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Does Service FDI Locate Differently to Manufacturing FDI?

A Regional Analysis for Great Britain

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Abstract

This paper analyses the location of foreign direct investment in services at the NUTS 2 region level for Great Britain over 1996-2005, covering the period of growth in FDI. It finds strong differences in service FDI location compared to manufacturing FDI. Unlike manufacturing, service FDI location is determined at no higher than the NUTS 2 region level, while it is more dynamic and converging to the larger markets. A similar pattern is found for the services that are most forward-linked to manufacturing industries. The paper concludes that access to final consumer demand is important for service FDI, with implications for UK regional policy.

Keywords: FDI; service sector; industrial location; convergence.

JEL classification: R30, R34, R12.

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1. Introduction

Foreign direct investment (FDI) in the service sector is a key driver of global FDI flows over recent decades, and it now accounts for half the value of ‘greenfield’ investment (UNCTAD, 2013). The growth in service FDI is most notable in developed countries (UNCTAD, 2004), and especially Great Britain where the number of service-based investment projects increased five-fold between 1985 and 2010 (UK TRADE and INVESTMENT, 2012). FDI is mobile and it brings many benefits to the regional economy, including employment and other development gains (BAGCHI-SEN, 1995), making it an important target for policymakers (see GABE and KRAYBILL, 2002; CROZET et al., 2004; WREN and JONES, 2011).¹ However, while the regional location of manufacturing FDI is extensively studied in the UK and elsewhere (e.g. HILL and MUNDAY, 1992; PELEGRIN and BOLANCÉ, 2008), relatively little is known about the location of service FDI at a sub-national level. This is of interest as manufacturing FDI has shifted its location in the UK from the periphery to the core of the economy (WREN and JONES, 2012), so that a key issue for regional development is whether service FDI has compensated for this or merely served to reinforce this location pattern.

While theory can offer insights regarding this issue, it does not give a clear prediction. It is argued that manufacturing is important for producer services due to the forward linkages, (RAMASAMY and YEUNG, 2010) and that service FDI plays a crucial role in facilitating global production (HANSEN, 1990; GROSS et al., 2005), so their location is complementary.

However, contrary to this, it is argued that FDI relies on global rather than regional supply chains (PHELPS, 2009) and in particular that services are both produced and consumed in the same place (KOLSTAD and VILLANGER, 2008; RIEDL, 2010), in which case service FDI location is driven by a large customer base for final demand. Much of the empirical evidence for service FDI location is at the national level, and it may not distinguish it from domestic service location, so that in practice the sub-national location of service FDI is essentially an empirical matter, including its location relative to manufacturing FDI.

In this paper service FDI location is examined at the NUTS 2 regional level for Great Britain over the period 1996-2005. This covers the strong growth in service FDI and to our knowledge it is the first study to investigate FDI location in the UK at this level.² The NUTS 2 regions are advantageous as it is possible to identify the major urban areas where activity may agglomerate (PELEGRIN and BOLANCÉ, 2008). To capture the location decision and allow for varying levels of investment over time, FDI is analysed as the annual regional share of the number of projects for Great Britain.³ This is relative to the economic size of regions using location quotients, so that if FDI is over-represented in a region then this implies that it is agglomerated, which is *prima facie* evidence for an agglomeration economy. The source of this agglomeration economy cannot be discerned, but the paper reveals that important forces are present in FDI location across regions. The data are for ‘productive’ investment only, i.e. ‘greenfield’ and re-investments, but which are of interest for regional policy purposes.

The paper has three main contributions. First, it seeks to determine where service FDI is locating at the British region level, about which little is known. Second, it investigates the issue of spatial autocorrelation to examine the spatial scale at which service FDI locates. If the data are uncorrelated across NUTS 2 regions then the locational determinants of FDI exist at no higher level. Finally, the paper investigates the dynamics of service FDI location using Markov transition matrices and in particular the convergence of location, which will indicate

the presence of agglomeration economies. Throughout, comparison is made with the location of manufacturing FDI in order to examine if service FDI is locating differently. In order not to mask important differences these location patterns of FDI are analysed separately, although a direct comparison is also made between these to see if they are converging.

Overall, the analysis reveals important differences between the location of service and manufacturing FDI, suggesting that on the whole the locational determinants differ between these. Service FDI locates at no higher level than the NUTS 2 region, and as it has grown it has converged to the regions with larger markets, suggesting that market access is important. Manufacturing FDI locates at a larger spatial scale and it is much less dynamic in its location compared to service FDI owing to its reliance on re-investment. Service and manufacturing FDI have both converged in location, but to different regions, which is also the case for the service industries that are most vertically linked to manufacturing. The paper concludes that service and manufacturing FDI are driven by different location factors, and that service FDI has not directly countered the shift in manufacturing FDI, which has regional policy implications.

The next section considers the literature and sets out competing hypotheses. Section 3 outlines the data and the method used to determine FDI location, and section 4 describes the FDI location patterns. Section 5 uses location quotients to analyse spatial autocorrelation and section 6 explores the dynamics of FDI location. Conclusions are drawn in section 7.

2. Background to the Study

The location of foreign direct investment across the regions of Great Britain is extensively studied (e.g. HILL and MUNDAY, 1992; STONE and PECK, 1996; BRAND et al., 2000; FALLON and COOK, 2010), but this is for manufacturing FDI and at a reasonably high level

of spatial aggregation, i.e. Standard Regions or Government Office Regions corresponding to the NUTS 1 regions of the European Union. This applies to similar work carried out in other European countries, such as PELEGRIN and BOLANCÉ (2008) on Spain and HILBER and VOICU (2010) on Romania, although location is sometimes explored at a lower level of spatial aggregation, such as CROZET et al. (2004). In the case of service FDI, research tends to be for particular regions and has focused on producer services, e.g. MARSHALL (1982) and BAGCHI-SEN (1995). In this paper total service FDI is examined at the NUTS 2 level, where on average there are three of these regions to each NUTS 1 region. To interpret the results competing hypotheses can be formed about how service FDI might locate relative to manufacturing FDI. This relies on the new economic geography (ASCANI et al., 2012). This highlights many of the same location factors as the international business location literature, but it draws attention to the way in which these interact and it predicts agglomeration.

Some location factors of the new economic geography relate to the industry or firm level, such as monopolistic competition or increasing returns to scale, but others pertain to the region level, including market size, transport costs and external economies, e.g. labour pools, intermediate goods suppliers or spillovers. While these include non-market knowledge flows, the new economic geography emphasises the pecuniary flows that occur in the intermediate goods and labour markets. Several forces drive the location decision, where in broad terms firms in an industry are drawn together by demand and production linkages, but driven apart by competition in the goods and labour markets (PUGA, 1999). Transport costs also matter, so that an industry may locate in the core or periphery of an economy depending on whether these are relatively high or low. While the model is couched in terms of manufacturing, the location factors that are identified could be applied to services (see KRENZ, 2010).

Several competing hypotheses follow from this model in the way service FDI locates

relative to manufacturing FDI. First, if service FDI is vertically linked to manufacturing FDI then an agglomeration of these is likely to occur by a circular causation argument, so that they locate close to each other. While it applies to producer services (RAMASAMY and YEUNG, 2010; KOLSTAD and VILLANGER, 2008), it may also apply to consumer services that are served by manufacturing. Second, and counter to this, if service FDI satisfies final consumer demand then a market-seeking motive is likely to be important for location (RIEDL, 2010). Service activities may be less amenable to economies of scale, while if face-to-face contact is important so that transport costs are high, then it also points to the importance of market size. This may be reinforced by the labour market if higher wages draw in more workers and drive up the demand for consumer services, while service FDI may hire from its own labour market pool. It contrasts with manufacturing FDI, which is likely to be reliant on input markets.

The empirical evidence on service FDI location is somewhat contradictory, as there is evidence that it locates with manufacturing FDI at a country or regional level (RAMASAMY and YEUNG, 2010; MARSHALL, 1982), but also evidence that it is drawn to final consumer demand (KOLSTAD and VILLANGER, 2008), although the former tends to be driven by producer services (BAGCHI-SEN, 1995). There is more evidence for manufacturing FDI, which shows that there are agglomerations by activity in some British regions (STONE and PECK, 1996; BRAND et al., 2000). A consistent finding is that the UK regional grants are important to manufacturing FDI location (TAYLOR, 1993; JONES and WREN, 2006). Up to the mid-1990s manufacturing FDI located mainly in the peripheral regions attracted by the grants (HILL and MUNDAY, 1992), but since this time there is a shift away from these areas that is coincident with a weakening in UK regional policy (WREN and JONES, 2012).

3. The FDI Dataset

The FDI data are project based and are sourced from *UK Trade and Investment*, which is the main government agency for inward investment. These data are used to report inward FDI flows by the UK government and they are similar to data used elsewhere to examine location (e.g. HILL and MUNDAY, 1992; DIMITROPOULOU et al., 2008). They relate to productive investment in the form of ‘greenfield’ FDI and expansions at existing sites, so that they do not include financial investment in the form of mergers and acquisitions.⁴ Productive FDI brings with it jobs and is of more interest from a UK regional policy perspective. Expansions are a major upgrading of an existing plant, such as a new production line (see WREN and JONES, 2009). These are likely to be less mobile as they involve a sunk cost at the initial location, although they may still substitute for FDI at another UK location.

The FDI data relate to firm commitments, possibly unannounced, and they capture the location decision. They are collected at national and regional levels by the government and its agencies. An analysis for a single region finds that almost all projects go ahead (JONES and WREN, 2004), and comparison of the regional distribution of FDI flows over 1996-2005 with the stock of foreign-owned plants at the end of the period in the UK production census reveals no significant difference (WREN and JONES, 2011). Nevertheless, it is possible that *UK Trade and Investment* may be less likely to capture smaller FDI projects, which are more likely to be in services. These smaller projects are of less interest, although the data do in fact include many smaller FDI projects in both services and manufacturing.⁵ There is no reason to believe that the data collection is biased towards any particular region.

(Table 1 about here)

In total, the data comprise 5,371 new and expansion investments by foreign-owned plants in Great Britain over the period 1996-2005. For each project the information includes the name of the investor, the year of commitment and the two-digit industrial activity. The investment scale is not known for about a third of projects, but the number of jobs is known

in nearly all cases. Table 1 gives the number of service projects by industry for the beginning and end of the study period, showing the strong growth in service FDI (it is less than that reported in the Introduction due to the exclusion of the acquisitions). Table 1 disaggregates the service sector by industry, and using the *UK Input-Output Table* it shows the share of an industry's output that goes to UK manufacturing as a proportion of either intermediate or total demand (i.e. including consumer demand). Ranked by the latter it reveals that service FDI growth tends to have occurred in the industries that are forward-linked to manufacturing. For the first five industries in Table 1 the increase in the number of service FDI projects is from 91 to 194 projects, but for the last five industries it is from 186 to 642. These forward-linked industries only loosely correspond to the OECD definition of producer services.⁶

3.1 Determining the Regional Location

The data give the project location at a NUTS 1 level, which correspond to the 11 Government Office Regions for Great Britain, whereas FDI location is sought at the NUTS 2 region level, which have greater administrative and policy meaning (BECKER et al., 2010). Amendments in 1999 split the NUTS 1 region for London into Inner and Outer London, but as a location search often failed to provide sufficient information to distinguish between these the NUTS 1 region for London is used. This means there are 35 regions for Great Britain, as in Appendix Figure 1. The *UK Trade and Investment* data give the ultimate owner and plant name, and the *Companies House Web Check* database was used to determine the NUTS 2 location, which allows search to be undertaken on the current, dissolved, previous and proposed name.

If a name search is successful, details of the company's address, date of incorporation, country of origin and industry are provided, so that the match can be made against the known FDI details, such as the NUTS 1 location. If a search was unsuccessful or inconclusive then

other sources were consulted, including the investor's website and the *192.com* business directory. Finally, for the outstanding cases, a search was made on *google.co.uk* against the company name and NUTS 1 region, while historical online checks were made using national and regional press websites. Overall, the success rate in finding the NUTS 2 location is 89%.⁷ This excludes London, but to make it comparable the respective success rate was applied to the overall number of London projects in each year.

The success rate in determining the NUTS 2 location is in the range 87% to 91% for each year. There is no increase in this rate for FDI locating later in time (see Figure 1 below), which suggests that closures are not an issue. There is also little variation in this rate across NUTS 1 regions, lying between 85% and 95%, although 79% for the East region that could reflect institutional factors.⁸ The success rate varies by the job scale, but this is expected, as smaller projects are more likely to Anglicize their name and have higher exit rates, making it more difficult to determine their location.⁹ The number of smaller projects increases around the year 2000, related to the 'dot.com boom' in computer-related activities, but overall the success rate in finding the NUTS 2 location of the smaller projects is constant over time.

(Figure 1 about here)

The overall success rate in finding the NUTS 2 location differs between services and manufacturing (87% and 92%), reflecting the smaller scale of service FDI. Of the projects for which the NUTS 2 location is known, 55% are in services and 43% in manufacturing, so only 2% are outside these sectors. Figure 1 shows the number of services and manufacturing projects for each year, disaggregated by new and expansion FDI. It shows that manufacturing FDI is broadly constant over time at about 250 projects a year, so that service FDI determines the overall temporal pattern of FDI. Service FDI is mainly in the form of new investments, and the spike from the boom around the year 2000 is apparent. Service FDI grew and became the dominant form of foreign investment in Great Britain over the study period.

3.2 The FDI Location Quotient

Initially, no reference is made to the size of regions, but as larger regions get more projects by virtue of their size, the subsequent analysis is based on location quotients. Let FDI_{kr} denote the number of projects in sector k (= services, manufacturing or all) and region r ($= 1, 2, \dots, R$) and the region size by Q_{kr} , where $\bar{x}$ is the mean of x across R regions, the FDI location quotient LQ_{kr} is:

$$LQ_{kr} = \frac{\frac{FDI_{kr}}{\sum_r FDI_{kr}}}{\frac{Q_{kr}}{\sum_r Q_{kr}}} \equiv \frac{\frac{FDI_{kr}}{Q_{kr}}}{\frac{FDI_k}{\bar{Q}_k}}. \quad (1)$$

The regional size Q_{kr} is measured by the gross domestic product, which captures the level of economic activity. This is a reasonable base for comparing FDI in regions of different size, and it is likely to be correlated with alternatives such as income or population. It can also be measured for services and manufacturing for each region in each year. A location quotient greater than unity suggests that FDI is ‘over-represented’ in a region and hence agglomerated, which is *prima facie* evidence for the existence of an agglomeration economy. If $LQ_{kr} = 1$ the second expression in (1) shows that a region r attracts FDI relative to its economic size equal to the mean of this across regions and this is the basis for examining convergence.

The remainder of the paper is structured as follows. Initially, the regional location pattern of FDI is considered, both for the number of projects and for the location quotients. Second, the spatial autocorrelation of location is analysed. This reveals whether the location determinants arise at the NUTS 2 region level or at a larger spatial scale. Finally, the Markov

transition matrices are analysed, which reveals information on the dynamics of FDI location and the issue of convergence. The latter is where the pattern of FDI location becomes more uniform across regions over time relative to the distribution of output. This analysis is for service FDI, but throughout comparison is made with the location of manufacturing FDI.

4. The Regional Location of Service FDI

The geographic distribution of FDI projects across the NUTS 2 regions is shown in Figure 2. For each region this calculates the national share of projects for Great Britain as a whole over 1996-2005 and maps this according to quintile classes, so that each class has seven of the 35 regions. The class boundaries expressed as decimals are given in the key to each figure. This does not allow for the economic size of the regions. Figure 2(a) is for all FDI and 2(b) and 2(c) are for service and manufacturing FDI. They show the regions with the largest absolute FDI share occur across the landmass of Great Britain and include parts of the south-east and north-east of England, south-west Scotland and west Wales. Manufacturing FDI is drawn to these regions but also to the rest of Wales and the contiguous regions in England. For service FDI the south east of England is important, including the regions that include Cambridge and Oxford Universities (areas 14 and 21 in Appendix Figure 1). These attract more service FDI than the more-populous metropolitan regions of West and South Yorkshire, Merseyside and south Wales. Measuring FDI by the number of jobs similar location patterns exist.¹⁰

(Figure 2 about here)

The regional distribution of FDI location quotients for 1996-2005 is mapped in Figure 3. There is a more pronounced pattern for all FDI in Figure 3(a) than Figure 2(a), such that the regions that do well in attracting FDI relative to their size are the groups of NUTS 2 regions that correspond to the NUTS 1 regions of north-east England, Wales and Scotland.

Regions that do poorly in attracting FDI are the south-west of England and a central belt of England that stretches from Lincolnshire on the east coast to Lancashire on the west coast (Appendix Figure 1). Figures 3(b) and 3(c) show that it is largely accounted for by manufacturing FDI, although these areas also attract little service FDI. Service FDI locates disproportionately in or around the major urban areas, including London, West Midlands, Manchester, Merseyside, Newcastle and Glasgow, as well as around Cambridge and Oxford.¹¹

(Figure 3 about here)

The temporal pattern of FDI location quotients is considered in Figure 4 for three 2-year periods: 1996-97, 2000-01 and 2004-05. In each case these are quintile classes, where the boundaries are again given in the keys. Underlying the location of manufacturing FDI there is a ‘North-to-South’ shift referred to above, which is especially evident between 2000-01 and 2004-05 (WREN and JONES, 2012). As service FDI has grown, Figure 4 shows that it has changed location, since whereas its location was similar to manufacturing FDI in 1996-97, albeit with a concentration in a corridor to the west of London, it is located in or close to the urban areas by the end of the study period, including parts of south-east England. Given the strong growth in service FDI it is this latter pattern that underlies Figure 3(b).

(Figure 4 about here)

5. The Spatial Scope of Service FDI Location

The above maps suggest that service FDI locates at a different spatial scale to manufacturing, which indicates that its locational determinants differ. The issue of spatial autocorrelation in FDI location is examined formally using the MORAN (1950) spatial association indicator I . This is at the NUTS 2 level for which a spatial weights matrix is based on the contiguity of

regions, i.e. a common land boundary (a higher order of contiguity is not considered since on average a NUTS 1 region comprises three NUTS 2 regions only). Significant positive spatial autocorrelation implies that NUTS 2 regions with a relatively high FDI location quotient tend to be contiguous with each other, suggesting that the location determinants operate at a higher spatial scale than the NUTS 2 level, but otherwise that location is at no higher level.

The global measure of spatial autocorrelation I_k for industry grouping k is as follows (ANSELIN, 1995), where z_{kr} and z_{ks} are the deviations from the respective regional means of the FDI location quotients for regions r and s , w_{rs} is a row-standardised spatial weights matrix that captures contiguity and R is the number of regions:

$$I_k = \frac{R \sum_r \sum_s w_{rs} z_{kr} z_{ks}}{\sum_r \sum_s w_{rs} \sum_r z_{kr}^2}.$$

The global Moran's I for the FDI location quotients are calculated for each year in Table 2. It shows that there is significant positive spatial autocorrelation for all FDI in most years and that for manufacturing it is for each year at the 10% level or higher.¹² Spatial autocorrelation is positive for service FDI, but generally insignificant. The results are consistent with Figure 3 and they suggest that service FDI location is determined by factors that operate at no higher level than the NUTS 2 region, but that the converse is the case for manufacturing FDI.

(Table 2 about here)

The global Moran's I can be decomposed to give a local Moran's I for each NUTS 2 region over 1996-2005. They are calculated relative to contiguous regions and they indicate the extent to which the global Moran's I gives a consistent pattern across regions. The local Moran's I are plotted in Appendix Figure 2 (horizontal axis) against the contiguous regions (vertical axes), where each is measured relative to the national value (see ANSELIN, 1995).

There is positive spatial autocorrelation in the upper-right or lower-left quadrant of this plot, but otherwise negative autocorrelation. Appendix Figure 2 shows positive autocorrelation in manufacturing FDI is common to nearly all regions, i.e. regions with relatively high location quotients are contiguous with each other. However, it is much weaker for service FDI where a broadly equal number of regions show positive or negative spatial autocorrelation. Overall, it reinforces the view that service FDI location is determined at no higher level than NUTS 2, so that its location determinants differ to that of manufacturing FDI.

6. The Dynamics of Service FDI Location

The dynamics of FDI location is now examined over 1996-2005. This offers further evidence on whether service FDI has located the same or differently to manufacturing FDI. The focus is on Markov transition matrices, which enables convergence of FDI location to be explored. Initially, some simple cross-sectional measures of convergence are considered.

6.1 *Cross-Sectional Measures*

If FDI location is converging in its location towards the regional output structure then over time we expect the FDI location quotients in (1) to tend to unity. A smooth distribution of the FDI location quotients across the NUTS 2 regions in any year can be constructed using kernel density methods and these are presented for selected years in Appendix Figure 3 for all FDI. As time passes it shows that the location quotients are less dispersed about unity, so that the regions attract FDI more in line with their share of economic activity over time, suggesting convergence. This is also the case for service and manufacturing FDI (not shown), although dispersion is lower for service FDI in any year, so that is more evenly spread in its location

across space. The distributions are right-skewed as the location quotients are bounded below, but a similar pattern is found if the location quotients are logged in order to avoid this.

(Table 3 about here)

To explore this issue further, Table 3 examines the relationship between FDI location and output using a concentration index CI_k . This is loosely based on the location quotient in (1) and it is half the value of the Krugman concentration index (COMBES and OVERMAN, 2004), for which SUN and NG (2000) provide an axiomatic foundation:

$$CI_k = \frac{1}{2} \sum_r \left| \frac{FDI_{kr}}{\sum_s FDI_{ks}} - \frac{Q_{kr}}{\sum_s Q_{ks}} \right|, \quad (2)$$

where FDI_{kr} and Q_{kr} are defined in (1), k denotes the included industries, and r and s are each summed across the 35 regions. The index is zero if FDI and output shares are the same across all regions, but unity if all FDI and output are located in a single but different region. The CI_k index in Table 3 indicates convergence for all FDI, with the index falling from 0.32 in 1996 to 0.15 in 2005. Similar patterns are evident for service and manufacturing FDI. Again, the indices are comparatively smaller for service FDI, so that this is more evenly spread out.

The second index in Table 3 is for σ -convergence, which has the advantage that spatial autocorrelation can be corrected for that might otherwise bias the index (in fact it was found to be the case for manufacturing FDI only). Using the method of correction in LE GALLO and DALL'ERBA (2008), the standard deviation of the FDI location quotients are presented in Table 3 for each year over 1996-2005. The standard deviations fall over time, suggesting σ -convergence, and it is more pronounced for service FDI. However, it is non-monotone over time arising from outlier regions that maintained or increased their FDI share over 2000-04. As a similar pattern is evident if the coefficient of variation is used instead,

then it suggests that there are difficulties with the cross-section measures of convergence.

6.2 Transition Matrices

The dynamics of FDI location is investigated using the Markov discrete transition probability matrix framework. This improves on σ -convergence as it considers how the cross-sectional distributions evolve over time. It also improves on β -convergence, which is for the ‘average’ region and does not consider the cross-sectional distribution. The distribution of regional FDI location quotients is discretized into quintile classes, which is likely to reveal the important features (QUAH, 1996).¹³ It does not lead to a loss of the Markov property of time-invariant transition probabilities as the temporal homogeneity of the probabilities is not rejected below. Stochastic kernels enable the intra-distributional mobility to be investigated but they do not provide tests for making comparisons (BODE and NUNNENKAMP, 2007).

Formally, the regional location quotients are discretized across NUTS 2 regions r ($= 1, 2, \dots, R$) and years t ($= 0, 1, 2, \dots, T$) into $N = 5$ quintile classes, so that for 1996-2005 there are 63 observations in each row of the transition matrix M , i.e. 20% of the 315 observations on 35 regions and 9 transitions. Let $s_i(t)$ denote the share of the R regions in class i ($\in N$) at time t , where $s_i(t) \geq 0$ and $\sum_i s_i(t) = 1$, then the regional distribution of shares at time t is a $1 \times N$ row vector $S(t) = [s_1(t), s_2(t), \dots, s_N(t)]$. Further, let $p_{ij}(t)$ denote the transition probability of the regions moving from class i in period t to class j in $t + 1$, where $i, j \in N$, $p_{ij}(t) \geq 0$ and $\sum_i p_{ij}(t) = 1$. If this satisfies the Markov property, i.e. $p_{ij}(t) = p_{ij}$ for all t , then it follows that at time $t + z$ ($> t$), $S(t + z) = S(0) M^{t+z}$, where M is the transition matrix with elements p_{ij} . If M is regular then repeated application yields the limiting distribution of regional shares $S = (s_1, s_2, \dots, s_N)$, and comparison of this with the initial distribution of shares $S(0)$ allows inferences to be drawn about the existence of a convergent process. If $s_i > s_i(0)$ for the median class(es)

and $s_i < s_i(0)$ for other classes with either small or large location quotients, then it is evidence of convergence in FDI as the regions that initially have relatively high FDI location quotients tend to have smaller FDI location quotients over time, and conversely.

(Table 4 about here)

The transition matrices M are reported in Table 4. The first column of each table gives the upper bounds, following by the transition matrix, and the last two columns give the initial and limiting distributions. Comparison of these distributions in parts (a) to (c) show that there is convergence for all, service and manufacturing FDI. If, as an alternative discretization, the interval classes are centred about unity, which gives upper bounds of 0.4, 0.8, 1.2 and 1.6 for Classes 1 to 4, there is also convergence in each case. Like the other results not reproduced below these results are available from the authors on request.

The Markov property, $p_{ij}(t) = p_{ij}$, is investigated by splitting the 10-year study period into two 5-year periods 1996-00 and 2001-05 ($m = 2$) and calculating a Pearson χ^2 statistic P for the difference in the transition probabilities $p_{ij|m}$ and that for p_{ij} in Table 4. The number of the comparisons determines the degrees of freedom, where $n_{i|m}$ is the number of transitions in the i th class, which is calculated for non-zero transition probabilities in the i th row A_i :

$$P = \sum_{m=1}^2 \sum_{i=1}^N \sum_{j \in A_i} n_{i|m} \frac{(p_{ij|m} - p_{ij})^2}{p_{ij}}. \quad (3)$$

For all, service and manufacturing the temporal homogeneity of the transition probabilities is not rejected even at the 10% level, which supports the Markov property.¹⁴ This is despite the non-monotone σ -convergence found above.

Disaggregating FDI by new and expansion projects, parts (d) and (e) of Table 4 show that there is convergence for these. This holds in each case for service FDI, while for new

manufacturing FDI there is a divergent pattern, but Figure 1 shows there are a small number of these projects. Part (f) of Table 4 gives the transition matrix for the service industries that are most linked to manufacturing, i.e. last five industry groupings in Table 1, but again FDI location converges. Finally, the speed of convergence is measured by the time taken to cover half the distance between the initial and limiting distributions, and calculated as the product of the number of years T and $-\log 2 / \log |\lambda|$, where λ is the second characteristic root of the transition matrix (see GEPPERT and STEPHAN, 2008). The half-life of manufacturing and service FDI are 11 and 8 years respectively, so that service FDI is converging faster.

6.3 *The Intra-Distributional Dynamics*

The intra-distributional dynamics of the transition matrix M offer insights into the factors that underlie the convergence of service FDI location. Mobility is the extent to which the regions move between the quintile classes over 1996-2005, which captures the dynamism of location. It is measured by the SHORROCKS (1978) Index = $(N - \text{tr } M) / N$, where N is the number of classes and $\text{tr } M$ is the trace operator. The index lies between 0 and 1, where a higher value indicates greater mobility. Applied to the matrices in Table 4 the Shorrocks Index is 0.64 for service FDI and 0.62 for manufacturing FDI. These indicate a similar and high degree of mobility. The index for new investment in part (d) of Table 4 is 0.68.

While FDI appears to be mobile in its choice of location across regions the leading diagonals of M show that at the extremes (Classes 1 and 5) there is persistence in location, so that the regions that get a very low or high FDI share tend to continue to do so. This contrasts with Classes 2 to 4 where there is much more movement of the regions between the classes. The persistence in location is particularly evident for manufacturing, where Class 5 comprises regions with location quotients greater than 1.71, whereas for service FDI it is 1.37. This can

be explained by the expansion projects, for which the lower bound for Class 5 is 1.89, so that a high level of manufacturing FDI implies ‘stickiness’ in location due to re-investment.

The dynamism of service FDI can be investigated by examining the extent to which the regions change their ranking of the FDI location quotients between the beginning and the end of the study period. This is known as mixing and it is captured by the Kendall statistic, $\tau = (N^C - N^D) / {}^R C_2$, where N^C and N^D are the number of concordant and discordant pairs, and R is the number of regions, i.e. ${}^R C_2 = 595$. A pair of regions is concordant if they have the same relative ranking in 1996 and 2005, but otherwise discordant. The Kendall statistic lies between -1 and +1, but $\tau = 0.32$ when calculated for all FDI, which suggests that the regions tend to keep their rankings. However, for service FDI it is lower at $\tau = 0.13$, so that there is greater mixing, which no doubt reflects its greater reliance on new investment.

6.4 *The Hypotheses*

Competing hypotheses for location were set out above, where it posited that service FDI will locate close to manufacturing due to vertical linkages, but locate away from manufacturing FDI due to final consumer demand. The spatial analysis does not allow the existence of these industrial linkages to be firmly established, although it does allow insights to be gained on the hypotheses and in particular whether service FDI locates differently to manufacturing FDI.

As an initial point, service FDI convergence is a homogeneous process across regions that does not depend on whether a region is close to other regions with a high or a low FDI location quotient. This can be established by dividing the NUTS 2 regions into two groups according to whether the mean location quotient of contiguous regions is greater or less than unity at the start of the period. The initial and limiting distributions are reported in Appendix Table 1 for all, service and manufacturing FDI. Using the Pearson χ^2 statistic in (3) the null

hypothesis that the transition matrices are the same as for the respective matrix in Table 4 can be rejected at the 10% level overall, but it is not rejected for service FDI. Of interest, if the contiguous regions have a high location quotient at the start of the period (i.e. $LQ_r > 1$) there is movement down the classes for manufacturing FDI, and conversely. This is consistent with WREN and JONES (2012) who at the NUTS 1 level find that manufacturing FDI has shifted location from the periphery to the core, perhaps due to a weaker UK regional policy.

The hypothesis that service FDI locates close to manufacturing FDI was examined by considering the ratio of the location quotients LQ_{kr} for service and manufacturing FDI. The associated transition matrix (not shown) does not exhibit convergence, which suggests that as service FDI has grown it has not converged with the location of manufacturing FDI. This is also the case if the service sector is restricted to those industries that are heavily dependent on manufacturing, i.e. the last five groups shown in Table 1. It is consistent with Table 4, which shows a similar convergence pattern for these. Overall, it is not surprising, as while there is homogeneity in the convergence of service FDI location, manufacturing FDI is spatially auto-correlated in its location and it is dominated by a shift from the periphery to core, so that both the location and convergence of manufacturing FDI are different to service FDI.

The alternative hypothesis, that service FDI locates according to consumer demand, was explored by dividing the NUTS 2 regions into two groups according to whether regional output is relatively high or low at the start of the period. This is a better way of capturing the urban areas than population density as the major urban areas can be combined with large rural tracts at the NUTS 2 region level.¹⁵ The homogeneity of the transition matrices for service FDI is now rejected at the 1% level (the Pearson χ^2 statistic in (3) is 48.4; $\chi^2_{0.01} = 37.6$) and inspection of transition matrices for the two groups (not shown) reveals that it is consistent with the location of service FDI in regions with higher output and away from the regions with lower output. It is most apparent for service FDI in classes 2 to 4 and related to the mobility

found above. It is supported by the maps that were produced in section 3 and gives support to the second hypothesis on the importance of market access for service FDI location.

7. Concluding Discussion

This paper examines the location of foreign direct investment in the service sector across the NUTS 2 regions of Great Britain over the period 1996-2005. This is for productive FDI only in the form of 'greenfield' investment and re-investments by existing plants, and it covers the period when service FDI became the dominant form of UK inward investment. The analysis is for the number of investments, which is correlated with the number of jobs. The purpose is to see where service FDI locates, how this has changed over time and whether it is different to manufacturing FDI. Overall, the paper finds that service FDI mainly locates in the south east of England due to its greater economic size, but relative to service output it agglomerates across Britain in or close to the major urban areas. Over time it has converged in location and become more evenly spread out relative to the regional distribution of service output. Since the location and convergence of service FDI are both spatially independent, this suggests that the processes are homogeneous across regions and so occur across the British landmass.

The paper finds strong differences between the location of service and manufacturing FDI. The latter is spatially correlated in both its location and convergence, so that its location determinants operate at a level higher than the NUTS 2 region and over time there has been a 'North-to-South' shift in manufacturing FDI location that seems to be related to a reduction in regional grants. Service FDI is more dynamic, as not only is it converging faster in location, but there is less persistence in its regional location, possibly due to its greater reliance on new investment rather than re-investment. In terms of the hypotheses that are set out in the paper, as service FDI has grown there is no evidence that it has converged towards the location of

manufacturing FDI. This is not only the case for service FDI as a whole, but for the service industries that are most vertically linked to manufacturing industry. It is not surprising given the different FDI location patterns. Rather, service FDI is converging to the NUTS 2 regions with greater output, suggesting that agglomeration economies are present. This could be to do with the larger consumer markets of these areas, or the availability of higher-skill or more-specialised labour, but the exact reasons cannot be discerned from this analysis.

Finally, there are several implications of the paper for regional policy. First, service FDI follows a different location pattern to manufacturing FDI. This suggests it is unlikely to compensate for the loss of manufacturing FDI in the more peripheral regions, but which has been a key tool of UK regional policy. Manufacturing FDI has been shifting from the North-to-South of Great Britain, coincident with the reduction in UK regional grants. It is important as service FDI now greatly outweighs manufacturing FDI in terms of the number of projects that locate in the UK and most likely in the number of jobs. Second, while service FDI is converging in location to the major urban areas, this has implications for the distribution of jobs between the urban and other areas even within the peripheral regions. While there may be gains to building-up the regional centres it implies a need for distributional policies at this level that identifies services. Of course, the paper finds that agglomeration economies from urban size are very strong, so that while UK regional policy may be able to affect a different sub-regional distribution of FDI, this may last only as long as the policy itself.

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Table 1: Service FDI by Industry

Industry group	Number of FDI projects			Manufacturing demand (%)	
	1996-97	2004-05	Change	Intermediate	Total
Education, Health and Social Work (75-85)	12	27	15	6.7	0.1
Retail, Hotels and Restaurants (52-55)	23	73	50	17.3	1.2
Wholesale, including Vehicles (50-51)	39	46	7	3.8	1.7
Other Social and Personal Services (90-99)	4	41	37	18.6	4.4
Real Estate and Renting (70-71)	13	7	-6	14.2	4.6
Insurance and Pension Funding (66-67)	9	8	-1	15.5	6.1
Telecommunications (64)	22	39	17	9.3	6.2
Other Business Activities (74)	67	135	68	9.7	7.7
Computer Consultancy and Activities (72)	69	258	189	19.6	8.9
Banking and Finance (65)	13	54	41	11.8	9.9
Transport and Travel (60-63)	22	61	39	16.3	10.7
Research and Development (73)	15	134	119	17.7	14.9
All Services (50-99)	308	883	575	12.5	4.9

Notes: Number of FDI projects in dataset for first and last two years of study period. Demand from manufacturing as a share of intermediate and total demand using 1995 UK *Supply and Use Table*. NACE revision 1.1 industry codes in parentheses.

Table 2: Global Moran's I for FDI Location Quotients

Year	All FDI	Service FDI	Manufacturing FDI
1996	0.381***	0.088	0.376***
1997	0.307***	0.176**	0.250***
1998	0.169**	0.215**	0.211**
1999	0.349***	0.090	0.401***
2000	0.154*	0.090	0.187**
2001	0.200**	0.038	0.236***
2002	0.312***	0.020	0.267***
2003	0.109	0.094	0.330***
2004	0.133*	0.108	0.137*
2005	0.320***	0.172**	0.277***
All Years	0.355***	0.155*	0.454***

Note: Moran's I calculated using a contiguous row-standardised weights matrix. Significance tests based on a one-tail test. Significant at *** = 1%, ** = 5% and * = 10% level.

Sources: Authors' own database. Office for National Statistics.

Table 3: Cross-Sectional Convergence Measures

Year	Concentration Index CI_k			σ -convergence		
	All FDI	Service FDI	Manuf. FDI	All FDI	Service FDI	Manuf. FDI
1996	0.32	0.26	0.36	0.67	0.82	0.83
1997	0.25	0.20	0.31	0.62	0.73	0.76
1998	0.20	0.23	0.31	0.62	0.66	0.75
1999	0.20	0.23	0.29	0.50	0.63	0.62
2000	0.25	0.26	0.32	0.53	0.53	0.78
2001	0.24	0.27	0.32	0.66	0.69	0.95
2002	0.17	0.23	0.31	0.66	0.76	0.94
2003	0.20	0.24	0.35	0.82	0.64	0.89
2004	0.18	0.19	0.23	0.54	0.51	0.67
2005	0.15	0.17	0.25	0.39	0.55	0.66

Note: Concentration index given by (2) and σ -convergence obtained by running a spatial lag model of the FDI location quotients for each year, from which the standard deviation of the residuals is obtained.

Sources: Authors' own database and Office for National Statistics.

Table 4: Transition Matrices

Upper Bound	Transition Probabilities					Initial Distribution	Limiting Distribution	
<i>(a) All FDI</i>								
	Class	1	2	3	4	5		
0.4463	1	0.429	0.270	0.206	0.064	0.032	0.2000	0.1907
0.6681	2	0.238	0.286	0.333	0.111	0.032	0.2000	0.1919
0.9568	3	0.191	0.238	0.318	0.206	0.048	0.2000	0.2439
1.4794	4	0.032	0.127	0.222	0.397	0.222	0.2000	0.2171
-	5	0.064	0.000	0.095	0.302	0.540	0.2000	0.1564
<i>(b) Service FDI</i>								
	Class	1	2	3	4	5		
0.2208	1	0.397	0.238	0.175	0.095	0.095	0.2000	0.1846
0.5651	2	0.191	0.302	0.286	0.159	0.064	0.2000	0.2099
0.8808	3	0.175	0.222	0.270	0.238	0.095	0.2000	0.2157
1.3721	4	0.079	0.191	0.175	0.365	0.191	0.2000	0.2138
-	5	0.095	0.079	0.159	0.191	0.476	0.2000	0.1760
<i>(c) Manufacturing FDI</i>								
	Class	1	2	3	4	5		
0.3692	1	0.302	0.270	0.238	0.095	0.095	0.2000	0.1922
0.5981	2	0.286	0.318	0.254	0.095	0.048	0.2000	0.2067
1.0266	3	0.222	0.270	0.270	0.159	0.079	0.2000	0.2226
1.7131	4	0.095	0.111	0.238	0.444	0.111	0.2000	0.2157
-	5	0.032	0.032	0.079	0.286	0.571	0.2000	0.1628
<i>(d) New ‘greenfield’ investments</i>								
	Class	1	2	3	4	5		
0.2444	1	0.381	0.254	0.238	0.095	0.032	0.2000	0.1993
0.5030	2	0.191	0.159	0.365	0.206	0.079	0.2000	0.1957
0.8217	3	0.222	0.238	0.206	0.270	0.064	0.2000	0.2192
1.2554	4	0.111	0.238	0.143	0.318	0.191	0.2000	0.2137
-	5	0.079	0.064	0.143	0.159	0.556	0.2000	0.1721
<i>(e) Expansion investments</i>								
	Class	1	2	3	4	5		
0.4113	1	0.349	0.286	0.238	0.079	0.048	0.2000	0.1875
0.7402	2	0.333	0.286	0.286	0.064	0.032	0.2000	0.2067
1.1374	3	0.111	0.270	0.302	0.254	0.064	0.2000	0.2197
1.8870	4	0.095	0.111	0.143	0.413	0.238	0.2000	0.2162
-	5	0.048	0.064	0.111	0.254	0.524	0.2000	0.1699
<i>(f) Vertically-linked service FDI*</i>								
	Class	1	2	3	4	5		
0.0001	1	0.480	0.147	0.120	0.133	0.120	0.2381	0.2041
0.5075	2	0.177	0.294	0.373	0.137	0.019	0.1619	0.1721
0.8715	3	0.159	0.222	0.270	0.254	0.095	0.2000	0.2183
1.3836	4	0.079	0.143	0.175	0.333	0.270	0.2000	0.2176
-	5	0.127	0.064	0.175	0.206	0.429	0.2000	0.1879

Note: Transition matrices based on quintile classes for FDI project location quotients. *Services for the last five industry groups in table 1 only, where owing to a large number of zeroes Class 1 has 23.81% of observations.

Figure 1: Number of Investments by Year and Type

Source: Authors' own database.

Figure 2: Geographic Distribution of FDI Project Shares

Note: FDI project shares in quintiles for NUTS 2 regions over 1996-05

Source: Authors' own database.

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Figure 3: Geographic Distribution of FDI Location Quotients

Note: FDI project location quotients in quintiles for NUTS 2 regions over 1996-05.

Sources: Authors' own database and Office for National Statistics.

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Figure 4: Temporal Distribution of FDI Location Quotients

(i) Services

(ii) Manufacturing

Note: FDI project location quotients in quintiles for NUTS 2 regions by sub-period.

Sources: Authors' own database and Office for National Statistics.

© EuroGeographics for administrative boundaries.

Appendix Figure 1: NUTS 2 Regions for Great Britain

Scotland:

- 1 – Highlands and Islands
- 2 – North Eastern Scotland
- 3 – Eastern Scotland
- 4 – South Western Scotland

North East:

- 5 – Northumberland and Tyne and Wear
- 6 – Tees Valley and Durham

Yorkshire and Humber:

- 7 – North Yorkshire
- 8 – West Yorkshire
- 9 – East Riding and North Lincolnshire
- 10 – South Yorkshire

East Midlands:

- 11 – Derbyshire and Nottinghamshire
- 12 – Lincolnshire
- 13 – Leicestershire, Rutland and Northamptonshire

East of England:

- 14 – East Anglia
- 15 – Bedfordshire and Hertfordshire
- 16 – Essex

London:

- 17 – London

South East:

- 18 – Kent
- 19 – Surrey, East and West Sussex
- 20 – Hampshire and Isle of Wight
- 21 – Berkshire, Buckinghamshire and Oxfordshire

South West:

- 22 – Gloucestershire, Wiltshire and North Somerset
- 23 – Dorset and Somerset
- 24 – Devon
- 25 – Cornwall and Isles of Scilly

Wales:

- 26 – West Wales and the Valleys
- 27 – East Wales

West Midlands:

- 28 – Herefordshire, Worcestershire and Warwickshire.
- 29 – West Midlands
- 30 – Shropshire and Staffordshire

North West:

- 31 – Cheshire
- 32 – Merseyside
- 33 – Greater Manchester
- 34 – Lancashire
- 35 – Cumbria

Note: Eleven NUTS 1 regions, under which NUTS 2 regions are classified. NUTS 1 region is used for London. Merseyside was a NUTS 1 region prior to 1998, but is included here as a NUTS 2 region only.

Appendix Figure 2: Local Moran's I Scatterplots for FDI Location Quotients

(a) Services

(b) Manufacturing

Note: Local Moran's I scatterplots for FDI project location quotients (z) against its spatial lag (w_z), where each is measured as a deviation from the respective national mean. Plotted lines give global Moran's I reported in table 2.

Sources: Authors' own database and Office for National Statistics.

Appendix Figure 3: Kernel Density Plots for FDI Location Quotients

Note: Epanechnikov kernel density estimates of the distributions of FDI location quotients for all projects for selected years.

Sources: Authors' own database and Office for National Statistics.

Appendix Table 1: Spatial FDI Location Quotients

Class	All FDI				Service FDI				Manufacturing FDI			
	$LQ_{kr} > 1$		$LQ_{kr} < 1$		$LQ_{kr} > 1$		$LQ_{kr} < 1$		$LQ_{kr} > 1$		$LQ_{kr} < 1$	
	Initial	Limiting	Initial	Limiting	Initial	Limiting	Initial	Limiting	Initial	Limiting	Initial	Limiting
1	0.118	0.138	0.278	0.237	0.178	0.174	0.217	0.194	0.132	0.157	0.257	0.216
2	0.092	0.101	0.303	0.272	0.170	0.172	0.222	0.239	0.063	0.097	0.318	0.292
3	0.170	0.227	0.228	0.266	0.200	0.242	0.200	0.194	0.111	0.118	0.275	0.307
4	0.255	0.274	0.148	0.169	0.185	0.204	0.211	0.221	0.299	0.326	0.117	0.142
5	0.366	0.260	0.043	0.055	0.267	0.207	0.150	0.152	0.400	0.302	0.035	0.042
	$P = 27.23^*$				$P = 17.84$				$P = 52.45^{***}$			

Note: Initial and limiting distributions for FDI location quotient (LQ_{kr}) at 1996-97 using quintile classes and upper bounds in table 4. Pearson χ^2 goodness-of-fit statistics (P) calculated for spatial independence. Critical values vary by degrees of freedom. Significant at *** = 1%, ** = 5% and * = 10%.

Endnotes

¹ In addition, BAGCHI-SEN (1995) notes the potential longer-term development benefits of producer services, including infrastructure development, formation of inter-industry linkages, structural adjustment and socio-cultural impact.

² CAPELLO et al. (2011) map service FDI relative to population for European regions at the NUTS 2 level for 1997-99 only, but which shows that the UK is the main location for service FDI. NACHUM (2000) examines sub-national service FDI location for some activities.

³ It is usually supposed that FDI chooses between countries and then regions, and the use of regional shares is consistent with this. If location is non-hierarchical it is still of interest to see where FDI locates in the UK and whether it is building-up in particular regions.

⁴ Acquisitions account for about 40% of total FDI projects. *UK Trade and Investment* collect these data for NUTS 1 regions but it is difficult for us to determine the NUTS 2 location of these as the name of the acquired plant is often not given, and which may be foreign owned.

⁵ The size distributions of service and manufacturing FDI projects are respectively: 1-5 jobs: 25%, 8%; 6-25 jobs: 38%, 26%; 26-200: 29%, 48%; 201-500: 6%, 13%; and 501+: 2%, 5%.

⁶ The OECD defines producer services as business and professional, financial, insurance and real estate. For the groups that correspond to these FDI increases from 102 to 204 projects.

⁷ Of the 5,371 investments, 1,151 (21%) located in London, so that the NUTS 2 location was found for 3,764 (89%) of the remaining 4,220 projects.

⁸ It relates to the period 2000-03 and may be due to the brief of the Regional Development Agency in 1999 to attract FDI. It does not result from boundary changes in the mid-1990s.

⁹ By project size, the success rate is: 1-5 jobs: 80%; 6-25 jobs: 86%; 26-200: 92%; 201-500: 96%; and 501+: 98%. Of the 456 projects for which the NUTS 2 location could not be found, 64% have 1 to 25 jobs, 79% have 50 or fewer jobs and 87% have 100 or fewer jobs.

¹⁰ Spearman rank correlation coefficients between the regional number of FDI projects and jobs are: all FDI: 0.91; service FDI: 0.88; and manufacturing FDI: 0.82. Each is significant at the 1% level. The maps for the number of jobs are available from the authors on request.

¹¹ These can be found in Appendix Figure 1 except for Glasgow (region 4) and Newcastle (5). Manchester and Merseyside are contiguous to Cheshire (31).

¹² The significance tests suppose the distribution of the Moran's I is asymptotically normal. The Moran's I is non-standardized and so not directly comparable over time.

¹³ Optimising the class intervals using the method of DEVROYE and GYÖRFI (1985) is unsatisfactory as it gives fourteen classes, many of which are very small.

¹⁴ The P statistics are 25.3, 9.7 and 13.0, against critical values of 27.2, 28.4 and 28.4 at the 10% level. For an LR test these are 26.8, 19.5 and 26.1, against the same critical values.

¹⁵ For example, Glasgow with Strathclyde in region 4 of Appendix Figure 1, Tyne and Wear with Northumberland in region 5 and south Wales with the west Wales in region 26.