales, Scotland and Northern Ireland (See **Table 1**).

The GDP data set for 17 European countries and the United States is taken from World Development Indicator (Edition September 2006) (World Bank). GDP is constant 2000 US dollars. The US GSP (gross state product) data sets for the cross-autocorrelations shown in **Figure 6** are taken from the Bureau of Economic Analysis, US Department of Commerce. The unit of real GSP is millions of chained 2000 dollars. Japanese prefectural GDP data (real) used in **Figure 4** are taken from Fukao and Yue's "Japanese prefecture data base"(Hitotsubashi University, Tokyo, Japan) (http://www.ier.hit-u.ac.jp/~fukao/japanese/data/index.html).

2. Estimation variables

We estimate the gravity augmented equation using sectoral data sets.
We use GMM and 2SLS estimations to resolve endogeneity problems. The sample is split into two and subsequently three sub-sample periods, i.e. from 1971 to 1987 and from 1988 to 2004 and then 1971-1981, 1982-1992, and 1993-2004.

Dependent variable

The paper focuses on the cyclical deviates of HP-filtered GVA, where the dampening parameter (λ) is set at 6.25. After computing cross- correlation, we apply the Fisher *z* transformation. The transformation is aimed at expanding the limited variation (from -1 to 1) in the cross correlation measure. Fisher's *z* transformation is a one-by-one mapping utilising a uniformly increasing monotone function *f*, defined as $f = 0.5\ln\left(\frac{1+\rho}{1-\rho}\right)$ for -1< ρ <+1.

***Independent variables*:**

GVA: The product of GVA average of two regions. GVA average is taken for each region in each sector in each period. The variable is expressed in logarithmic form.

DISSIM: This stands for a dissimilarity index computed from all sector information for the regions. The dissimilarity index in region *A* is defined as

$Dissim_A = \sum_j \left(\frac{GVA_{jA}}{\sum_i GVA_{ji}} - \frac{\sum_j GVA_{jA}}{\sum_i \sum_j GVA_{ji}} \right)^2$ where *i* denotes region and *j* denotes the sectors (all 14 manufacturing sectors plus agriculture, mining and services). Then, ***DISSIMMAN*** is derived as $DISSIMMAN = Dissim_A + Dissim_B$. The ***DISSIM*** index is the summation of the squared differences between the shares of industries in a region and the average across regions. This measures how different the distribution of industries in the region is from the average. It can be termed a concentration index.

DISSIMMAN**:** Using the definition of ***DISSIM***, this index is calculated for just the 14 manufacturing sectors.

SPECIALISATION: This stands for the value of an index of specialisation between two regions. We use the Krugman (1991)specialisation index:

$$SPECIALISATION_{AB} = \sum_i \left| \frac{GVA_{Aj}}{\sum_j GVA_{ij}} - \frac{GVA_{Bj}}{\sum_j GVA_{ij}} \right|$$

This sums the absolute difference of the industrial structures of the two regions and can be thought of as a measure of specialisation between regions.

SPECIALISATIONMAN**:** Using the definition of ***SPECIALISATION,*** this index is calculated for just the 14 manufacturing sectors.

DIST**:** driving distance between principal cities of two regions, expressed as log km.

Driving: driving time between principal cities of two regions measured in (log) minutes. (In the case of Northern Ireland, a ferry is taken).

Distance and driving time in our estimations are calculated by programs of "Multi-map", "motoring" "get direction" --"driving" and "quickest" for UK regions
http://www.multimap.com/motoring/?t=r&map=54.06188,-0.20642|6|4
Northern Ireland distance and time is calculated by "AA.com" route planner
http://www.theaa.com/travelwatch/planner_main.jsp?database=B

Neighbor: the dummy for contiguity

Sector 1-12: Our estimation uses 12 sectors out of 14 manufacturing sectors. These are sectoral dummies (12 sectors). See the code numbers of the 12 sectors in **Table 1**.

Region 1-12**:** These are regional dummies (12 regions). See the code numbers of the 12 regions in **Table 1**.

Appendix A: Moran's I (Spatial Autocorrelation)

These statistics are aimed at studying (global) spatial autocorrelation in terms of GVAs across regions. **Figure A-1** shows the value of Moran's *I* calculated over the (log of) first differences in GVA in the 12 regions. I-statistics are bounded in value between -1 and +1. We used geographical distance as a weight matrix, W. The formula for Moran's I is given as

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(X_i - \overline{X})(X_j - \overline{X})}{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij} \frac{1}{n}\sum_{i=1}^{n}(X_i - \overline{X})^2}$$

where *Xi* (*Xj*) is GVA in region *i* (*j*), $\overline{X}$ is average GVA across regions. Values for the *I*-statistics value closer to 1 indicate clustered (spatially concentrated) data points with similar characteristics, whilst the values close to -1 imply gathering data points with totally different characteristics. When the value is zero, it is randomly distributed in space: there is no spatial pattern in the distribution of characteristics.

<<Figure A-1>>

Appendix B: Testing for Convergence

In this appendix we explore the evidence for convergence of income levels across the regions of the UK. To do so, we invoke the test procedures suggested by Bernard and Durlauf (1995) which draw on the concept of cointegration and unit-root testing. Our tests will be for pairwise cointegration: we do not attempt to draw on the recent literature which tries to address the question of convergence within a whole panel (e.g. Pedroni and Yao, 2006). It is doubtful whether such an extension could add anything in our context.

It makes little sense to direct the unit root tests to regional aggregates as such. From a welfare point of view it is only *per capita* measures that are meaningful as the object of examination. This obliges us to draw upon a data set for an earlier period than the one used in the main body of the paper (in fact, the one used in Barrios *et al*., 2003) because consistent population estimates are not available for us to use for our preferred data set.[6] Instead, the data used here, besides referring to an earlier period (1971-1991) also involve a slightly different set of defined regions.

Our convergence tests correspond to those that have become known in the literature as β- and σ- convergence. The former refers to the idea that poorer regions need to grow faster than richer ones if per capita income levels are to be equalized. Hence we can examine whether the growth gap has a unit root or not. If it does, then the presumption is that convergence of *levels* is not occurring – whilst the growth gap remains the same the levels (in logs) gap remains the same. (But note that rejection of the unit root is a necessary but not sufficient condition for equalization – it could be compatible with the existence of *increasing* divergence). Alternatively we can apply the tests directly to the levels (in logs) gap. Here the finding that the unit root cannot be rejected is a finding that convergence is unlikely to be happening. In either case we can apply the augmented Dickey-Fuller (ADF) test. It is well-known that this test has weak power against the alternative (i.e. against the null of cointegration) so that the results may be somewhat indecisive. The results are reported in **Tables B-1** and **B-2**. In **Table B-1** we find that the augmented Dickey-Fuller test when applied to the levels gap can provide only three cases in which the unit root can be rejected. In **Table B-2** we report that the test finds only one case where the unit root cannot be rejected for the growth gap. In terms of the growth gap, almost all pairs are found to have a unit root and thus per-capita GVA growth convergence may be occurring.

<<Table B-1>>

<<Table B-2>>

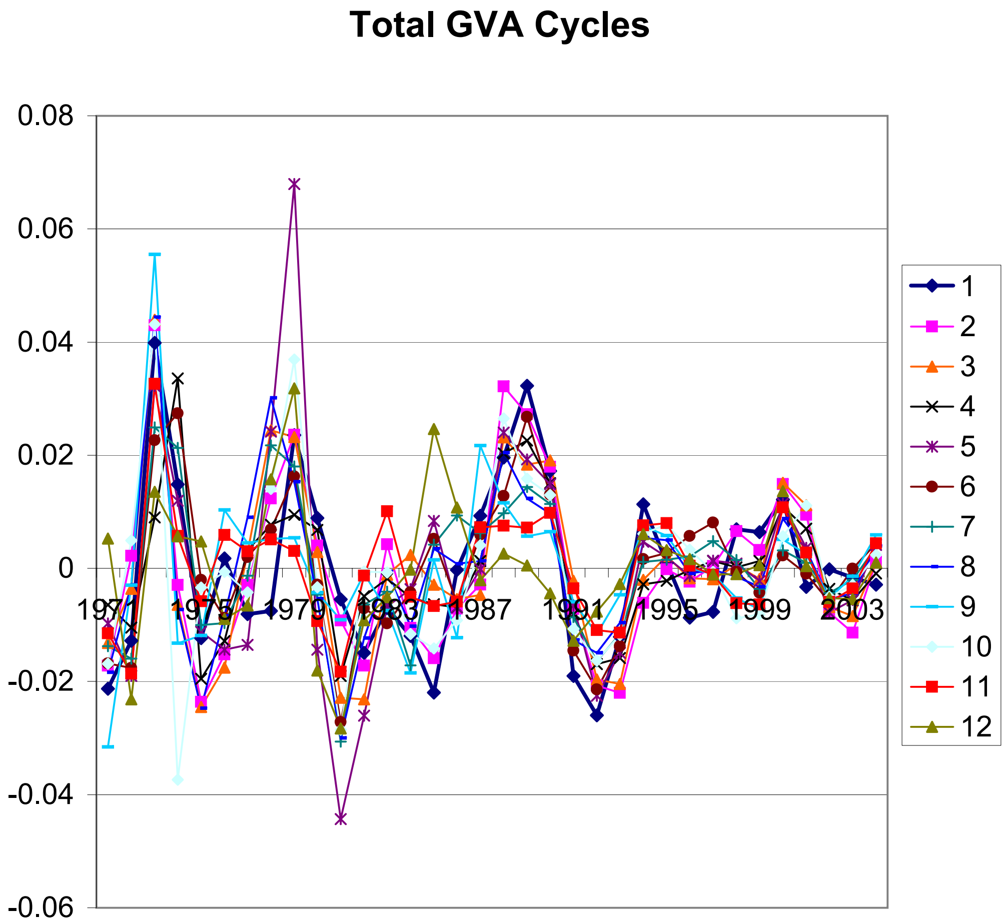
[6] The regional population data are taken from the ONS. The regional classification employed in the ONS population data is 11 UK regions, which is different from 12 regions in the GVA data we used in the main text (Table 1) but corresponds exactly to the GVA data Barrios et al. used. To be consistent in regional classification, we adopt Barrios et al.'s GVA and ONS population data sets.

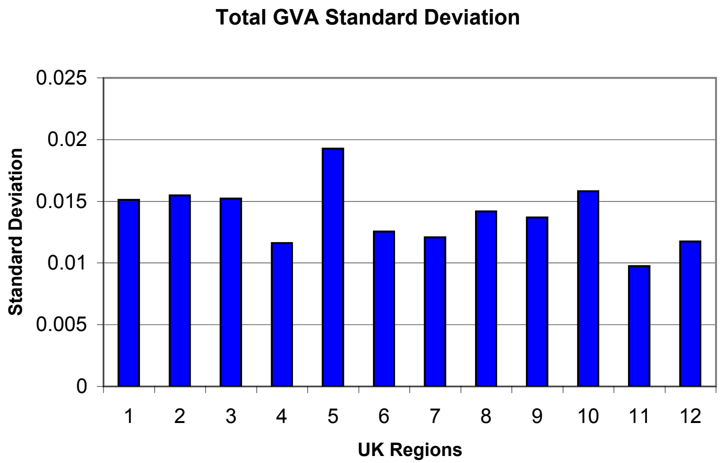
Appendix C: Sector-GVA Cross-correlations

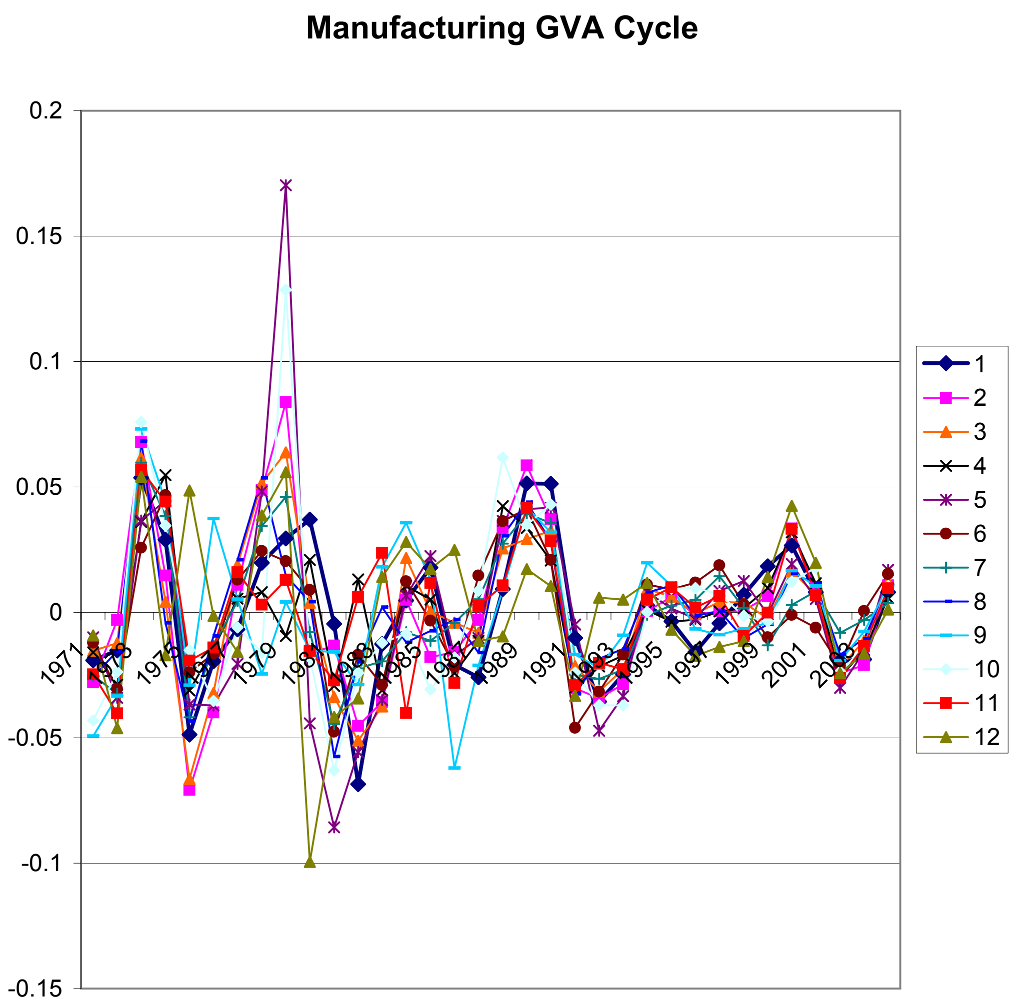
Here sector-GVA cross-correlations in some representative sectors show **Figure C**. Compared with overall-GVA (**Figure 2**), cross-correlations have larger variance in every sector and also have quite different features across sectors. This indicates that sectors are substantially heterogeneous and differently distributed across regions in geographical location. The heterogeneity impacts the idiosyncrasy of *intra*national trade cycle.

<<Figure C>>

Figure 1: UK Regional GVA Cycles (HP Filtered GVA)






Manufacturing GVA Cycle
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
1
2
3
4
5
6
7
8
9
10
11
12

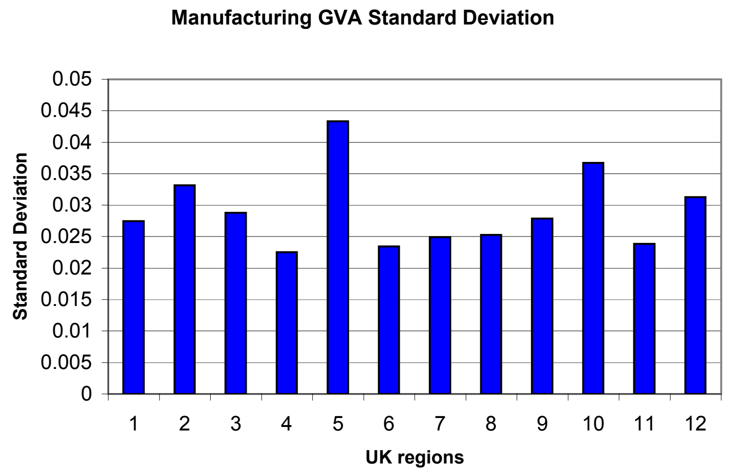

Manufacturing GVA Standard Deviation
Standard Deviation
UK regions
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
1
2
3
4
5
6
7
8
9
10
11
12

Figure 2: UK 12 Regions Cross-correlations

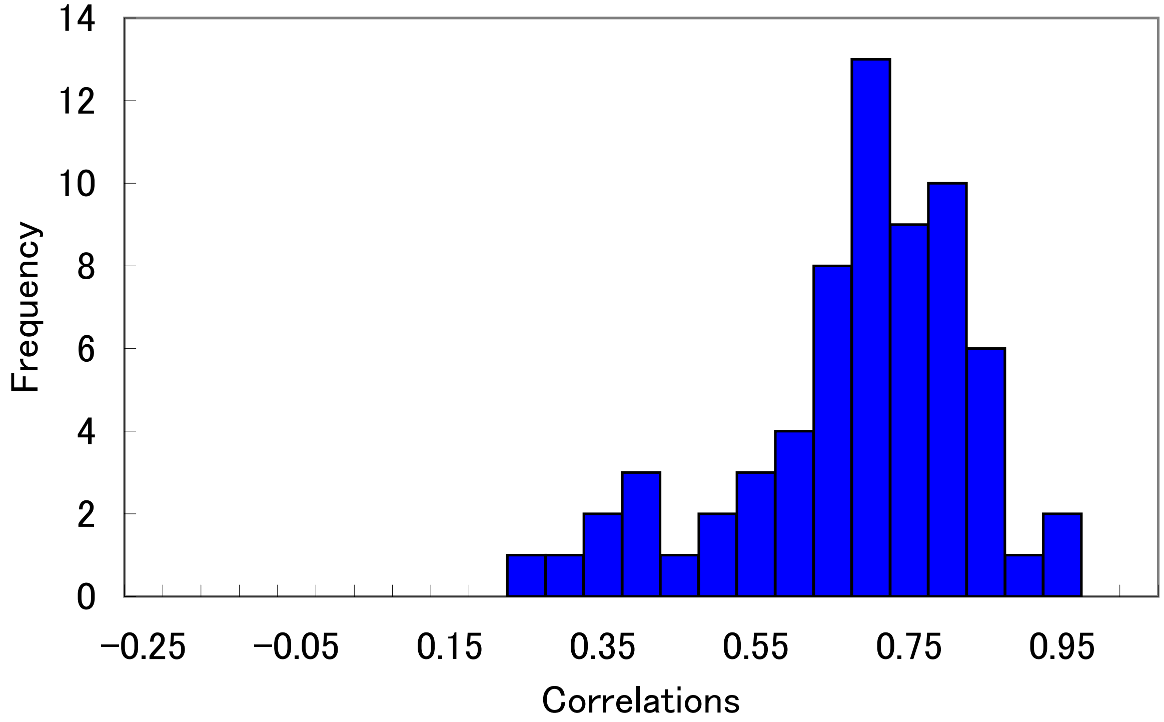


Figure 3: Average and Variance of GVA Correlations (moving average periods)

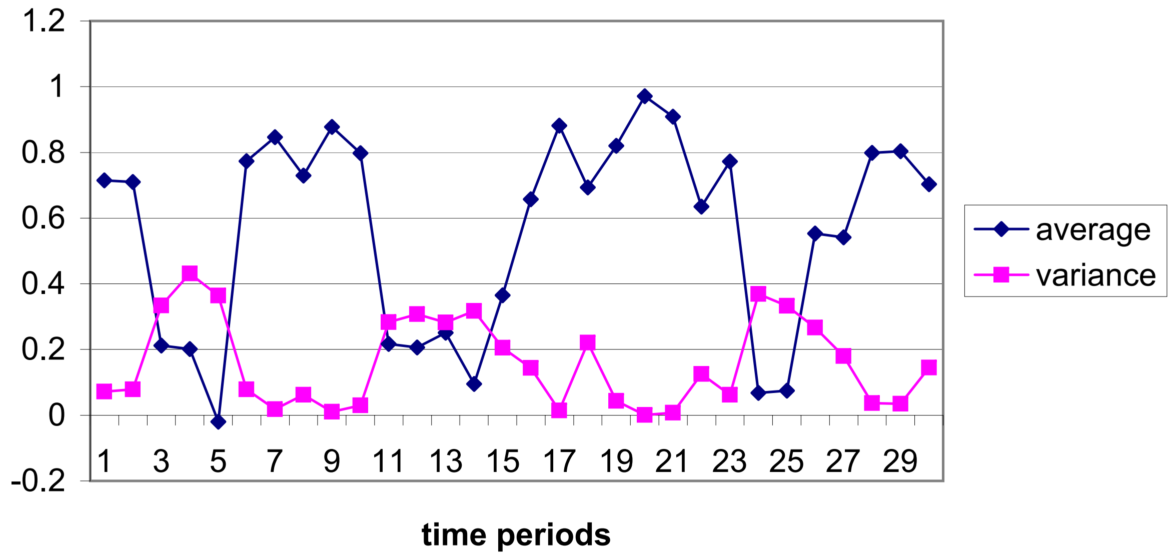


Figure 4: Japanese GDP cross-correlation

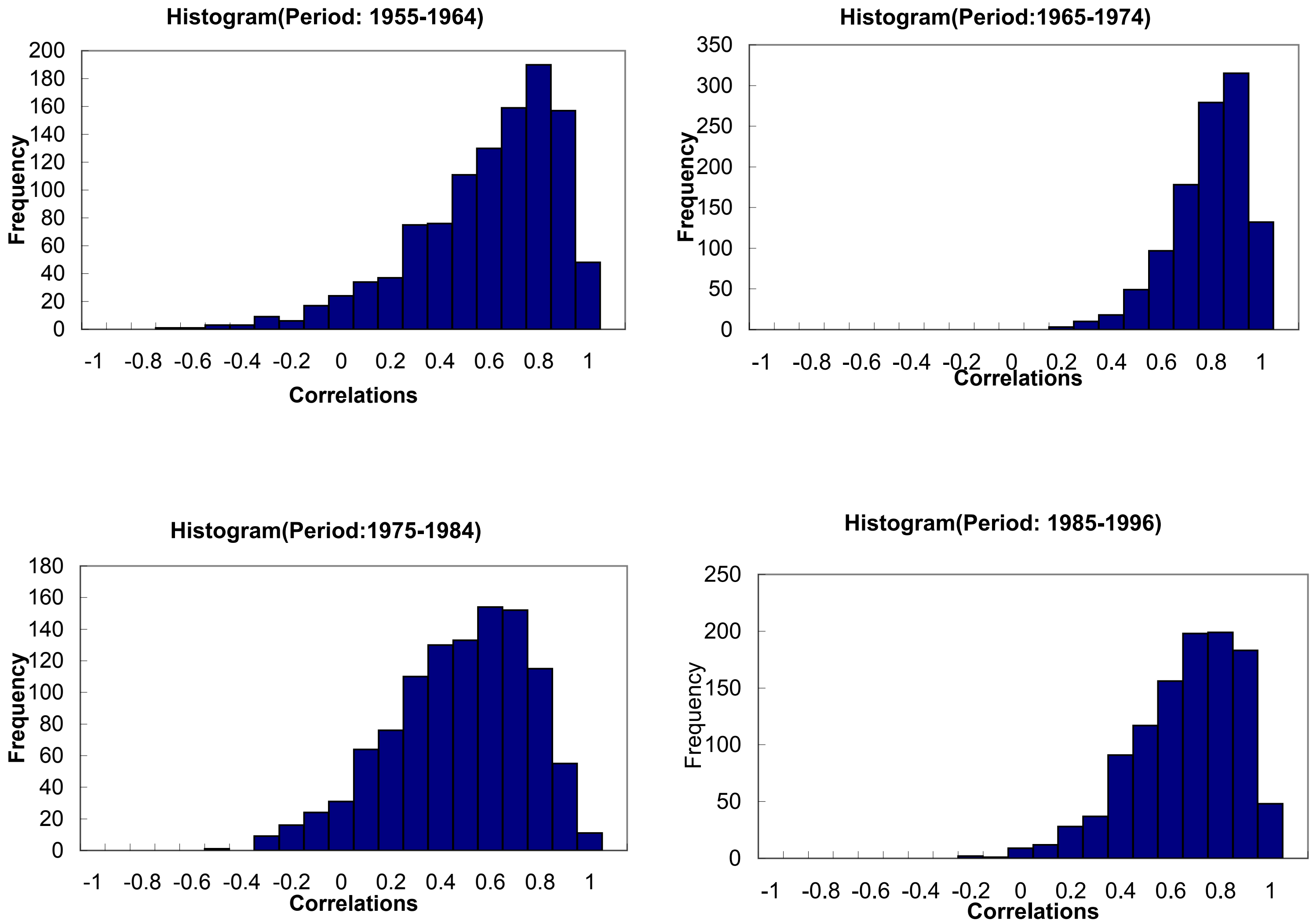
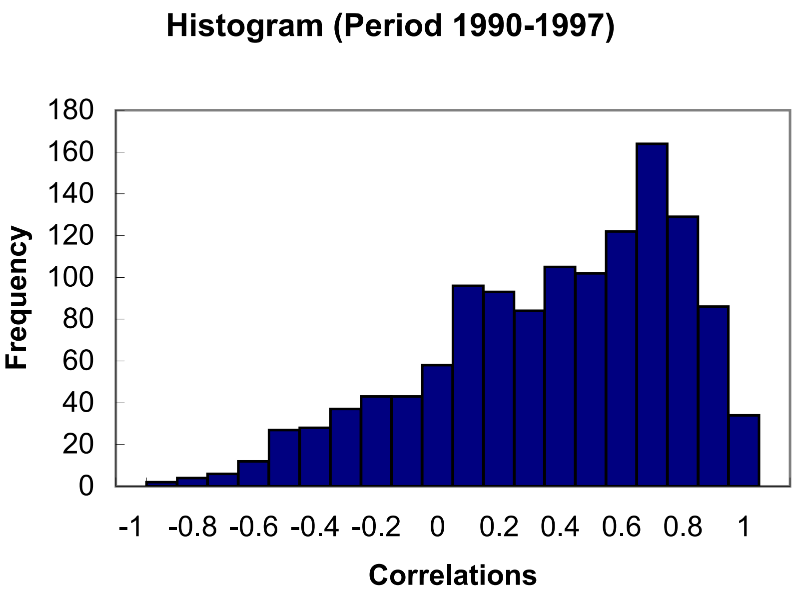


Figure 5: US state GSP Cross-correlation



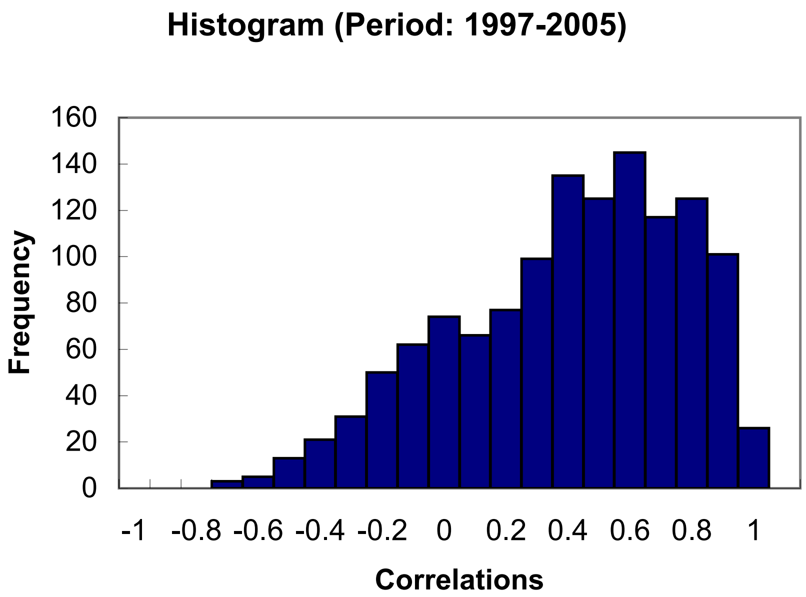


Figure 6: EU Currency Members Cross-correlation: 1975-1995

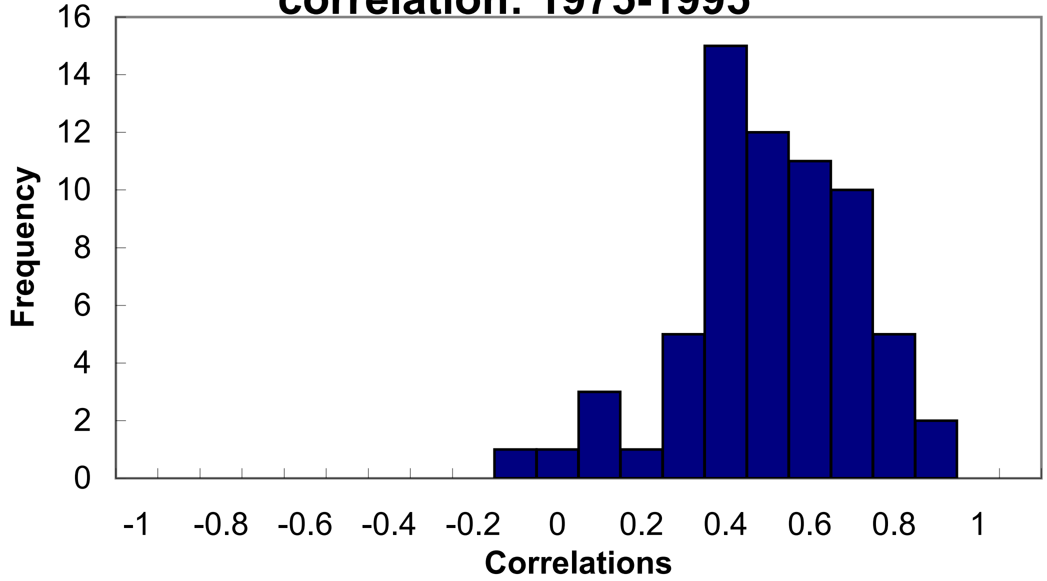


Figure 7: Manufacturing Ratio

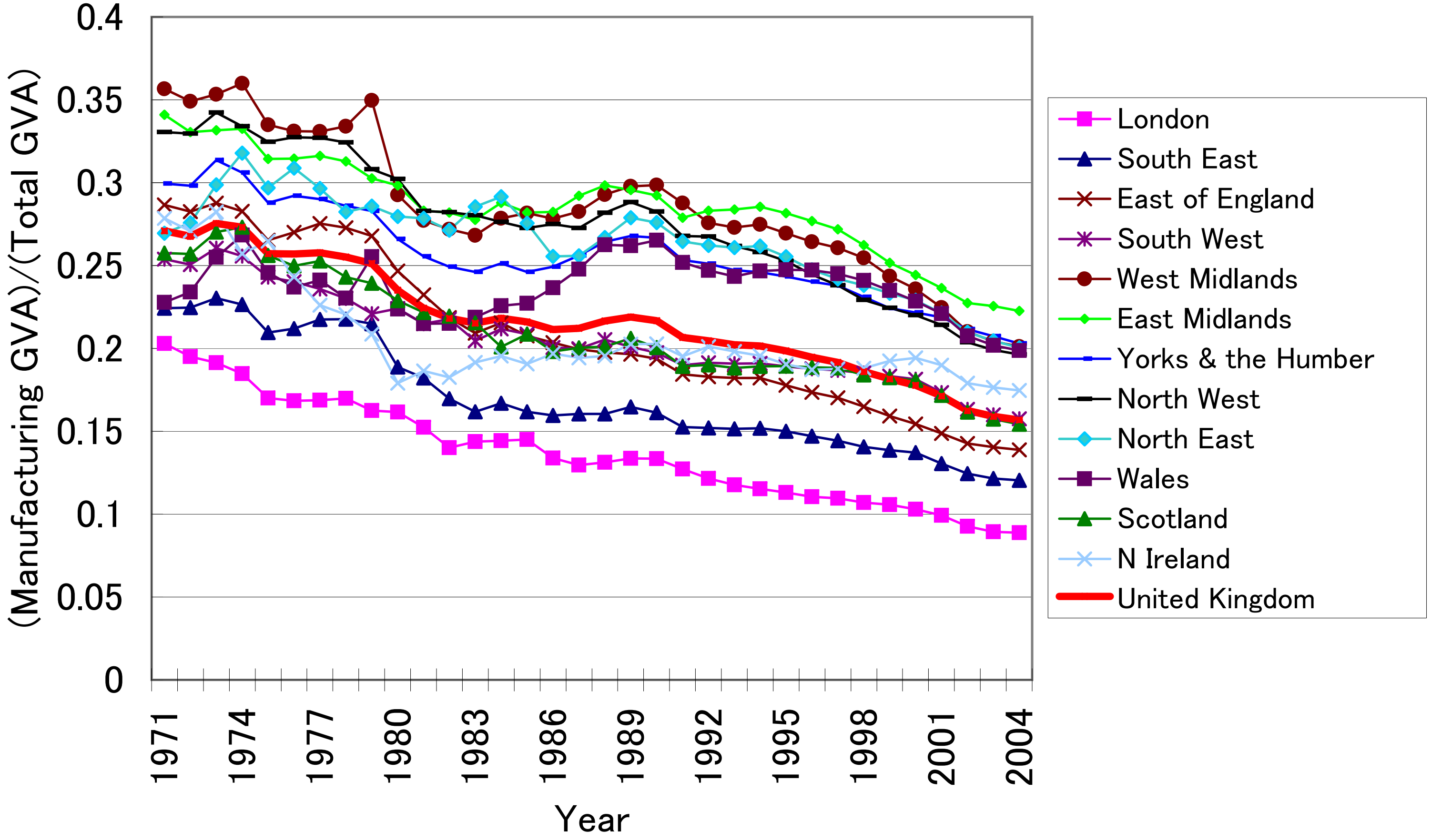


Figure 8-1: Total GVA-trend (after filtering)

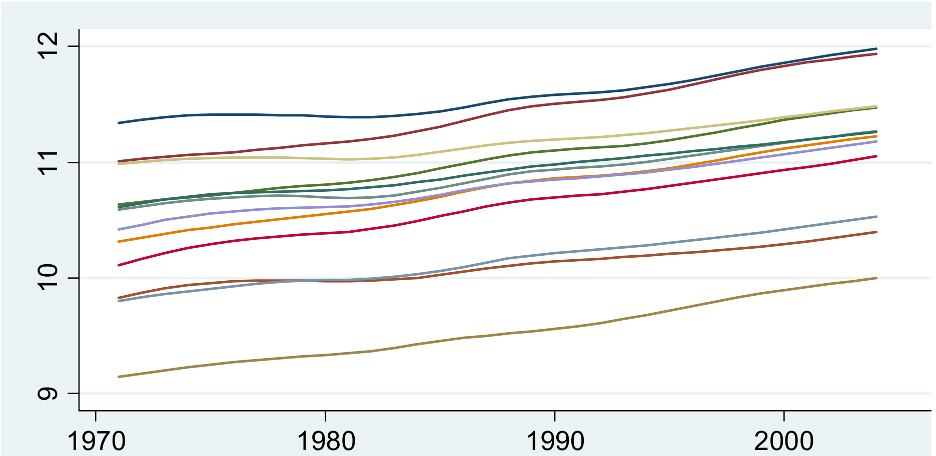


Figure 8-2: Trends in Sectors

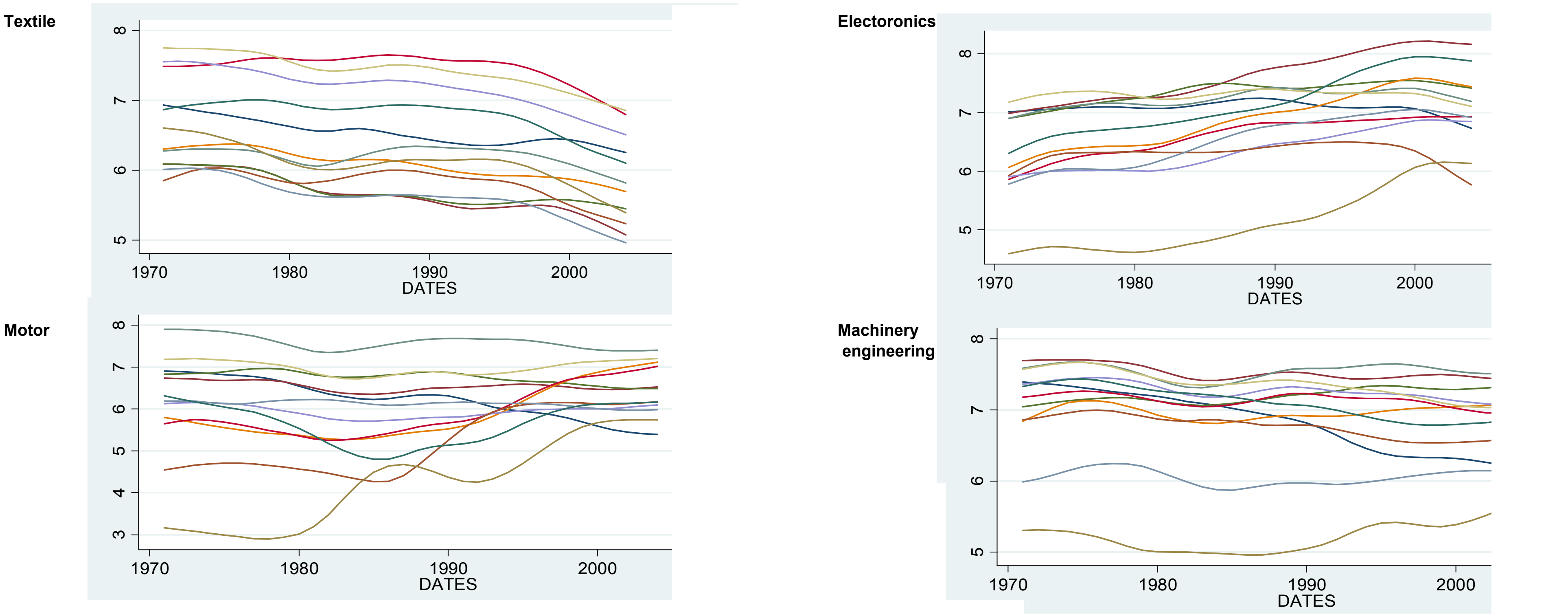


Figure 9: Cross-correlations in UK Regions and EURO Countries

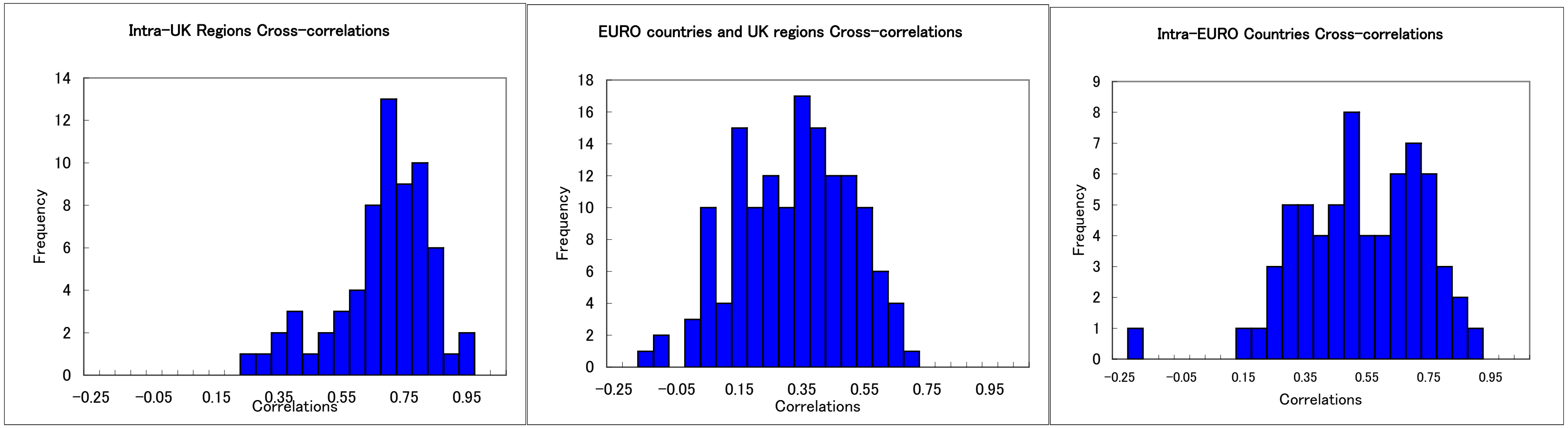
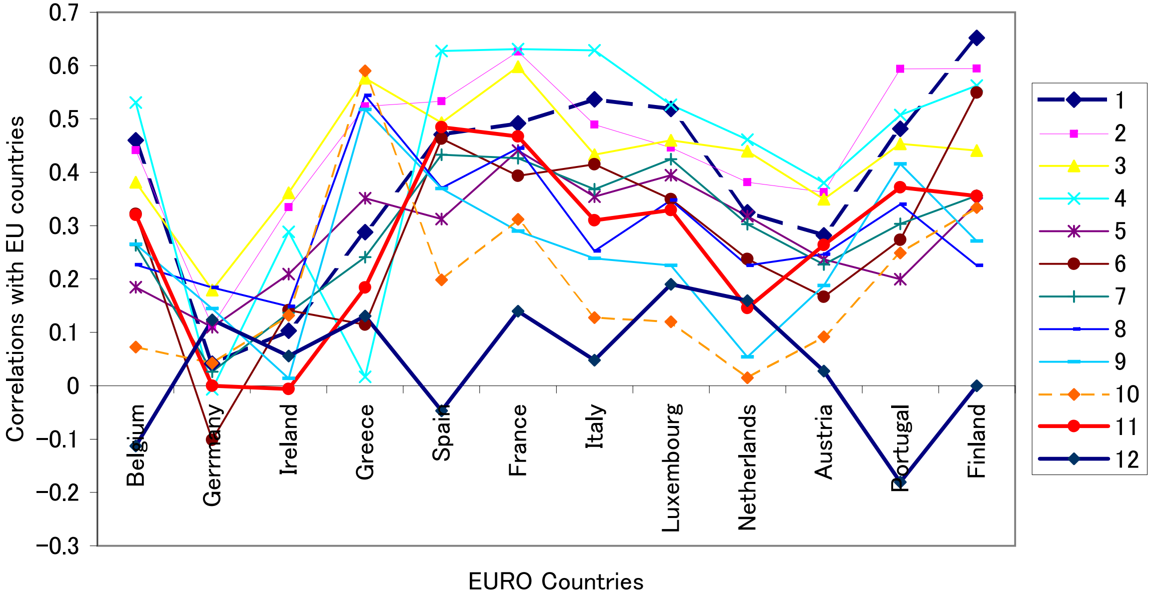


Figure 10: Correlations in 12 UK regions with EURO Countries



UK Regions	1	2	3	4	5	6	7	8	9	10	11	12
Belgium	0.4599	0.4415	0.3812	0.5306	0.1845	0.3218	0.2635	0.2266	0.2652	0.0724	0.3201	-0.1126
Gerrmany	0.0413	0.1124	0.1796	-0.0067	0.11	-0.1014	0.0265	0.184	0.1443	0.0423	0.0001	0.1238
Ireland	0.1034	0.3345	0.3614	0.2882	0.2093	0.1413	0.1366	0.1486	0.0138	0.1322	-0.0063	0.0555
Greece	0.2876	0.5235	0.5763	0.0167	0.3513	0.1146	0.2409	0.544	0.5175	0.5904	0.1843	0.1308
Spain	0.4708	0.5333	0.4931	0.6273	0.3127	0.4632	0.4331	0.3709	0.3692	0.1987	0.4849	-0.047
France	0.4916	0.6265	0.5979	0.6308	0.4408	0.3935	0.4266	0.445	0.2897	0.3118	0.4675	0.1399
Italy	0.5368	0.4893	0.433	0.6287	0.3544	0.4153	0.368	0.2525	0.2386	0.1278	0.3101	0.0478
Luxembourg	0.5187	0.4461	0.4602	0.5265	0.3948	0.3499	0.4248	0.3477	0.2252	0.1199	0.3292	0.19
Netherlands	0.3252	0.3817	0.4396	0.461	0.3178	0.2374	0.3029	0.2254	0.054	0.0148	0.146	0.1593
Austria	0.2821	0.3626	0.3498	0.38	0.2367	0.167	0.2271	0.2466	0.188	0.0919	0.2641	0.0275
Portugal	0.4819	0.5938	0.4536	0.5075	0.1997	0.2733	0.3034	0.3401	0.4157	0.2486	0.3716	-0.1804
Finland	0.6518	0.5943	0.4407	0.5628	0.3418	0.5494	0.3563	0.2257	0.2709	0.3339	0.3554	0.0001

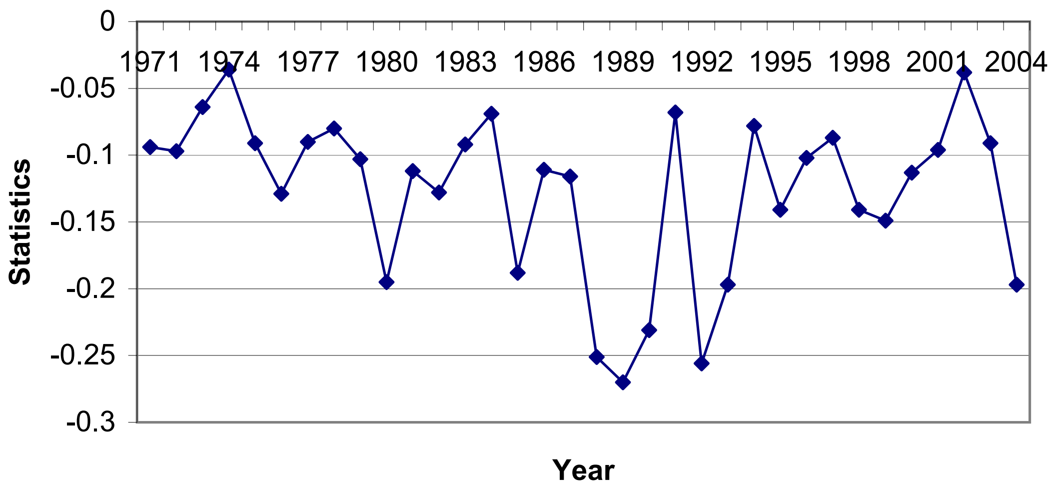


Figure A-1: Moran's I Statistic

Figure C: GVA Cross-correlations in Some Sectors

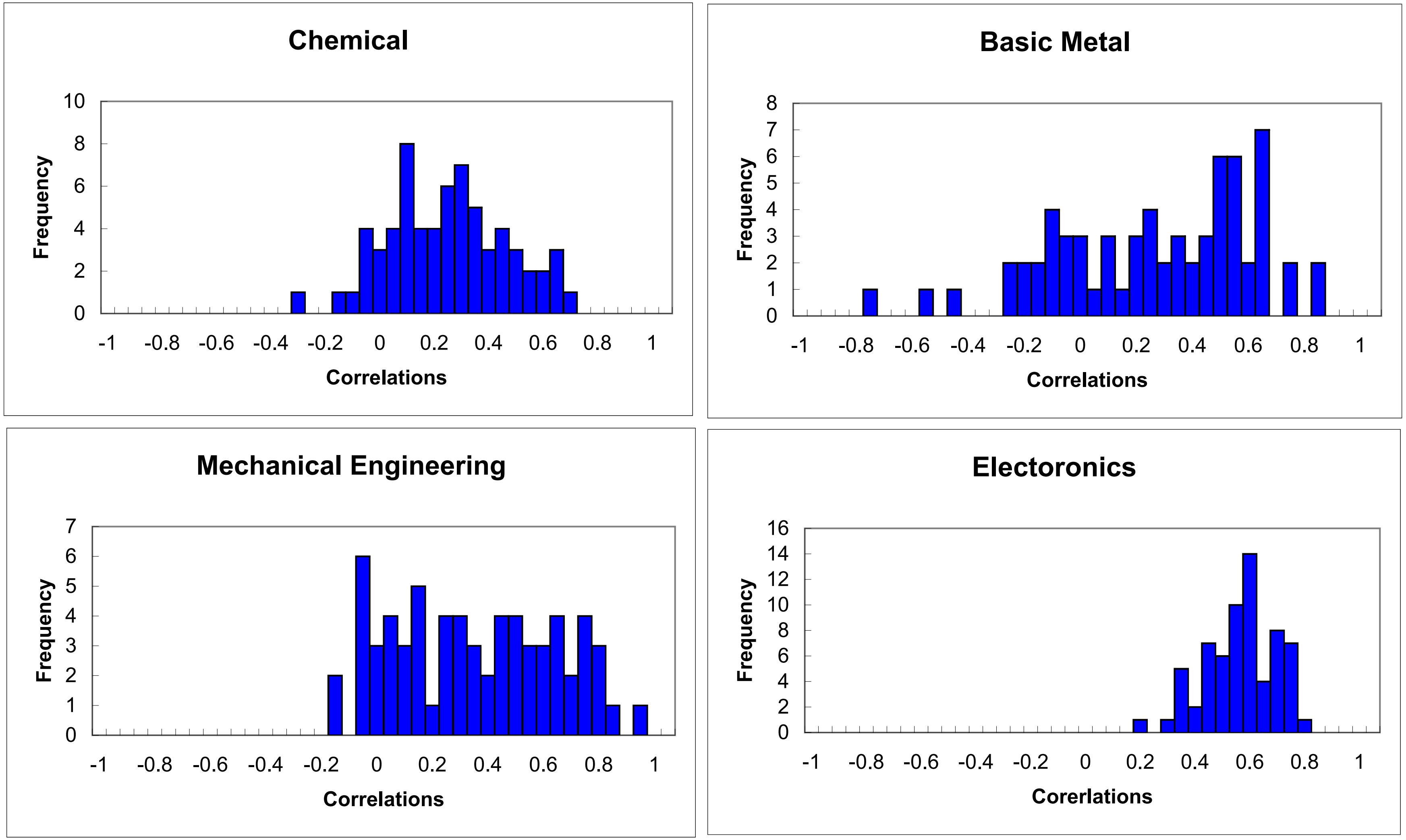


Table 1: Sector and Region Codes

12 UK region code

1	London
2	South East
3	East of England
4	South West
5	West Midlands
6	East Midlands
7	Yorks & the Humber
8	North West
9	North East
10	Wales
11	Scotland
12	N Ireland
13	United Kingdom(total)

sector code

1	food
2	textile
3	printing
4	chemical
5	rubber
6	mechanical engineering
7	electoronics
8	motor
9	basic metal
10	wood
11	other transport eq
12	non-metal

Table 2: HP Filtered Total UK GVA correlation

	1	2	3	4	5	6	7	8	9	10	11	12
1												
2	0.8108											
3	0.6932	0.9295										
4	0.7042	0.7284	0.6956									
5	0.644	0.7235	0.8079	0.6627								
6	0.7349	0.6588	0.6845	0.8373	0.7855							
7	0.6692	0.683	0.7437	0.7802	0.8298	0.8964						
8	0.6383	0.8237	0.9114	0.6067	0.7638	0.6948	0.8203					
9	0.6335	0.6371	0.6307	0.3114	0.4644	0.5268	0.5593	0.7631				
10	0.6055	0.7672	0.7746	0.3546	0.7005	0.508	0.563	0.7962	0.7406			
11	0.6723	0.6577	0.6945	0.5816	0.6187	0.7121	0.7287	0.7606	0.7686	0.6521		
12	0.2852	0.3022	0.4792	0.3507	0.7907	0.5796	0.6787	0.5452	0.2303	0.3988	0.448	
total uk	0.8596	0.9241	0.9287	0.7851	0.8649	0.8452	0.87	0.9065	0.7207	0.7892	0.8089	0.5413

Table 3: Regional Overall GVA Regressions

Dependent variables are HP filtered regional overall GVA

	1			2			3			4			5			6		
	Coefficients	z-value		Coefficients	z-value		Coefficients	z-value		Coefficients	z-value		Coefficients	z-value		Coefficients	z-value	
GVA	0.018	1.77	*	0.017	2.03	**	-0.004	-0.2		-0.041	-1.33		0.008	0.35		-0.038	-0.99	
DISSIM	-0.719	-0.65											-1.865	-0.87				
DISSIMMAN				-2.078	-0.66											-4.015	-0.73	
SPECIALISATION							1.107	0.86					1.477	0.92				
SPECIALISATIONMAN										2.678	1.71	*				3.038	1.66	*
Distance	-0.090	-1.00		-0.147	-1.44		-0.119	-1.22		-0.096	-0.93		-0.069	-0.56		-0.164	-1.14	
Neighbor	0.127	1.24		0.105	1.02		0.152	1.23		0.238	1.67	*	0.201	1.31		0.238	1.53	
region1																		
region2																		
region3																		
region4																		
region5																		
region6																		
region7																		
region8																		
region9																		
region10																		
region11																		
region12																		
Constant	1.259	2.36	**	1.584	2.66	**	1.416	2.46	**	1.260	2.05	**	1.116	1.53		1.640	1.95	*
Estimation Methods	2SLS random-effects IV panel			2SLS random-effects IV panel			2SLS random-effects IV panel			2SLS random-effects IV panel			2SLS random-effects IV panel			2SLS random-effects IV panel		
The number of samples	132			132			132			132			132			132		
The number of groups	66			66			66			66			66			66		
Wald Chi squared	36.15			35.91			25.07			24.79			20.4			22.33		
MSE																		
Hansen J																		
R-squared (overall)	0.1683			0.1582			0.028			0.0177			0.0058			0.0038		

	7		8		9		10		11		12	
	Coefficients	z-value	Coefficients	z-value	Coefficients	z-value	Coefficients	z-value	Coefficients	z-value	Coefficients	z-value
GVA	0.081	0.86	0.012	0.15	0.056	0.79	0.036	0.56	0.076	0.81	0.084	0.9
DISSIM	-0.459	-0.9							-0.204	-0.36		
DISSIMMAN			0.518	0.31							-1.741	-0.74
SPECIALISATION					-0.422	-0.99			-0.357	-0.74		
SPECIALISATIONMAN							1.187	1.17			1.460	1.19
Distance	-0.075	-0.74	-0.075	-0.75	-0.074	-0.75	-0.088	-0.84	-0.075	-0.75	-0.091	-0.86
Neighbor	-0.019	-0.23	-0.019	-0.24	-0.029	-0.36	-0.001	-0.01	-0.027	-0.33	0.003	0.04
region1	0.473	1.65 *	0.444	1.57	0.499	1.73 *	0.401	1.32	0.503	1.74 *	0.398	1.29
region2	0.665	2.06 **	0.697	2.22 **	0.713	2.28 **	0.751	2.28 **	0.698	2.16 **	0.741	2.22 **
region3	0.723	2.3 **	0.755	2.47 **	0.732	2.43 **	0.788	2.45 **	0.723	2.35 **	0.778	2.4 **
region4	0.535	1.76 *	0.550	1.83 *	0.528	1.8 *	0.588	1.86 *	0.525	1.77 *	0.596	1.86 *
region5	0.752	2.77 **	0.746	2.72 **	0.743	2.87 **	0.726	2.51 **	0.742	2.84 **	0.763	2.61 **
region6	0.584	2.13 **	0.587	2.17 **	0.574	2.17 **	0.651	2.28 **	0.574	2.15 **	0.666	2.28 **
region7	0.724	2.54 **	0.739	2.65 **	0.716	2.63 **	0.806	2.73 **	0.714	2.59 **	0.810	2.7 **
region8	0.769	2.71 **	0.757	2.68 **	0.752	2.74 **	0.819	2.8 **	0.756	2.75 **	0.859	2.82 **
region9	0.522	1.6	0.522	1.64 *	0.528	1.66 *	0.568	1.71 *	0.527	1.64 *	0.575	1.72 *
region10	0.543	1.78 *	0.547	1.82 *	0.548	1.86 *	0.607	1.93 *	0.546	1.84 *	0.616	1.92 *
region11	0.708	1.93 *	0.666	1.86 *	0.638	1.82 *	0.723	1.93 *	0.663	1.9 *	0.717	1.89 *
region12	0.287	0.87	0.274	0.84	0.301	0.92	0.267	0.78	0.302	0.92	0.271	0.78
Constant	(dropped)		(dropped)		(dropped)		(dropped)		(dropped)		(dropped)	
Estimation Methods	GMM		GMM		GMM		GMM		GMM		GMM	
	Time dummy is omitted.		Time dummy is omitted.		Time dummy is omitted.		Time dummy is omitted.		Time dummy is omitted.		Time dummy is omitted.	
The number of samples	132		132		132		132		132		132	
The number of groups												
Wald Chi squared												
MSE	0.2754		0.275		0.2685		0.2915		0.2691		0.2979	
Hansen J	0		0		0		0		0		0	
R-squared (overall)												

Table 4: UK Intra-national RBC Results (GMM)

	1		2		3		4		5	
	Coefficient	z	Coefficient	z	Coefficient	z	Coefficient	z	Coefficient	z
GVA	0.026	8.08 **	0.065	3.57 **	0.025	8.89 **	0.026	8.08 **	0.064	3.41 **
DISSIM	-1.840	-2.77 **	-10.959	-2.59 **	-1.678	-2.91 **	-1.840	-2.77 **	-10.810	-2.46 **
DIST	-0.092	-2.83 **	-0.315	-4.91 **	-0.092	-3.06 **				
Driving							-0.107	-2.79 **	-0.248	-4.99 **
Neighborhood										
region1	0.352	3.74 **			0.374	4.15 **	0.380	3.62 **		
region2	0.502	5.03 **			0.528	5.50 **	0.522	4.82 **		
region3	0.519	5.14 **			0.546	5.65 **	0.547	4.88 **		
region4	0.462	5.00 **			0.488	5.62 **	0.479	4.81 **		
region5	0.459	5.17 **			0.482	5.74 **	0.473	5.00 **		
region6	0.487	5.59 **			0.513	6.22 **	0.508	5.32 **		
region7	0.475	5.31 **			0.502	5.82 **	0.499	5.04 **		
region8	0.607	6.53 **			0.626	7.05 **	0.634	6.19 **		
region9	0.330	3.22 **			0.358	3.69 **	0.347	3.16 **		
region10	0.302	3.2 **			0.330	3.65 **	0.329	3.13 **		
region11	0.391	3.41 **			0.418	3.87 **	0.412	3.33 **		
region12	0.310	2.86 **			0.337	3.31 **	0.436	2.84 **		
sector1			-0.191	-2.72 **	-0.445	7.78 **			-0.191	-0.73
sector2			0.435	6.26 **	0.138	2.36 **			0.435	1.55
sector3			0.308	4.54 **	0.034	0.6			0.308	1.14
sector4			0.036	0.56	-0.240	-4.43 **			0.036	0.13
sector5			0.493	7.08 **	0.201	3.62 **			0.493	1.78 *
sector6			0.238	3.52 **	-0.035	-0.61			0.239	0.88
sector7			0.491	7.02 **	0.226	3.91 **			0.492	1.84 *
sector8			0.017	0.25	-0.279	-5.06 **			0.017	0.06
sector9			0.287	3.91 **	0.019	0.31			0.287	1.05
sector10			0.299	4.31 **	(dropped)				0.299	1.06
sector11			(dropped)		-0.294	-5.04 **			0.000	0
sector12			0.397	5.49 **	0.090	1.5			0.397	1.4
Observations	1584		1584		1584		1584		1584	
Root MSE	0.4724		0.5365		0.4246		0.4724		0.5341	
Hansen J	0		0		0		0		0	
	Constant is dropped		Constant is omitted		Constant is dropped		Constant is dropped		Constant is omitted.	

* denotes statistically significant at 10%
** denotes statistically significant at 5%

6			7			8		
Coefficient	z		Coefficient	z		Coefficient	z	
0.025	8.89	**	0.026	8.43	**	0.026	8.39	**
-1.678	-2.91	**	-1.587	-2.57	**	-1.558	-2.49	**
						-0.111	-2.33	**
-0.107	-3.03	**	-0.125	-2.3	**			
			-0.041	-0.4		-0.055	-0.48	
0.402	4.04	**	0.446	3.16	**	0.423	3.26	**
0.548	5.31	**	0.601	3.71	**	0.589	3.79	**
0.574	5.39	**	0.626	3.88	**	0.605	4.01	**
0.506	5.42	**	0.551	3.94	**	0.542	4.03	**
0.496	5.59	**	0.539	4.07	**	0.533	4.13	**
0.534	5.95	**	0.580	4.2	**	0.566	4.31	**
0.526	5.54	**	0.573	4.07	**	0.555	4.2	**
0.652	6.70	**	0.697	5.01	**	0.676	5.24	**
0.374	3.63	**	0.423	2.8	**	0.415	2.84	**
0.356	3.57	**	0.404	2.73	**	0.383	2.79	**
0.438	3.79	**	0.493	2.91	**	0.482	2.96	**
0.463	3.25	**	0.530	2.54	**	0.393	2.65	**
-0.445	7.77	**	-0.446	-7.8	**	-0.446	-7.81	**
0.138	2.36	**	0.138	2.37	**	0.138	2.36	**
0.034	0.6		0.034	0.59		0.033	0.59	
-0.240	-4.42	**	-0.240	-4.44	**	-0.240	-4.45	**
0.201	3.62	**	0.201	3.63	**	0.201	3.63	**
-0.035	-0.61		-0.035	-0.61		-0.035	-0.62	
0.226	3.91	**	0.225	3.92	**	0.225	3.92	**
-0.279	-5.06	**	-0.279	-5.08	**	-0.279	-5.07	**
0.019	0.31		0.019	0.3		0.019	0.3	
(dropped)			(dropped)			(dropped)		
-0.294	-5.04	**	-0.294	-5.05	**	-0.294	-5.04	**
0.090	1.5		0.090	1.5		0.090	1.5	
Observations	1584		Observations	1584		Observations	1584	
Root MSE	0.4246		Root MSE	0.4247		Root MSE	0.4248	
Hansen J	0		Hansen J	0		Hansen J	0	
Constant is dropped			Constant is dropped			Constant is dropped		

Table 5: UK Intra-national RBC Results (2SLS)

	1			2		
	Coefficient	t-value		Coefficient	t-value	
GVA	0.025	8.74	**	0.025	8.74	**
DISSIM	-1.678	-3.05	**	-1.678	-3.05	**
DIST	-0.092	-3.19	**			
Driving				-0.107	-3.19	**
region1	-0.043	-0.95		-0.061	-1.00	
region2	0.110	2.64	**	0.085	1.46	
region3	0.128	3.15	**	0.110	2.03	**
region4	0.071	1.61		0.043	0.67	
region5	0.064	1.30		0.033	0.46	
region6	0.095	2.01	**	0.070	1.04	
region7	0.084	1.86	*	0.063	0.98	
region8	0.208	3.89	**	0.189	2.69	**
region9	-0.060	-1.49		-0.089	-1.58	
region10	-0.088	-2.09	**	-0.107	-1.84	*
region11	(dropped)			-0.025	-0.51	
region12	-0.081	-2.06	**	(dropped)		
sector1	-0.535	-10.12	**	-0.535	-10.12	**
sector2	0.048	0.91		0.048	0.91	
sector3	-0.056	-1.06		-0.056	-1.06	
sector4	-0.330	-6.25	**	-0.330	-6.25	**
sector5	0.111	2.11	**	0.111	2.11	**
sector6	-0.125	-2.36	**	-0.125	-2.36	**
sector7	0.136	2.58	**	0.136	2.58	**
sector8	-0.368	-6.99	**	-0.368	-6.99	**
sector9	-0.071	-1.34		-0.071	-1.34	
sector10	-0.090	-1.7		-0.090	-1.7	*
sector11	-0.384	-7.29	**	-0.384	-7.29	**
sector12	(dropped)			(dropped)		

Observations	1584	Observatio	1584
F	26.22	F	26.22
R-square	0.2817	R-square	0.2817
	Constant is omitted		Constant is omitted
	Sector dummies are omitted		Sector dummies are omitted

* denotes statistically significant at 10%

** denotes statistically significant at 5%

Table 6: 3-subsample period UK Intra-national RBC Results (GMM)

	1		2		3		4		5		6	
	Coefficient	z	Coefficient	z	Coefficient	z	Coefficient	z	Coefficient	z	Coefficient	z
GVA2	0.011	2.64 **	0.008	1.99 **	0.008	2.17 **	0.008	2.18 **	0.050	3.16 **	0.050	3.17 **
GVA3	0.110	2.86 **	0.027	6.88 **	0.025	6.92 **	0.025	6.92 **	0.138	4.35 **	0.136	3.41 **
DISSIM2	-2.244	-2.63 **	-1.553	-1.92 *	-1.588	-2.11 **	-1.588	-2.11 **	-2.309	-2.87 **	-2.312	-2.88 **
DISSIM3	-20.759	-2.44 **	-2.208	-2.91 **	-1.875	-2.71 **	-1.875	-2.7 **	-3.747	-4.19 **	-3.726	-3.78 **
DIST			-0.093	-3.04 **	-0.093	-3.19 **						
Driving	-0.294	-4.31 **										
DIST2							-0.074	-1.91 *	-0.089	-2.79 **	-0.089	-2.79 **
DIST3									-0.245	-3.63 **	-0.243	-2.82 **
Neighborhood							0.026	0.73	0.003	0.1		
region1			0.409	4.51 **	0.467	5.27 **	0.497	4.32 **	-0.221	-4.66 **	-0.079	-1.94 *
region2			0.538	5.7 **	0.602	6.51 **	0.622	5 **	-0.149	-3.85 **	-0.005	-0.11
region3			0.541	5.65 **	0.607	6.46 **	0.630	5.1 **	-0.143	0	0.000	0
region4			0.480	5.53 **	0.546	6.42 **	0.574	5.11 **	-0.197	-4.96 **	-0.054	-1.12
region5			0.488	5.7 **	0.550	6.62 **	0.577	5.18 **	-0.176	-3.58 **	-0.032	-0.73
region6			0.513	6.22 **	0.577	7.2 **	0.604	5.53 **	-0.175	-4.12 **	-0.031	-0.63
region7			0.494	5.82 **	0.559	6.73 **	0.587	5.23 **	-0.197	-4.7 **	-0.053	-1.06
region8			0.646	7.29 **	0.700	8.11 **	0.726	6.3 **	0.000	0	0.143	0
region9			0.375	3.89 **	0.441	4.72 **	0.466	3.8 **	-0.282	-7.14 **	-0.139	-2.85 **
region10			0.362	4.02 **	0.428	4.84 **	0.456	3.96 **	-0.299	-7.44 **	-0.156	-3.18 **
region11			0.454	4.23 **	0.519	5.01 **	0.537	3.97 **	-0.219	-5.34 **	-0.077	-1.58
region12			0.317	3.09 **	0.383	3.87 **	0.409	3.26 **	-0.299	-6.73 **	-0.158	-2.86 **
sector1	-0.286	-0.8			-0.531	-9.57 **	-0.696	-12.53 **	-0.589	-9.85 **	-0.589	-9.7 **
sector2	0.314	0.81			-0.001	-0.02	-0.166	-2.85 **	0.055	0.91	0.055	0.88
sector3	0.278	0.75			(dropped)		-0.165	-2.76 **	(dropped)		(dropped)	
sector4	-0.084	-0.23			-0.359	-6.55 **	-0.524	-9.54 **	-0.357	-6.3 **	-0.357	-6.3 **
sector5	0.412	1.08			0.110	2.03 **	-0.055	-1.02	0.156	2.75 **	0.156	2.72 **
sector6	0.181	0.49			-0.096	-1.77 *	-0.261	-4.79 **	-0.102	-1.84 *	-0.102	-1.84 *
sector7	0.427	1.17			0.165	2.76 **	(dropped)		0.141	2.32 **	0.141	2.32 **
sector8	0.025	0.06			-0.281	-5.61 **	-0.446	-8.86 **	-0.226	-4.17 **	-0.226	-4.13 **
sector9	0.143	0.39			-0.125	-2.26 **	-0.290	-5.23 **	-0.145	-2.55 **	-0.145	-2.54 **
sector10	0.195	0.51			-0.118	-2.02 **	-0.283	-4.82 **	-0.054	-0.88	-0.055	-0.88
sector11	0.000	0			-0.307	-5.36 **	-0.472	-8.22 **	-0.255	-4.14 **	-0.255	-4.1 **
sector12	0.382	0.98			0.054	0.99	-0.111	-2.03 **	0.138	2.36 **	0.137	2.27 **
Observations	2376		Observatior 2376		Observatio 2376		Observatio 2376		Observatio 2376		Observatio 2376	
Root MSE	0.7489		Root MSE 0.558		Root MSE 0.5205		Root MSE 0.5204		Root MSE 0.523		Root MSE 0.5231	
Hansen J	0		Hansen J 0		Hansen J 0		Hansen J 0		Hansen J 0		Hansen J 0	
	Constant is dropped		Constant is omitted		Constant is dropped		Constant is dropped		Constant is dropped		Constant is omitted.	

* denotes statistically significant at 10%
** denotes statistically significant at 5%

Note: GVA2 is the average GVA in the second subsample period (1982-1992) and GVA3 is the one in the third period (1993-2004). The same notations are applied to DIST2/DIST3 and DISSIM2/DISSIM3.

Table 7: 3-subsample period UK Intra-national RBC Results (2SLS)

	1		
	Coefficient	t-value	
GVA2	0.050	2.91	**
GVA3	0.136	3.18	**
DISSIM2	-2.312	-2.7	**
DISSIM3	-3.726	-3.61	**
DIST2	-0.089	-2.54	**
DIST3	-0.243	-2.64	**
region1	0.079	1.62	
region2	0.153	2.92	**
region3	0.158	3.13	**
region4	0.104	1.88	*
region5	0.126	2.08	**
region6	0.127	2.03	**
region7	0.105	1.72	*
region8	0.301	5.23	**
region9	0.019	0.42	
region10	0.002	0.04	
region11	0.081	1.94	*
region12	(dropped)		
sector1	-0.726	-9.9	**
sector2	-0.082	-1.53	
sector3	-0.137	-2.25	**
sector4	-0.494	-8.15	**
sector5	0.019	0.35	
sector6	-0.239	-3.87	**
sector7	0.004	0.06	
sector8	-0.363	-6.72	**
sector9	-0.282	-4.36	**
sector10	-0.192	-3.59	**
sector11	-0.392	-7.24	**
sector12	(dropped)		
Observations	2376		
F	19.97		
R-square	0.175		

Constant is dropped

* denotes statistically significant at 10%
** denotes statistically significant at 5%

Note: GVA2 is the average GVA in the second subsample period (1982-1992) and GVA3 is the one in the third period (1993-2004).
The same notations are applied to DIST2/DIST3 and DISSIM2/DISSIM3.

Table B-1: GVA per capita Regional Convergence Unit Root Tests (1971-1997)

Dickey-Fuller test

	South East	East Angli	South Wes	West Midla	East Midla	Yorkshire &	North Wes	North	Wales	Scotland	Northern Ireland
South East											
East Angli	U										
South West	(X)	X									
West Midla	U	U	U								
East Midla	U	U	U	(X)							
Yorkshire & Humberside	U	U	U	U	U						
North West	U	U	U	U	U	U					
North	U	U	U	U	U	U	U				
Wales	U	U	U	U	U	U	U	U			
Scotland	U	U	U	U	U	U	U	U	U		
Northern Ireland	U	U	U	U	U	U	U	U	U	U	

(X) denotes $p<0.05$, i.e. unit root is rejected.
X denotes $p<0.01$: i.e. Unit root is rejected
Otherwise, there is unit root
Note:ln(GVApercapita_A)-ln(GVApercapita_B)
Note: Different regional classification of UK 12 regions from main text (Table1)

Table B-2: GVA per capita growth Regional Convergence Unit Root Tests (1971-1997)

Dickey-Fuller test

First difference GVA (Growth gap)

	South East	East Angli	South Wes	West Midla	East Midla	Yorkshire &	North Wes	North	Wales	Scotland	Northern Ireland
South East											
East Angli	X										
South West	X	X									
West Midla	X	X	X								
East Midla	X	X	X	X							
Yorkshire & Humberside	X	X	X	X	X						
North West	X	X	X	X	X	X					
North	X	X	X	X	X	X	X				
Wales	X	X	X	X	X	X	X	X			
Scotland	X	X	X	U	X	X	X	X	X		
Northern Ireland	X	X	X	X	X	X	X	X	X	X	

Note that X denotes rejection of unit root (convergence).
Note that U denotes unit root (p-value is more than 0.01).
Note: ln(GVApercapita_A_t)-ln(GVApercapita_A_t-1)-(ln(GVApercapita_B_t)-ln(GVApercapita_B_t-1))
Note: Different regional classification of UK 12 regions from main text (Table1)