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The Dynamics of FDI Location: A Markov Analysis for British Regions

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Abstract
The paper uses the framework of Markov chains to examine convergence in the location of inward foreign direct investment across the regions of Great Britain over 1985-2005. An analysis is undertaken by industry group that disaggregates manufacturing and services. It finds convergence in regional FDI shares, both overall and by industry, which supports agglomeration. As explanations, a weakening of regional policy has led manufacturing FDI to spread-out from 'north' to 'south', but in services there is a shift in FDI location within the 'south' from core to contiguous regions, suggesting diseconomies at the core. The paper finds different spatial processes and draws implications for regional policy.

Keywords: Foreign direct investment; location; transition matrices; agglomeration; and regional policy
JEL Classifications: O12, L20, R58

1. Introduction

Foreign Direct Investment (FDI) features prominently in the economic programmes of many regions and states (Head *et al*, 1999; Kim *et al*, 2003; Crozet *et al*, 2004; Wren, 2005), with implications for regional development and policy. Research has focused on the locational determinants of this investment (e.g. Coughlin *et al*, 1991; Friedman *et al*, 1992), but the extent to which FDI builds-up across regions, leading to convergence or divergence, is rarely examined, if at all. The empirical evidence is that agglomeration dominates classical location factors (Head *et al*, 1995; Guimaraies *et al*, 2000), including grants (Devereux *et al*, 2007), which over time suggests divergence. However, theory is less certain, with the new economic geography finding that entry has opposing effects on competition and costs, but perhaps with limited policy implications (Puga, 1999).

The issue of divergence or convergence in regional FDI location is of interest, as inward investment from overseas has assumed critical importance to UK regional policy, with £2 billion (US$3 billion) in grants being used to support this investment since the mid-1980s. However, the effect of the regional grants appears to be weakening, with the core region of South East England now getting 40% of all inward investment projects to the UK, much of it in the service sector and which has accounted for the majority of FDI since the late 1990s (Jones and Wren, 2008a). FDI tends to localize relative to foreign plants in the same industry, for which there is strong evidence (Guimaraies *et al*, 2000; Devereux *et al*, 2007; Duranton and Overman, 2008), and this is also the case for regions (Brand *et al*, 2000).[1] Nevertheless, as FDI matures, there are reasons to suppose that the agglomeration force is less pronounced and FDI follows a different location pattern.

One reason for this is that co-location generates diseconomies from congestion and market crowding (Baldwin *et al*, 2003), and a second is that agglomeration could be

a response to informational and other barriers to early-stage FDI (see Teece, 1985), but which in the long run are surmountable. As FDI becomes more prevalent geographically it may further weaken the agglomerative force. Casual observation offers support, as the South East and East Anglia regions of Great Britain had more than two-thirds of the UK manufacturing jobs in foreign ownership over 1945-65 (Dicken and Lloyd, 1976), but 90 per cent of FDI located in the traditional assisted area regions of the north and west by 1990, no doubt encouraged by the large-scale regional policy investment grants from the mid-1960s. In the case of early-stage Japanese FDI in the 1980s, a strong preference for co-location is also found for the UK and US (Taylor, 1993; Head *et al*, 1995).[2]

The purpose of this paper is to analyse the location of new inward FDI across the regions of Great Britain for the period 1985-05 in order to investigate for divergence or otherwise. It is investigated in the framework of Markov chains (Seneta, 2006; Janssen and Manca, 2006), which is advantageous given the well-known difficulties of the β-convergence approach (see Friedman, 1992; Quah, 1993a; Bosker and Krugell, 2008).[3] The Markov approach is appropriate as agglomeration is a dynamic process that implies transition in the regional FDI shares, while Crozet *et al* (2004) and Lee *et al* (2007) find that that the number of foreign firms in an region has a greater effect on location than do the number of domestic firms. Given that FDI may exhibit a different location pattern as it matures the analysis is carried out for four industry sub-groups showing different FDI growth profiles, and which disaggregate the manufacturing and service sectors.

The paper finds that FDI has converged in its regional location over time, which is the case for both manufacturing and service industries and which overall demonstrates the importance of the agglomeration economies in location. In the case of manufacturing it reflects the weakening of the regional grants, which are no longer able to overcome the 'pull' of the south of England, while (like manufacturing when it first arrived) service

sector FDI also favours the south. Convergence in the service FDI arises as the regions contiguous to the 'core' South East region have increased their shares, while they are also the major beneficiaries of the north-to-south shift in manufacturing FDI, suggesting diseconomies at the core. The policy implications are that FDI now heavily favours the south of England, such that regional policy may be necessary to encourage these projects to locate further afield, as occurred for manufacturing in earlier decades.

The paper begins in the next section by briefly outlining the nature of the Markov approach, and Section 3 considers the data and regional FDI location pattern. Section 4 identifies industries that show different FDI growth profiles, and Section 5 conducts the Markov analysis. The results are discussed in Section 6 and Section 7 concludes.

2. The Markov Framework

Markov chain methods are used to examine convergence in per capita incomes, of which there are plenty of examples, including Quah (1993b), Fingleton (1997), Magrini (1999), Le Gallo (2004) and Bosker and Krugell (2008). However, we know of no attempt to use these methods to examine the dynamics of plant location, so that this represents a novel and important contribution of the paper. The issues at stake are whether British regions have diverged or converged in their FDI shares over time, and how it varies both across industries and by time and space. There exist many accounts of Markov methods, such as Janssen and Manca (2006) and Bickenbach and Bode (2003).

For the total number of FDI projects locating at the national level we consider the distribution of projects across regions r (= 1, 2, …, R) at each time t (= 0, 1, 2, …). The unit interval [0, 1] is partitioned into a finite number of ordered, exhaustive and mutually exclusive interval classes N, such that at time t, $s_i(t)$ denotes the share of the R regions in class i ($\in N$), where $s_i(t) \geq 0$ and $\sum_i s_i(t) = 1$. The Markov approach supposes that for a

region in class i at time t there is a transition probability $p_{ij}(t)$ of it being in class j at time t+1, where $i, j \in N$, $p_{ij}(t) \geq 0$ and $\sum_i p_{ij}(t) = 1$.

As a simplifying first step, which is tested below, it is typically assumed that the transition probabilities are time homogeneous of order 1, such that $p_{ij}(t) = p_{ij}$ for all t. It means there is an N x N row-standardised transition matrix M with elements p_{ij}, such that if the regional distribution of FDI at time t is given by the row vector $S(t) = (s_1(t), s_2(t), \ldots s_N(t))$, then the regional FDI distribution $S(t+1)$ at time t+1 is:

$$S(t+1) = S(t)\, M = S(0)\, M^t. \qquad (1)$$

Taking data for R regions and T time periods it is possible to determine the p_{ij} elements of M, from which the dynamics may be discerned, e.g., the spread and skewness of the distribution, the amount of internal mixing and mobility and how these change over time (Rey, 2004). Further, provided M is regular, as t tends to infinity in (1), it is possible to determine the limiting distribution $S = (s_1, s_2, \ldots, s_N)$.[4] In effect, this solves the equation $S\, M = S$, with the constraint $\sum_i s_i = 1$.[5] It is interpreted as a steady-state equilibrium in that the distribution of regional FDI shares is constant over time, but as Fingleton (1997) notes, S is probabilistic so that a region may still move between classes in this state.

Comparison of S with the initial distribution $S(0)$ reveals if there is convergence, divergence or possibly neither. Thus, if $s_i < s_i(0)$ in the median class(es) but $s_i \geq s_i(0)$ in lower and higher classes it suggests divergence, and conversely there is convergence. In the former case, there is a tendency for FDI to accumulate in some regions over time, giving these a larger share of total FDI, while other regions receive a smaller share and migrate to the lower classes, so that the regions diverge in their FDI shares.

3. The Data and Regional Distribution of FDI

The data used in this study were obtained from the national inward investment agency, UK Trade and Investment (UKTI), and give annual information on all known investment projects carried out by foreign-owned plants in Great Britain over 1985-05.[6] These data are used by the Government to report FDI for Great Britain as a whole. After cleaning and checking, the dataset gives information on 11,488 FDI projects, with details of the industrial activity and location by region. Data is known for Greater London for years 1995 onwards only, but in any case we chose to include this with the South East region, which like other regions makes it akin to a city-region, with an urban area surrounded by suburban and rural parts.[7] This gives ten Government Office regions for Great Britain, which are equivalent to the *Eurostat* NUTS I regions.

The distribution of FDI projects across British regions over 1985-05 is shown in Table 1. A distinction is made between the South East and contiguous regions, which are described as the 'south' and other regions that are labelled the 'north'. While the British 'north-south' divide often characterises popular debate as a line between the mouths of the rivers Severn and Humber, this is close to that adopted here, but the distinction is not arbitrary and it is useful for interpreting the results. This is because the regional grants, which are the primary means by which the UK attracts FDI under the European Union state aid rules, are available mainly in the 'north' and this received 94% of the total grant to FDI by value over 1985-05 at constant prices (Jones and Wren, 2008a). Virtually all the grant goes to manufacturing, given conditions on eligible investment. The 'north-south' distinction roughly equally divides Great Britain in population terms.[8]

The total number of FDI projects was little changed up to the early 1990s, since when it has increased more or less year-on-year (Jones and Wren, 2008b). Comparison

is made in Table 1 in the number and share of FDI projects locating in regions between the initial and terminal years (mean annual value for 1985-87 and 2003-05 respectively). It shows the strong increase in the number of FDI projects over time – from 357 to 863 projects a year – but whereas the 'north' initially had 72% of FDI projects, it was just 41% by the end. Further, while almost all the 'north' regions saw a decline in their FDI share (growth quotients in Table 1), the South East share increased strongly from 19% to 40%, compared to an output share of 33%.[9] This is suggestive of convergence, with FDI locating away from the regions where it located towards the beginning of the period, but equally the build-up of FDI in the 'south' could be evidence of divergence.

This analysis is for initial and terminal years only, and the issue is best examined in the Markov framework that allows for dynamics over the whole sample period. As we indicated, this is at the NUTS I level over 1985-05, which gives a long time series but a relatively small number of regions. However, these regions make sense as they are the level at which economic development policy and the FDI grants operate, for which there is regional autonomy prior to and after the formation of Regional Development Agencies in 1999 (Yuill *et al*, 1990). Further, there is a long history of examining agglomeration economies at the regional scale (Parr, 2002), while each region has an urban core where FDI tends to locate (Devereux *et al*, 2007). The size of the regions also mitigate against spatial dependence due to spillovers or other linkage effects (Rey, 2001), although this can be examined in the framework of transition matrices, which is considered below. Finally, regional FDI trends may be difficult to discern from a sub-regional analysis, but for which reliable data on FDI are in any case not available over such a period.[10]

Attention now turns to the Markov analysis. Given the relatively small number of observations this poses issues for this analysis, but we test the sensitivity of the results to the interval classes used, and for our preferred classes the transition matrices are regular.

We also examine the time and spatial homogeneity of the results, including by industry group, for which the number of observations is unchanged. However, before all this, we first make the choice regarding the industry groups.

4. FDI Dynamics and Industry Groups

It was hypothesized that industries that are just beginning to invest internationally may exhibit a different regional location pattern to those industries that have been investing internationally for some time and showing weak or declining growth in the total amount of FDI. This is an empirical matter, but it suggests it is important to distinguish between industries that are of different vintages and therefore showing FDI growth profiles.

Our dataset identifies the 4-digit industrial activity of each project, and from this it is possible to form 42 broadly homogeneous industries.[11] Details are these are given in Appendix Table 1, which shows the number and growth in FDI projects over 1985-05 and the year in which the median project occurred. For the analysis it is feasible to form a limited number of industry groups only, or the transition matrices become irregular, so initially these were formed on the basis of growth rates.[12] However, it virtually always placed manufacturing and services in different groups, so it was decided to first divide the 42 industries into these two sectors and then to further sub-divide each of these into two groups, which splits the data roughly equally. These are Groups I to IV in Appendix Table 1, where Groups I and II comprise manufacturing and III and IV are services.

For Group I, every industry had fewer FDI projects at the end of the period than at the beginning (like elsewhere these are defined as 3-year averages to reduce the effect of year-to-year fluctuations), and the median year is no later than 1995. The converses are the case for Group II, which suggests these two groups are different vintages and it is broadly confirmed by casual inspection of Appendix Table 1. The industries in Group I

include basic metals, chemicals, machinery and metal products, but for Group II they are medical and optical instruments, motor vehicles, office machinery and pharmaceuticals. In the case of Groups III and IV there is no simple distinction by the year, but they differ markedly in growth rates (exceptionally, growth is calculated for these between the first and last ten years of the study period owing to generally very low levels of FDI early on – see Figure 1). Every industry in Group IV has a double-digit growth rate, but it rarely exceeds 5% for III. Group III includes insurance, personal services and wholesale, but Group IV has computing, financial intermediation and telecommunications.

The annual share of total FDI projects in each industry group is shown in Figure 1 over time. It confirms the different growth rates, since whereas manufacturing had not less than 70% of projects for years up to 1997 it only had only 30% by 2005. The Group II share was broadly constant, but the Group I share declined more or less monotonically over time. In services the shares increase, but for Group IV peaking at 50% of total FDI in 2000 and then falling back. This is related to the dotcom boom in Computer Activities and Software (see Appendix Table 1), although other industries spiked at this time, such as Computer Consultancy and Other Business Activities. A different pattern ensued for services after 2000, since when the Group III share has increased strongly.

5. The Analysis

As a first step, it is useful to calculate simple sigma measures of dispersion between the beginning and end of the study period, both for all industry and each industry group. These are for the mean annual FDI shares across regions for the initial (i.e. 1985-87) and terminal years (2003-05). The results for the sigma measure are given in Table 2. This shows divergence overall, but related to the high-growth service industries (Group IV), while other industry groups converge. It also reveals that the service industries are more

dispersed across regions than is manufacturing industry, both at the beginning and end of the period. The issue of divergence is examined through transition matrices.

As a further point, spatial dependence could render these matrices inappropriate, so it is necessary to check for the presence of this (Rey, 2001). Dependencies might be in the form of technology or productivity spillovers or through production linkages, and mean that the FDI share in one region depends on the FDI share in neighbouring regions. Bickenbach and Bode (2003) outline a test for spatial independence that is based on the Pearson (or LR) χ^2 statistic (it is like that used to examine time and spatial homogeneity below). It involves partitioning the sample into regions that border other regions that on average have relatively high a low FDI shares, although this is unlikely to perform well in the presence context. This is because spillovers depend on size, both for the giver and recipient of an externality, but regional sizes differ markedly even for those with similar initial FDI shares (e.g. South East and West Midlands in Table 1). Further, the regions have extensive coastlines (only the West Midlands is land-locked), which will reduce the spillover independent of whether bordering regions have high or low FDI shares.

As an alternative we test for spatial autocorrelation directly using the Moran's *I* (Moran, 1950), i.e. do regions with high FDI shares border one another? The Moran's *I* was calculated for each year over 1985-05 for the number of FDI projects in each region weighted by the respective share of national employment. As *R* increases the Moran's index is asymptotically normally distributed (Cliff and Ord, 1973). The null hypothesis of positive spatial autocorrelation, representing positive spillovers and linkages, was made under a one-tail test, but the test statistic for contiguity never achieved significance at the 5% level in any year (it was significant at the 10% level in two years only). This suggests an absence of positive spatial autocorrelation, which was also the case when the

distance between the major urban centre of each region was used instead, as well as for manufacturing. Overall, it suggests the regions are not spatially dependent.

5.1 Transition Matrices

The transition matrices were estimated with observations for annual FDI shares for the ten British regions over 1985-05. It was based on quintile classes, which discretizes the FDI shares over the study period into five equal groups ($N = 5$). The transition matrices M for all industry and each industry group are shown in Table 3. To interpret these, in the case of all industry, $p_{11} = 0.691$, so that 69.1% of the regions in Class 1 remained in that class in the following year, but ($p_{12} =$) 26.2% transited to Class 2 and ($p_{13} =$) 4.7% to Class 3. In each case, M is regular, so it is possible to calculate the limiting distributions S in Table 3, which reveal where the distributions tend to in the long run.

Comparison of the initial and limiting distributions in Table 3 offers no support for divergence, and if anything it suggests convergence in the regional FDI shares. This is the case overall and for Groups I, II and IV. The pattern for Group III is indeterminate due to the increase in the FDI share in the lowest class, but otherwise it converges. The location pattern is therefore one of convergence, which is for all industry and broadly by sector and industry group. This is at odds with the sigma measure, for which divergence is found related to Group IV, but it points to the inadequacy of this other measure. The dramatic increase in FDI in Group IV over the period (see Figure 1), with about 60% of the increase locating in the South East, greatly increases the variance of the FDI shares. However, the transition matrices suggest the dominant *process* is that of convergence.

The Markov analysis uses quintile classes, but this means that the interval classes vary both between industry groups and relative to that overall. It was noted above that it is useful to examine sensitivity of the results. The transition matrices were re-estimated

but with common upper bounds of 0.05, 0.075, 0.10, 0.15 and 1. This gives a reasonably even initial distribution of FDI shares for all industry of 25%, 21%, 16%, 19% and 19% respectively, although it is highly unequal for some industry groups. The results, given in Appendix Table 2, no longer indicate convergence overall, but suggest a migration in the FDI shares to the smaller class. However, like the sigma measure, this is related to Group IV, while other industry groups show convergence. For Group IV common upper bounds seem inappropriate, as 50% of the initial observations for this industry group are in the smallest class.[13] Quintile classes are therefore preferred, and these indicate that the dominant pattern is convergence both for Group IV and overall.

5.2 Regional Mobility

Convergence may be associated with a smooth flow of FDI to the regions in which it was previously under-represented, or it may be accompanied by relatively large changes in the regional FDI shares, suggesting a high degree of mobility in regional location. A casual inspection of the transition matrices in Table 3 suggests the latter (e.g., if a region is in Class 3 the probability of it being in that class the next year never exceeds 0.5), but it is worthy of closer inspection. Clearly, of interest is the leading diagonal of M, and it is investigated using a variant of the Shorrocks' (1978) Index, as follows:[14]

$$SI = \frac{N - tr\ M}{N}. \qquad (2)$$

where $N = 5$ and $tr\ M$ is the trace operator of M. SI has a minimum value of zero when $M = I$ so there is no mobility, but $SI = 1$ when the leading diagonal has zeros.

The Shorrocks' Index SI is calculated in Table 4 based on the transition matrices using quintiles. Overall, $SI = 0.44$, which indicates a reasonably high degree of mobility,

as the average probability that a region transits to another class in the next year is around a half. The values of *SI* for the four industry groups are in the range 0.50 to 0.58, and they are consistent with the smaller value overall. There is relatively little variation in these across industry groups, and again they indicate a high degree of mobility.[15]

Another way to look at the convergence process is to examine the mobility of the regions in terms of the rank ordering in FDI shares. It is possible that high values of the Shorrocks' Index (high mobility) may be associated with low internal mixing of regions. The rank mobility index known as Kendall's τ is used (Rey, 2004). It involves all pair-wise comparisons of regions in their relative ranking between initial and terminal dates, based on the number of concordant N^C and discordant N^D pairs, i.e. identical or reversed rankings respectively. The index lies in the range [-1, +1] and it is given by:

$$\tau = \frac{N^C - N^D}{{}^R C_2}. \qquad (3)$$

In our case, R = 10, so ${}^{10}C_2 = 45$ is the number of pair-wise comparisons. The index is evaluated in Table 4 for initial and terminal dates of 1985-87 and 2003-05. In each case τ is positive, so $N^C > N^D$, but (with the exception of Group II) it is not especially high in value, suggesting limited internal mixing. Thus, while there is a high degree of mobility of regions across classes, on balance the regions keep their rankings. Since τ = 0.69 for Group II it is especially the case for this industry group. This is possibly because these projects arrived later, when regional policy was uniformly weaker (see below).

5.3 Time Homogeneity

The high degree of mobility of regions across classes indicated by the Shorrocks' index suggests convergence may not be a stationary process, and that it varies over time. The

time homogeneity of the transition probabilities for the Markov process was examined using the Pearson χ^2 test statistic (Bickenbach and Bode, 2003). Broadly, this involves partitioning the overall study period into a finite number of sub-periods q (= 1, 2, …, Q), estimating a transition matrix for each of these, and then for each row of each matrix, i (= 1, 2, …, N), for each sub-period, comparing the transition probabilities ($p_{ij|q}$) with that for the period as a whole (p_{ij}).[16] Let A_i denote the non-zero transition probabilities in the ith row and $n_{ij|q}$ the number of regions transiting from class i to j in sub-period q, then the Pearson statistic P_M for the transition matrix M is given by:

$$P_M = \sum_{q=1}^{Q} \sum_{i=1}^{N} \sum_{j \in A_i} n_{ij|q} \frac{\left(p_{ij|q} - p_{ij}\right)^2}{p_{ij}} \qquad (4)$$

This has an asymptotic χ^2 distribution with the degrees of freedom given by the number of independent pair-wise comparisons between $p_{ij|q}$ and p_{ij}.

To examine time homogeneity, three 7-year sub-periods were chosen, 1985-91, 1992-98 and 1999-05 (i.e. Q = 3), which represent natural breaks for the analysis. In the case of manufacturing, the regional impact of the regional grants was weakened in 1992 when areas outside the 'north' were designated for the first time, while spending on the grants fell in real terms from 2000. Further, Figure 1 shows different growth profiles for service FDI for the three sub-periods. The Pearson test statistics are presented in Table 5, which gives the 5% critical value in each case. To interpret and understand these, it shows the contribution of each sub-period to the overall test statistic P_M.

Table 5 shows that time homogeneity is rejected at the 5% level for all industry and for Groups I, II and IV, but at the 10% level for Group III. In the case of all industry and the manufacturing industries (I and II) the rejection is related to the third sub-period 1999-05, but for the service industries (III and IV) each sub-period tends to contribute to

this, which is perhaps not surprising given the FDI growth profiles exhibited in Figure 1. It is difficult to determine if the regional FDI shares converged or diverged in each sub-period as they are based on 70 observations, but the limit distribution for all industries suggests they continued to converge over 1999-05 but in a different manner.

6. Discussion of Results

Overall, the paper finds evidence of convergence in regional FDI shares over 1985-05, which is for all industry, for manufacturing and services, and for industries experiencing different growth rates in the number of foreign investments over the whole period. From a normative perspective, FDI convergence could be viewed as beneficial, detrimental or possibly neither, depending both on where it occurs and the judgement being exercised. On the one hand, agglomeration at the core could be viewed as beneficial on efficiency grounds given that it transmits positive externalities, but on the other hand a loss of FDI at the periphery could be viewed as detrimental for distributional reasons.

In order to consider this, FDI location between initial and terminal years over the study period is summarised in Table 6 according to the regions that comprise the 'north' and 'south'. In the latter case, a disaggregation is made between the core South East and other regions. A breakdown is also made between sectors, which is important given that the grants have overwhelmingly supported manufacturing FDI in the 'north'.

In absolute terms manufacturing FDI has fallen by 20% in the 'north' (Table 6), and relative to Great Britain as a whole it has fallen from 75% to 60% (Table 1), so that convergence in manufacturing has been achieved by a shift of new inward FDI from the 'north' to 'south'. It implies convergence in manufacturing FDI has been at the expense of the periphery. However, in the case of services a different pattern follows, as while it was initially at low levels, Table 6 shows that it grew more strongly in the 'south', and

in particular in the regions in the 'south' outside of the core South East (which is also the case for manufacturing). Convergence in services is therefore associated with a shift in FDI from the South East to contiguous regions within the 'south'. Nevertheless, while there is convergence, the South East region continued to receive the lion-share of service FDI, with its share increasing from 36% to 51% over the study period.[17]

Finally, to examine these different spatial processes it is possible to test for the spatial homogeneity of the transition matrices. It involves repeating the homogeneity test in (4), but for the whole sample period and with the regions partitioned into 'north' and 'south'. In this case, spatial homogeneity is rejected at the 1% level for all industry, and for each industry group.[18] The results for the 'north' suggest it is associated with a shift in regional shares down the size classes, consistent with a change in FDI location from 'north' to 'south' and the weakening of regional policy. Further, for the 'south' the limit distribution shows convergence, which confirms the change in FDI location from core to contiguous regions, and it suggests there is some limited spreading-out of FDI.

7. Conclusions

The purpose of this paper has been to investigate the location of FDI projects across the regions of Great Britain over 1985-05. It is perhaps the first time that the issue of FDI location has been analysed in the framework of Markov chains. Overall, the paper finds evidence of convergence in location with a reduction over time in the number of regions with relatively large or small FDI shares. This is also the case by sector (manufacturing and services) and for industries showing different growth profiles in the number of FDI projects over time. On balance, regions have tended to keep their relative ranking, but the study points to a high degree of mobility in FDI location over time.

The central result of the paper is to demonstrate the importance of agglomeration in the regional location of FDI over a long time period, although the extent to which this is due to externalities or pecuniary external effects cannot be ascertained. In the case of manufacturing the role of the regional grants in locating FDI to the 'north' was pointed to, but this seems to be unravelling. In particular, the weakening of UK regional policy, in both its areal coverage and expenditure, means that it is no longer able to counter-act the agglomerative pull of the 'south', so that FDI is locating in the south, generating a pattern of convergence. Likewise, there is convergence in service FDI, but a different spatial process, as the change in location is from the core South East to the regions that are contiguous. In fact, regions in the south outside the core show the greatest growth in FDI in services and manufacturing over the period 1985-05, which perhaps indicates that there are diseconomies from locating in the South East of England.

The implication of this is that it suggests UK regional policy is no longer able to bias the distribution of manufacturing FDI in favour of the less-developed regions, as it once did. Further, service FDI favours the core South East region, and while there is evidence of it spreading-out geographically this is only as far as neighbouring regions. It suggests there is scope to develop regional policy in relation to service FDI, especially as this now accounts for the majority of all foreign investment in the UK. In the absence of this, it seems FDI as a whole will continue to favour the south of England, which has already increased at ten times the rate in the south compared to the north since 1985. As regards future work, the paper finds an interesting shift in FDI location within the south of England, and this warrants further exploration at the sub-regional level.

Table 1: Regional Distribution of FDI Projects, 1985-05

Region	No. of Projects		Share of Projects		Growth quotient*	GDP share 2005
	Initial	Terminal	Initial	Terminal		
South East	68	347	19.0	40.2	2.12	32.9
South West	14	42	3.8	4.9	1.29	8.0
East	5	64	1.5	7.4	4.93	10.2
East Midlands	14	53	4.0	6.1	1.53	6.7
('South')	*(101)*	*(505)*	*(28.3)*	*(58.6)*	*(2.07)*	*(57.8)*
West Midlands	71	65	20.0	7.5	0.38	8.3
York & Humber	20	42	5.6	4.8	0.86	7.7
North West	32	84	8.9	9.7	1.09	10.3
North East	29	52	8.0	6.1	0.76	3.5
Scotland	48	61	13.3	7.0	0.53	8.4
Wales	57	54	15.9	6.3	0.40	4.0
('North')	*(256)*	*(358)*	*(71.7)*	*(41.4)*	*(0.58)*	*(42.2)*
Great Britain	357	863	100.0	100.0	1.00	100.0

Notes: 'Initial' = annual mean over 1985-87 and 'terminal' = annual mean over 2003-05. * Growth quotient is calculated between initial and terminal years, standardised by national growth rate, i.e. the ratio of the fourth and third columns.

Table 2: Sigma Measures of Convergence

	All industry	Group I	Group II	Group III	Group IV
1985-87	0.066	0.059	0.074	0.114	0.117
2003-05	0.107	0.042	0.055	0.104	0.173

Note: Figures are standard deviations of the mean regional shares of FDI for each sub-period.

Table 3: Transition Matrices and Limiting Distributions: Quintiles

Upper Bound	Initial Distribution	Class	Transition probabilities (t - 1 to t)					Limiting Distribution
(a) All Industries								
			1	*2*	*3*	*4*	*5*	
0.046	0.200	*1*	0.691	0.262	0.047	0	0	0.196
0.066	0.200	*2*	0.270	0.351	0.243	0.108	0.027	0.207
0.098	0.200	*3*	0	0.282	0.487	0.232	0	0.227
0.139	0.200	*4*	0.024	0.098	0.268	0.464	0.146	0.195
1.000	0.200	*5*	0	0	0.024	0.171	0.805	0.175
(b) Group I: Manufacturing - Decliners								
			1	*2*	*3*	*4*	*5*	
0.044	0.200	*1*	0.595	0.333	0.048	0.024	0	0.196
0.073	0.200	*2*	0.270	0.351	0.216	0.135	0.028	0.201
0.112	0.200	*3*	0.073	0.195	0.293	0.342	0.097	0.202
0.152	0.200	*4*	0.050	0.100	0.225	0.325	0.300	0.207
1.000	0.200	*5*	0	0.025	0.225	0.200	0.550	0.194
(c) Group II: Manufacturing - Growers								
			1	*2*	*3*	*4*	*5*	
0.044	0.200	*1*	0.659	0.195	0.122	0.024	0	0.191
0.072	0.200	*2*	0.237	0.395	0.263	0.105	0	0.212
0.103	0.200	*3*	0.050	0.250	0.350	0.275	0.075	0.206
0.155	0.200	*4*	0.025	0.200	0.250	0.300	0.225	0.199
1.000	0.200	*5*	0	0	0.024	0.293	0.683	0.191
(d) Group III: Services - Growers								
			1	*2*	*3*	*4*	*5*	
0.028	0.200	*1*	0.488	0.220	0.146	0.122	0.024	0.205
0.053	0.200	*2*	0.263	0.316	0.290	0.079	0.052	0.190
0.081	0.200	*3*	0.125	0.275	0.200	0.250	0.150	0.198
0.138	0.200	*4*	0.075	0.100	0.300	0.425	0.100	0.213
1.000	0.200	*5*	0.073	0.048	0.049	0.171	0.659	0.193
(e) Group IV: Services - Strong Growers								
			1	*2*	*3*	*4*	*5*	
0.001	0.200	*1*	0.558	0.023	0	0.256	0.163	0.118
0.036	0.200	*2*	0	0.500	0.395	0.105	0	0.292
0.068	0.200	*3*	0	0.405	0.460	0.135	0	0.293
0.167	0.200	*4*	0.195	0.122	0.244	0.317	0.122	0.177
1.000	0.200	*5*	0.146	0.024	0	0.171	0.659	0.119

Table 4: Tests of Mobility

	All industry	Group I	Group II	Group III	Group IV
Class Mobility (SI)[1]	0.44	0.58	0.52	0.58	0.50
Rank Mobility (τ)[2]	0.38	0.33	0.69	0.29	0.38

Notes: 1 = variant of Shorrocks' Index, as in text (range 0 to 1); and 2 = Kendall's τ statistic (range -1 to +1).

Table 5: Tests of Time Homogeneity

	All industry	Group I	Group II	Group III	Group IV
1985-91	12.2	7.8	8.3	13.0	63.2
1992-98	11.6	11.7	9.3	19.3	124.9
1999-05	20.3	34.2	31.7	18.2	117.2
Sum	44.1*	53.7*	49.3*	50.5	305.4**
Critical value (5%)	41.3	51.0	46.2	55.8	43.8

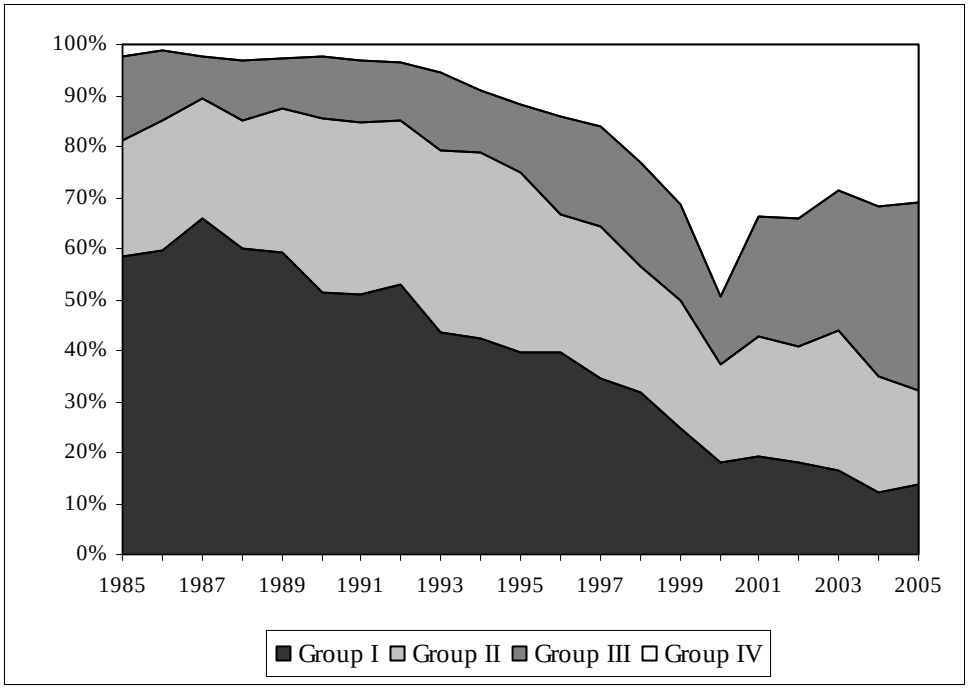
Note: Pearson χ^2 goodness-of-fit statistic (P_M); significant at ** = 1% level, * = 5%.

Table 6: Location of FDI by Sector and Region

	Manufacturing			Services			All industry		
	Initial	Terminal	Ratio	Initial	Terminal	Ratio	Initial	Terminal	Ratio
'North'	683	554	*0.8*	86	519	*6.1*	769	1,073	*1.4*
'South'	229	382	*1.7*	74	1,134	*15.4*	303	1,516	*5.0*
(South East)	(145)	(197)	*(1.4)*	(58)	(844)	*(14.6)*	(203)	(1,041)	*(5.1)*
(Rest of 'South')	(84)	(185)	*(2.2)*	(16)	(290)	*(18.1)*	(100)	(475)	*(4.8)*
Great Britain	912	936	*1.0*	160	1,653	*10.3*	1,072	2,589	*2.4*

Notes: Total number of FDI projects, where Initial = 1985-87 and Terminal = 2003-05. Ratio = Terminal / Initial. For regions comprising 'North' and 'South', see Table 1.

Figure 1: Industry Group FDI Shares by Year



Appendix Table 1: Classification of Industry Groups, 1985-05

Industry (NACE, rev. 1)	No. of projects	Growth rate	Median year
Group I: Manufacturing - Decliners			
Textiles and Textile Products (17 and 18)	170	0.8	1995
Wood and Wood Products (20)	94	0.3	1991
Pulp, Paper and Paper Products (21)	201	0.9	1994
Chemicals (24, excl. 24.4)	473	0.8	1994
Rubber and Plastic Products (25)	418	0.8	1995
Mineral Products (26)	155	0.8	1995
Basic Metals (27)	193	0.3	1993
Metal Products (28)	380	0.9	1996
Machinery (29)	797	0.6	1994
Electronic Components (32.1)	493	0.2	1993
TV and Radio (32.2 and 32.3)	271	0.2	1991
	(3,645)	*(0.8)*	*(1994)*
Group II: Manufacturing - Growers			
Food, Beverages and Tobacco (15 and 16)	360	2.9	1998
Leather and Leather Products (19)	26	1.7	1997
Publishing and Printing (22)	131	4.0	1998
Coke, Refined Petroleum Products (23)	25	-*	2000
Pharmaceuticals (24.4)	231	2.8	1999
Office Machinery (30)	131	2.0	1997
Electrical Machinery (31)	399	2.8	1997
Medical and Optical Instruments (33)	339	1.1	1996
Motor Vehicles (34)	779	1.5	1996
Other Transport (35)	189	5.8	1997
Furniture and Leisure Goods (36)	217	2.5	2002
Recycling (37)	30	-*	2002
	(2,857)	*(1.6)*	*(1997)*
Group III: Services - Growers			
Wholesale (50 and 51)	411	2.3	1998
Retail (52)	224	4.3	2002
Hotels and Restaurants (55)	65	2.1	1999
Transport and Travel (60 to 63)	314	5.5	2001
Insurance and Pension Funding (66)	40	2.9	2001
Auxiliary Financial Intermediation (67)	80	4.9	2000
Renting (71)	47	3.0	1997
Research and Development (73)	423	6.9	2003
Professional Business Services (74.1 and 74.2)	426	5.4	2001
Public Administration (75)	20	6.3	2000
Health and Social Work (85)	67	4.4	2000
Social and Personal Services (90, 92, 93, 95 and 99)	176	2.8	2001
	(2,293)	*(4.1)*	*(2001)*
Group IV: Services - Strong Growers			
Telecommunications (64)	257	12.6	2000
Financial Intermediation (65)	229	11.9	2001
Real Estate (70)	30	29.0	2003
Computer Consultancy (72.1 and 72.2)	940	16.8	2002
Computer Activities and Software (72.3 to 72.6)	507	40.4	2000
Other Business Activities (74.3 to 74.8)	393	11.0	2001
Education (80)	36	17.0	2001
	(2,392)	*(16.5)*	*(2001)*
Total	11,187	2.3	1998

Note: Growth rate is ratio of the number of projects between 2003-05 and 1985-87 for all industry and manufacturing but the last and first 10 years for service industries, owing to small numbers early on. * indicates no projects in initial period. Median year is when median FDI project occurred.

Appendix Table 2: Transition Matrices and Limiting Distributions: Common Bounds

Upper Bound	Initial Distribution	Class	Transition probabilities (t - 1 to t)					Limiting Distribution
(a) All Industries								
			1	*2*	*3*	*4*	*5*	
0.050	0.257	*1*	0.726	0.255	0.019	0	0	0.279
0.075	0.209	*2*	0.300	0.400	0.175	0.125	0	0.225
0.100	0.162	*3*	0	0.273	0.485	0.242	0	0.166
0.150	0.186	*4*	0.053	0.105	0.211	0.421	0.210	0.175
1.000	0.186	*5*	0	0	0.026	0.211	0.763	0.155
(b) Group I: Manufacturing - Decliners								
			1	*2*	*3*	*4*	*5*	
0.050	0.271	*1*	0.636	0.237	0.073	0.036	0.018	0.269
0.075	0.143	*2*	0.444	0.185	0.111	0.259	0	0.140
0.100	0.114	*3*	0.167	0.167	0.125	0.333	0.208	0.117
0.150	0.258	*4*	0.060	0.080	0.180	0.480	0.200	0.270
1.000	0.214	*5*	0	0.046	0.091	0.273	0.590	0.204
(c) Group II: Manufacturing - Growers								
			1	*2*	*3*	*4*	*5*	
0.050	0.252	*1*	0.653	0.225	0.102	0.020	0	0.251
0.075	0.181	*2*	0.324	0.378	0.108	0.190	0	0.193
0.100	0.138	*3*	0.069	0.207	0.276	0.310	0.138	0.144
0.150	0.205	*4*	0.075	0.150	0.250	0.250	0.275	0.193
1.000	0.224	*5*	0	0.002	0.004	0.267	0.667	0.219
(d) Group III: Services - Growers								
			1	*2*	*3*	*4*	*5*	
0.050	0.371	*1*	0.622	0.189	0.135	0.040	0.014	0.367
0.075	0.167	*2*	0.364	0.273	0.091	0.181	0.091	0.168
0.100	0.148	*3*	0.233	0.100	0.267	0.200	0.200	0.152
0.150	0.133	*4*	0.231	0.231	0.231	0.307	0	0.143
1.000	0.181	*5*	0.054	0.027	0.081	0.135	0.703	0.170
(e) Group IV: Services - Strong Growers								
			1	*2*	*3*	*4*	*5*	
0.050	0.500	*1*	0.673	0.109	0.129	0.020	0.069	0.513
0.075	0.114	*2*	0.550	0.250	0.150	0.050	0	0.128
0.100	0.157	*3*	0.344	0.156	0.281	0.063	0.156	0.154
0.150	0.024	*4*	0.400	0.600	0	0	0	0.026
1.000	0.205	*5*	0.191	0	0.143	0	0.667	0.179

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Notes

[1] Brand *et al* (2000) find FDI accounts for 80% of the output of electronics and electrical engineering in Scotland, but for the West Midlands it is 60% of transport equipment and for Wales these are electronics (38%), metals (28%) and transport equipment (21%).

[2] It suggests the country of origin is important, but different countries tend to invest in different industrial sectors (see Jones and Wren, 2006).

[3] In its simplest form, the β-convergence approach involves estimating a cross-section between initial and terminal dates, and examining the estimated coefficient on the initial level. Quah (1993a) shows it is inappropriate to draw dynamic implications from cross-section evidence, while Quah (1993b) argues the stable steady-state growth path implicit in the β-convergence approach makes it questionable. Fingleton (1999) finds the Markov approach attractive by virtue of its ability to accommodate shocks and discontinuities.

[4] The Markov matrix M is regular if there exists some positive integer k such that all the elements of the matrix M^k are positive (Janssen and Manca, 2006, p. 107).

[5] We can write $S\,M = S$ as $S\,(M - I) = 0$, where I is the identity matrix. It has a solution $S = 0$, so it must be solved with the constraint, giving N equations in N unknowns.

[6] The data are described in Jones and Wren (2008a), where its advantages relative to the UK production census, the *Annual Business Inquiry*, are discussed. At a regional level it is shown that the datasets do not differ significantly statistically, but that 'census' data samples only smaller plants and omits many projects, which in any case may be difficult to identify. Wren and Jones (2009) find that virtually all projects go ahead for a detailed analysis of the dataset for North East England over 1985-98.

[7] Changes were made to the boundaries in 1996 when the UK moved to Government Office Regions from Standard Regions, mainly affecting the South East and East. Prior to 1996 the South East included the counties of Bedfordshire, Essex and Hertfordshire, which are now in the East, and the North East included the county of Cumbria, which is now in the North West. Cumbria is rural and received little FDI, while projects were assigned to the South East from the East *pro rata* according to the pattern after 1996.

[8] At the end of the study period, the 'north' has 48% of population but 42% of GVA.

[9] Indeed, the extent of this can be observed from the fact that over the period 1985-05, the number of foreign investments increased at ten times the rate in the 'south' compared to the 'north', i.e. 40% in the 'north' (257 to 358 projects) but 400% in the 'south'.

[10] An alternative source is the *Annual Business Inquiry*, which has spatially referencing, but in fact this samples as little as 1 in 5 plants with less than 100 employees (Griffith, 1999) and most FDI start-up plants fall within this size band (Jones and Wren, 2006).

[11] These are mainly 2-digit industries or amalgamations at this level, although a few 2-digit industries are sub-divided: NACE industry 24 into chemicals and pharmaceuticals; 72 into computer consultancy and software; and 74 into professional business services and other business activities. About 300 investments in agriculture, mining, construction and utilities are excluded from the analysis.

[12] This is on the basis of comparable growth rates, unlike those presented below.

[13] In the time homogeneity tests below common upper bounds also mean the transition matrices are irregular by sub-period, giving further support for the quintile classes.

[14] It is a variant of Shorrocks, who uses N - 1 as the denominator, but this has appeal as it fixes the maximum value at unity. There are a number of similar indices (Rey, 2004).

[15] If common bound classes are used there is little difference, except that SI = 0.63 for Group IV, related to the small number of observations in Class 4 (Appendix Table 2).

[16] Another test is the LR test, which is asymptotically equivalent (Bickenbach and Bode, 2003). This was calculated for all industry, but the same conclusion was arrived at.

[17] These are 58 of 160 (36%) and 844 of 1,653 projects (51%) in Table 6.

[18] Likewise, spatial homogeneity was rejected for each of industry Groups I, II and III at the 1% level, but at the 5% level for Group IV.

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