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THE DETERMINANTS OF REGIONAL SPECIALISATION IN BUSINESS SERVICES: AGGLOMERATION ECONOMIES, VERTICAL LINKAGES AND INNOVATION

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ABSTRACT

The paper accounts for the determinants of sectoral specialisation in business services across the EU-27 regions as determined by: (1) agglomeration economies (2) the region-specific structure of intermediate linkages (3) technological innovation and knowledge intensity and (4) the presence of these factors in neighbouring regions. The empirical analysis draws upon the REGIO panel database over the period 1999-2003. By estimating a Spatial Durbin Model, we find that urbanisation economies, intermediate linkages and innovation, in particular Information and Communication Technologies, are important determinants of specialisation in business services. We also find significant spatial effects in explaining regional specialisation in business services, which supports the argument of the literature on agglomeration economies.

Keywords: Business Services, Regional Specialisation, Agglomeration economies, Services-Manufacturing Linkages, Technological Innovation, Spatial Durbin Model.

JEL Codes: R12, L80, O3

1. Introduction

Advanced economies – and increasingly some of the fast growing developing economies such as India (Dasgupta and Singh, 2005) – are experiencing processes of structural change that produce profound modifications in the sectoral structure of employment leading to specialisation in services (OECD, 2008a). This process of tertiarisation has been ongoing for several decades in advanced OECD countries, resulting in an increasing number of attempts to identify, conceptually and empirically, its determinants and its impact on aggregate economic growth (see Peneder, 2003; Peneder et al., 2003; Parrinello, 2004; Savona and Lorentz, 2005; Schettkat and Yocarini, 2006; Montresor and Vittucci, 2011, among the most recent studies).

A substantial part of the literature focuses on the impact of specialisation in a particularly dynamic branch of services - business services (BS in what follows[1]) - on economic growth. Business services have in fact exhibited higher rates of growth of employment, value added and productivity with respect to other branches of services and to the rest of the economy, contributing to cross-country differences of growth patterns (Francois, 1990b; Rowthorn and Ramaswamy, 1999; Guerrieri et al. 2005; Kox and Rubalcaba, 2007a and 2007b).

An increasing emphasis has been put on the extent to which cross-country growth divergences in Europe are to be found in regional polarisation patterns of employment and productivity growth (Guerrieri et al., 2005; Fagerberg et al. 1997; Meliciani, 2006; Sterlacchini, 2008 among others). Part of the regional literature focuses on innovation clusters and regional 'clubs' of technological change to explain regional polarisation in Europe (Moreno et al., 2005; Crescenzi et al., 2007; Verspagen, 2007; Sterlacchini 2008), overlooking the two-way relationship between sectoral specialisation – particularly in BS - and technology and innovation performance.

In this context, disentangling the factors that drive the increasing BS specialisation at a regional level is therefore of great importance to understand its impact, shed light on the ongoing divergence of growth rates across regions in the EU and appropriately target industrial and innovation policy at the sub-national level.

We claim that BS specialisation of regions is an outcome of three different sets of determinants, themselves interlinked:

- The classical sources of *agglomeration economies* – localisation, urbanisation and Jacob's externalities – are strongly associated with the spatial distribution of industries, as traditional models of economic geography show (Fujita, Krugman and Venables, 1999; Midelfart-Knarvik et al., 2000)[2]. We expect that BS specialisation is driven by traditional localisation economies. In line

[1] In this study BS include R&D, computer and related services and other business services.

[2] For a recent reassessment of agglomeration theories in a historical perspective, see also McCann and van Oort (2009).

with the literature on urbanisation economies (Glaeser et al., 1992 and 1995; Henderson et al. 1995), we also expect that highly urbanised and densely populated regions – with the presence of highly qualified human capital – are ceteris paribus more prone to specialise in BS.

- The role of *intermediate demand*, the structure of intermediate linkages between business services and their users and the region-specific sectoral structure have an impact on BS specialisation (Guerrieri and Meliciani, 2005; Savona and Lorentz, 2005). This is often acknowledged in the regional literature as the presence of Hirschmann forward and backward linkages affecting regional specialisation and growth polarisation (Hirschmann, 1958; McCann and van Oort, 2009). Fast growing industries - and business services in particular, highly dependent on the intermediate demand by manufacturing industries - tend to concentrate spatially depending on the structure of backward and forward linkages. We expect therefore that regions characterised by high shares of service intensive user industries are ceteris paribus more likely to specialise in BS.
- The region-specific *knowledge infrastructure,* the *innovation*, particularly the *Information and Communication Technologies* (ICT) intensity, are increasingly recognised in the innovation literature as playing for services the role that traditional R&D plays for high-tech manufacturing sectors (Cainelli et al., 2006; Evangelista, 2006; OECD, 2008b; Gallouj and Savona 2009; Abreu et al. 2010; Doloreux and Shearmur, 2011). A fertile innovation environment – characterised by ICT intensity, public R&D expenditures and a large reservoir of skilled population – is expected to favour regional specialisation in BS.

Further, in line with some contributions (van Oort 2007, Raspe and van Oort, 2007) we claim that all the above determinants have a strong spatial dependence: we expect that BS specialised regions tend to cluster; that being surrounded by highly urbanised and densely populated regions, as well as by regions specialised in service-intensive user industries and having an innovation-prone environment (i.e. a high share of ICT related innovation, public knowledge support and highly skilled people) also positively affect the BS specialisation of the typical region.

To our knowledge, there are no studies investigating the intertwined sets of these determinants within a unified empirical framework. This paper aims therefore to fill this gap and add to the regional economic literature by providing an in-depth view of spatial dependence in the determinants of specialisation in BS. Also, it intends contributing to the literature on services – and on innovation in services - by providing a spatial picture of the technological and intermediate demand determinants of BS specialisation, which have so far been looked mainly at the country level (Guerrieri and Meliciani, 2005; Savona and Lorentz, 2005; Kox and Rubalcaba, 2007a).

In particular we empirically address in a spatial econometric framework the determinants of specialisation in BS across the EU-27 regions over the period 1998-2003, looking at the role played by: (1) region-specific sources of agglomeration and urbanisation economies; (2) the region-specific structure of intermediate linkages; (3) technological innovation and knowledge intensity and (4) the presence of these factors in the neighbouring regions, whose effect might spill over the typical region.

The remainder of the paper is organised as follows: Section 2 reviews the literature that is relevant in choosing the variables related to specialisation in business services and supporting our empirical model. Section 3.1 summarises the theoretical constructs derived by the literature and translates them into empirical proxies; Section 3.2 provides a descriptive picture of BS specialisation across the EU regions; section 3.3 explains the econometric strategy while section 3.4 discusses the results of the Spatial Durbin model estimations. Section 4 summarises the findings and draws the main conclusions of the paper.

2. Regional specialisation in Business Services: Agglomeration, intermediate demand and technology determinants

2.1 The spatial dimension of BS specialisation: Agglomeration economies

The classical theories of agglomeration economies date back from the contribution of Marshall in the late nineteenth century and have since sparked a substantial amount of theoretical and empirical work (for a historical review, see McCann and van Oort, 2009; see also van Oort, 2004 and 2007; Burger et al., 2008). Agglomeration economies have been analysed mainly with respect to their impact on regional growth and development and rarely accounted for as a determinant of sectoral specialisation, even when the sectoral dimension has been explicitly taken into account (Combes, 2000; van Oort, 2007). Raspe and van Oort (2007) argue that *geographic, dynamic* and *sectoral* context-dependency in the analysis of agglomeration effects has been overlooked and would deserve major attention.

Traditionally, the sources of agglomeration economies are to be found in:

- *localisation externalities* stemming from sectoral density, which favours internal and external economies of scale, though these depend on the specific sector (see for instance Combes, 2000; van Oort, 2007);
- *urbanisation externalities,* while independent from the sectoral structure, are due to urban and population density, which facilitate knowledge spillovers (Glaeser et al., 1992 and 1995; Henderson et al. 1995);
- *Jacobs' externalities* deriving from the variety of activities within urban contexts (Jacobs, 1969; Duranton and Puga, 2000). This type of externalities tends to be higher in regions with a

relatively higher *related* rather than *unrelated* variety of urban activities (Frenken et al., 2007; McCann and van Oort, 2009).

In a seminal contribution, Hirschmann (1958) identifies different types of externalities, depending on whether activities are related to one another by backward or forward linkages, i.e. whether certain sectors concentrate where their clients are located or, rather, they migrate where new or growing sectors that provide them with output are located. These aspects – along with the one more specifically related to the structure of intermediate linkages between BS and their users, discussed in the next section – are particularly important in the context of this work.

In the case of business services, the location of customer industries is particularly relevant, as these services are typically supplied to firms through strong supplier user interactions (Muller and Zenker, 2001; Miles, 2005), crucially relying on geographical proximity. Consistently with this, Antonietti and Cainelli (2007) find that spatial agglomeration - where the probability of finding specialised external providers, face-to-face contacts and close spatial interaction is high- is an important factor affecting the location of business services. Within a different framework, Combes (2000), van Oort (2007) and Burger et al. (2008) find that localisation externalities are positively related to services employment growth more than to employment growth in other sectors, arguing that service sectors benefit more from concentration than other economic activities.

In line with this evidence, an interesting study has been carried out for US counties over the period 1972-2000 (Desmet and Fafchamps, 2005) to test the spatial distribution of service vs. non-service jobs. The results show that non-service jobs have been spreading out whereas service employment has been clustering in areas of high aggregate employment, supporting the conjecture that agglomeration economies work strongly for service employment.

Finally the literature highlights a specific role for large urban areas as attractors of business services (Jacobs, 1969, Duranton and Puga, 2000). Duranton and Puga (2005) present a model of functional specialisation where multinational firms locate their "headquarter functions" in large urban regions. Such a location makes it possible for the headquarters to locally buy inputs from specialised business service firms in areas such as R&D, marketing, financing, law, exporting, logistics, etc. Moreover, the location of headquarters favours the co-location of specialised intermediate business service firms from which the headquarters can buy locally when they choose to outsource various services. A further reason inducing knowledge-intensive services to be located in regions with large urban areas is that they need to employ skilled labour and human capital, which tend to be concentrated in cities (Glaeser, 1999; Karlsson et al., 2009).

All in all, the arguments of agglomeration economies put forward by the literature suggest that localisation and urbanisation externalities favour the specialisation in BS, which tend to cluster in regions with dense urban areas and a strong functional specialisation in knowledge-intensive and high skilled activities. Knowledge flows more fluidly where both *spatial* and *sectoral* contiguity are relatively high. While the importance of spatial contiguity has been largely acknowledged in the regional literature, less attention has been devoted to study the role of sectoral interdependencies. We turn to this in next section.

2.2 Intermediate demand and inter-sectoral linkages

The evidence on agglomeration, together with Hirschmann's backward and forward linkages mentioned above – i.e. the fact that services tend to localise where spatial and sectoral contiguity to users is high – is reinforced by the specific nature of intermediate linkages between BS and their users.

Aside from the regional literature, several authors have argued that the rise of services, particularly of business services, in the last thirty years is mostly due to changes in the production processes in many sectors and to the ensuing increase in the demand for services as intermediate goods (Francois, 1990; Rowthorn and Ramaswamy, 1999; Guerrieri and Meliciani, 2005; Savona and Lorentz, 2005; Francois and Woerz, 2007). The growing complexity in the organisation of manufacturing production and distribution resulting from new technologies, and the significant increase in coordination problems has raised the service content of many manufactured goods, which goes well beyond the simple 'outsourcing' or 'contracting out' of services (Ten Raa and Wolff, 2001; Miozzo and Soete, 2001).

Some recent studies investigate the pattern of inter-sectoral linkages between business services and manufacturing. Guerrieri and Meliciani (2005), using Input-Output data, show regularities across countries in the intensity of use of Financial, Communication and Business services (FCB). In particular they find that knowledge-intensive manufacturing industries make considerable use of FCB services, while labour and scale-intensive industries are, on average, low or medium users of FCB services. Similar results are found by Francois and Woerz (2007) that show how business services are highly demanded especially by knowledge intensive industries. Empirical evidence supporting the key role of intermediate demand - rather than final consumption or trade- in business services growth is also provided by Savona and Lorentz (2005) (see also Kox and Rubalcaba, 2007a and 2007b and Montresor and Vittucci, 2011).

Overall this evidence suggests that the sectoral composition of regional economies and the nature of intermediate demand and inter-sectoral linkages strengthen the effects of agglomeration on regional BS specialisation. We therefore expect regions with a high share of high tech and knowledge-intensive manufacturing industries to experience a higher demand for business services and, therefore, to be more likely to specialise in these activities.

2.3 Innovation, ICT and BS specialisation

Services have long been considered laggard in terms of innovation performance, and sluggish in terms of productivity growth. However, there is increasing evidence that many service firms play important roles in innovation, and not only in the use, but also in the creation and diffusion of new technologies and of non-technological forms of innovation. Most of the empirical literature in innovation in services is based on the Community Innovation Survey (CIS), a large-scale firm-level survey carried out across Europe. CIS accounts not only for R&D-related innovation, but also for non-R&D innovative input such as training, design, know how and marketing, and of course expenditures in ICT. This wider perspective on the nature of innovation is even more appropriate for services for which traditional R&D, and 'hard' technological activities play only a marginal role (Evangelista 2000; Tether, 2005; Cainelli et al., 2006; Gallouj and Savona, 2009; Abreu et al., 2010).

Some service sectors are not only among the major users of ICT, but also play a crucial role in diffusing ICT-based technology to other sectors: the diffusion of knowledge-intensive service industries is deeply affected by the parallel diffusion and implementation of new information and communication technology systems (Soete, 1987; Antonelli, 1998; Miozzo and Miles, 2003). ICT allow for increased stockability and transportability; they also allow services to be produced in one place and consumed simultaneously in another, affecting productivity performance (Evangelista, 2000; Van Ark et al., 2003; Cainelli et al., 2006, Crespi et al., 2006; Marrano et al., 2007).

Along with the increasing role of innovation and ICT in BS, human capital also appears to be a crucial factor for these activities[3]. Kox and Rubalcaba (2007b) find that business services tend to employ highly qualified people relatively more than most other industrial or service sectors. The European Labour Force Surveys as reported in Kox and Rubalcaba (2007b) indicate that in European countries the education profile of employees in aggregate manufacturing and services is dominated by the intermediate educational level. In manufacturing there is also a high share of workers with low education levels, while in services high levels of education prevail over low levels. When we look at the three categories of services considered in this study, both computer services and R&D services show very high shares of highly educated employees.

The regional literature has recently acknowledged the role of innovation and particularly of ICT for regional knowledge production and growth (Acs et al., 2002; Raspe and van Oort, 2007;

[3]For a recent review on the role of human capital in regional development see Faggian and McCann, 2009.

Doloreux and Shearmur, 2011). Raspe and van Oort explicitly take into account a series of proxies for the knowledge intensity of urban contexts, among which educational levels, ICT, R&D. They find these factors to be strongly related to the growth of knowledge intensive activities in services in Dutch urban areas.

R&D has been found to be less necessary for innovation in services, though the presence of high public R&D expenditure at the regional level favours innovation in high-tech manufacturing sectors and (indirectly) affects regional specialisation in BS positively. It should be noted that BS include private R&D. In this respect, the empirical literature has not provided a conclusive answer on whether complementarity or substitutability between public and private R&D takes place. Although there is slightly more evidence supporting the presence of positive spillovers of publicly funded R&D on private R&D investments, in some cases the opposite evidence has also been found, with a displacing effect within the two (for a detailed review on the issue of complementarities/substitutability between public and private R&D see David et al., 2000). Our hypothesis is that the possible crowding-out effect of public R&D on private R&D is counterbalanced by positive spillovers on BS specialisation.

To summarise, as business services strongly rely on ICT and innovation and extensively employ highly educated people, we expect regional specialisation in these sectors to be positively affected by the regional density of ICT, by R&D expenditure and by the availability of highly skilled workers.

3. The spatial determinants of specialisation in BS. Empirical analysis

3.1 A summary of the variables included in the econometric analysis

Table 1 below provides a synthesis of the theoretical hypotheses derived from the literature reviewed in the previous section. These are translated into operational variables and empirical proxies included as dependent variable and regressors in the econometric analysis (see Section 3.3).

Existing theories and empirical evidence reviewed in Section 2 identify three sets of determinants of BS regional specialisation: agglomeration economies; intermediate demand and input-output linkages between BS and their users; innovation in services. Each one of these theoretical approaches leads to identify operational variables (localisation, urbanisation economies and Hirschmann linkages; ICT, public R&D intensity and human capital) which can be more easily translated into proxies for our empirical analysis.

[Insert Table 1 about here]

Urbanisation economies (AGGL) were found in the literature to favour specialisation in BS, which tend to cluster in regions with urban areas and more densely populated. Therefore proxies of these economies are:

POP: the share of population over the regional area (population density);

CAPITAL: dummies for regions where capital cities are located.

Hirschmann linkages/intermediate demand (INTDEM) are proxied by the weighted share of employment in manufacturing industries that are strong users of business services over total employment. In particular, we take a vector measuring the use of services on output for manufacturing sectors that are above average BS users and, for each region and year, we multiply it by total employment in each respective manufacturing sector; this number is then divided by the region's i total employment in year t:

$$INTDEM_{it} = \frac{\sum_{j=1}^{m} W_j E_{ijt}}{\sum_{j=1}^{n} E_{ijt}}$$

where:

i=region, j=sector, t=time, m=number of above average BS users manufacturing sectors, n=total number of sectors, E=employment, W=weight given by the average (across European countries) share of business services in total industry output as computed from Eurostat symmetric Input Output tables in 2000. The indicator is higher the higher is regional employment in manufacturing sectors that are strong users of BS with respect to total regional employment for each year.

Table 2 reports the coefficients that are used as weights to construct our indicator. These are obtained by regressing the share of business services in total output on industry dummies for all European countries included in the analysis in the year 2000. Focussing on manufacturing sectors, those that make considerable use of business services are all (with the exception of Tobacco products) knowledge-intensive industries (Printed matter and recorded media; Chemicals and chemical products; Office machinery and computers, Radio, television and communication equipment and apparatus; Medical, precision and optical instruments, watches and clocks), while labour and scale-intensive industries appear, on average, to be low or medium users of business services. This pattern shows clear regularities across countries[4]: this allows us to expect that our

[4] The regression has shown that there are significant industry effects in explaining the use of business services across countries: R^2=0.67, F=41.52 significant at 1%. For more details, see Guerrieri and Meliciani (2005).

indicator, that uses as weights the mean coefficients for above-average BS user industries reported in Table 2, is a good proxy for 'potential' intermediate demand.

[Insert Table 2 about here]

Finally the operational variables capturing innovation in services (Information and Communication Technologies, Public expenditure in R&D and Human capital) are proxied respectively by:

ICT: Patents in ICT over population;

RD: public R&D expenditures over GDP;

HC: Human capital, measured as the share of population with tertiary education.

The choice of the proxies is determined by the theoretical and empirical findings reviewed in Section 2 and summarised in Table 1 and by data availability. In particular, in the case of ICT, patents was the only variable available at the regional level. While ICT spending could also be a meaningful proxy for the amount of ICT available at the regional level, the patenting activity is a better measure of the innovation output of ICT (Acs et al., 2002).

One of the overarching questions behind the selection of variables within a spatial econometric framework is the choice of the most appropriate spatial unit of analysis (Burger et al., 2008), known as the MAUP (Modifiable Areal Unit Problem). This refers to the different magnitude of agglomeration economies effects depending on the spatial unit of analysis considered. The MAUP is both a theoretical and methodological problem (Burger et al., 2008; van Oort, 2007) and a priori-hypothesis on the spatial extent of the phenomenon investigated should be specified. We are aware that the NUTS2 spatial level of aggregation is relatively large compared to the one traditionally used in spatial models, though the inclusion of all the EU 27 regions rather than of a single country certainly represents a trade-off in this respect. All in all, the lack of availability of spatial data at finer level of disaggregation with respect to NUTS2 does not allow us to consider MAUP related aspects in the present paper. However, in the next Section we will use spatial descriptive statistics that will allow to give a preliminary idea of the extent of spatial correlation of BS specialisation at the NUTS 2 level. Specifying different distance matrices for all our variables will also help interpreting the results of the spatial econometric analysis. Further investigation of the MAUP with more disaggregated data will certainly be a central issue of our research agenda.

3.2 Patterns of spatial correlation

In order to measure spatial correlation in business services and its determinants we have to specify the pattern of spatial interactions among regions as captured by the spatial weight matrix. The choice of the spatial weight matrix is important since it defines the boundaries within which spatial interactions occur and the intensity of these interactions. In the literature two main criteria are used to evaluate geographical connections: a *contiguity* indicator or a *distance* indicator.

In the first case, it is assumed that interactions can only exist if two regions share a common border (the contiguity indicator can be refined by taking into account the length of this common border). The problem with the contiguity matrix is that some regions might not share borders with any other region (this is the case of islands). Therefore it doesn't seem to be the best choice in our sample of European regions. We therefore rely on a distance based matrix.

In the case of a distance matrix, it is assumed that the intensity of interactions depends on the distance between the regions. In defining a distance matrix various indicators can be used depending on the definition of the distance (great circle distance, distance by roads etc.) and depending on the functional form we choose (the inverse of the distance, the inverse of the squared distance etc.). Finally, a distance-cutoff above which spatial interactions are negligible must be chosen. Following, among others, Dall'Erba and Le Gallo (2007), we use the great circle distance between regional centroids. In particular each element of the spatial weight matrix is defined as follows:

$w_{ij}=0$ if $i=j$; $w_{ij}=1/(d_{ij}^k)$ if $d_{ij}<=D$ and $w_{ij}=0$ if $d_{ij}>D$

where w_{ij} is an element of the row standardised weight matrix **W** (with row standardisation spatially weighted variables represent an average across neighbouring regions); d_{ij} is the great circle distance between centroids of regions i and j; k defines the functional form and D is the cutoff parameter above which spatial interactions are assumed to be negligible.

In order to choose the functional form and the cutoff distance we rely on a-priori considerations on the scope of spatial spillovers in our sample and on comparisons of the overall explanatory power of the model (as measured by the R-squared and Log-likelihood) estimated with different spatial matrices as suggested by Lee (2009). Since our regions are already large (NUTS 2) we choose the minimum bandwidth allowing each region to have at least one neighbour and we take the inverse of the distance (this is the matrix that maximises the R-squared and Log-likelihood in regression analysis). We also test for robustness using larger distance bands and the inverse of the squared distance (k=2).

Spatial correlation is assessed by means of the Moran's I statistic (a measure of global spatial correlation), by the Moran scatterplot (Anselin, 1996), and by the Moran local indicator of spatial association "LISA" (Anselin, 1995). Moran's I statistic gives a formal indication of the degree of linear association between the vector z_t of observed values and the vector Wz_t of spatially weighted averages of neighbouring values, called the spatially lagged vector. Values of I larger (smaller) than the expected value $E(I)=-1/(n-1)$ indicate positive (negative) spatial autocorrelation. Statistical inference is based on the permutation approach with 10,000 permutations (Anselin, 1995). Moran's I statistic is a global statistic and does not allow to assess the local structure of spatial autocorrelation. The local Moran helps assessing whether there are local spatial clusters of high or low values (a positive value indicates spatial clustering of similar values (high or low) whereas a negative value indicates spatial clustering of dissimilar values between a region and its neighbours)[5]. All statistics are computed in the final year of analysis (2003).

Figure 1 shows Moran's scatter and reports the associated global Moran's coefficient based on the distance matrix defined above for all the variables used in the regression analysis. The Moran function attempts to illustrate the strength of spatial autocorrelation using a scatterplot of the relation between a variable vector (measured in deviations from the mean) and the spatial lag of this variable.

[Insert Figure 1 about here]

The highest degree of spatial correlation (as measured by the global Moran coefficient) is found for patents in ICT over population and for manufacturing intermediate demand (respectively 0.545 and 0.424 both significant at 1%), followed by specialisation in business services and population density (with Moran values of respectively 0.344 and 0.330 both significant at 1%), while relatively low values are found for tertiary education (0.092) and public R&D (0.042)[6]. In the case of R&D, the lack of spatial correlation is not surprising considering the importance of government choices (strengthening local advantages but also helping to reduce regional gaps). Also in the case of tertiary education institutional and political factors might play an important role in the regional distribution of the variable as shown by the fact that many Greek and Polish regions have high values of the indicator while in Italy, UK and Germany there are very differentiated patterns not matching with geographical clusters (see Figure 1).

In the case of the ICT variable, there appears to be important clustering effects with most regions located in the upper right or bottom left quadrants (indicating positive spatial correlation

[5] For a thorough use of measures of LISA on European regions, see Ertur and Koch (2006).

[6] In the case of public R&D the local Moran is not significant at conventional levels; while in the case of tertiary education it is low but significant.

respectively of high and low values), while only a few regions are located in the upper left or bottom right quadrants (indicating negative spatial correlation of respectively low (high) ICT regions surrounded by high (low) ICT regions). As shown by the local Moran statistics[7], clusters of high ICT regions include South East and Central UK regions; the two Finish regions; most German regions belonging to Nordrhein-Westfalen, Baden Wurttemberg (surrounded by the French region of Alsace) and Bayern (surrounded by the Austrian regions Salzburg and Vorarlberg). Clusters of low ICT regions include almost all Polish regions (with the two surrounding Eastern regions of Check Republic, Central Moravia and Moravskoslezsko); Eastern Hungary; Greek regions with the exception of Attiki and the cluster of two Portuguese regions (Norte and Centro) with two Spanish regions (Galicia and Extremadura).

With respect to intermediate manufacturing demand, clusters of high intermediate demand regions again include UK South Eastern (but not central) regions, not distant from the two French regions of Haute Normandie and Ile de France; three Hungarian regions including the region of the capital and the two Western regions of Transdanubia; clusters of low manufacturing intermediate demand include again the cluster of Portuguese and Spanish regions (with again Norte and Centro of Portugal and Extremadura but also Andalucia); the cluster of Greek regions and also a cluster of Southern Italian regions.

In the case of population density, negative values of local Moran (negative local spatial correlation) are found mainly for highly populated urban areas surrounded by less populated regions (this is the case, for example, of Wien, Attiki, Comunidad de Madrid, Praha, Ile de France, Berlin). Clusters of regions with high population density include several UK regions (mainly located in the South East, the area of London, South-West Yorkshire, East Midlands and North West); a group of Dutch (Western) and German (in the border area of Nordrhein-Westfalen) regions and Bruxelles. Clusters of low populated areas include some Central and South Western regions of France (some of them, Aquitaine and Midi Pyrenées, sharing borders with low populated Spanish regions: Comunidad Foral de Navarra and Aragon); Finnish and Greek regions.

As for specialisation in business services, we find many capital regions with negative local Moran coefficients; again there is a cluster of highly specialised regions including Dutch, Belgian and German regions and another cluster of UK regions; clusters with low values include also Polish regions and a group of Portuguese and Spanish regions (Norte and Centro of Portugal and the Spanish region of Extremadura).

[7] Local Moran coefficients and their significance levels are available on request.

Overall we observe some similarities but also differences in the geographical clustering of our dependent and explanatory variables. These are summarised in Table 3 that reports the correlation coefficients for all variables and their spatial lags.

[Insert Table 3 about here]

From the table we see that specialisation in business services is highly correlated with population density (0.75) and also with potential manufacturing demand (0.57), ICT (0.52) and capital cities (0.46). Lower, but still significant, correlation coefficients are found with public R&D (0.26) and tertiary education (0.21). Looking at the lagged variables, the highest correlation of specialisation in business services is found with its own lag (0.45). Significant positive correlation is also found with lagged ICT, lagged population density, and lagged potential manufacturing demand, while negative correlation is found with lagged tertiary education and lagged capital cities[8] (this last significant only at 10%); finally no relationship is found with lagged R&D. Looking at correlation among the explanatory variables, the highest values are found between ICT and manufacturing demand (0.53) and between population density and regions with capital cities (0.51). Tertiary education is positively correlated only with population density, regions with capital cities and its own lag (with correlation coefficients respectively of 0.30, 0.34 and 0.16), while the only positive significant correlation coefficients for public R&D are found with regions with capital cities (0.23) and ICT (0.17, significant at 5%).

Overall, it appears that tertiary education and public R&D have low or not significant spatial correlation and are loosely (and in some cases even negatively) correlated with the other variables and their spatial lags. This is probably due to the relevance of institutional and political factors in affecting the spatial distribution of these variables.

Since specialisation in business services is the main variable of interest in the paper, comparative advantage in business services (employment in business services in region *i* over total employment of region *i* divided by employment in business services for all regions over total employment for all regions) has been further used to map the EU regions in terms of BS specialisation in 2003 (Figure 2). Consistently with the Moran scatterplot, the map visually helps revealing the presence of an agglomeration pattern in the regional distribution of BS specialisation, with the main exceptions of the capital cities.

Many of the regions highly specialised in business services are regions where capital cities are located, in line with the urbanisation literature (Glaeser et al., 1992; Glaeser, 1999). This is the case

[8] While the variable “regions with capital cities” is a dummy variable, its spatial lag is not anymore a dummy variable but assumes values between zero and one depending on the distance with regions where capital cities are located (higher values indicating lower distance).

not only in high income countries, but also in Spain, Portugal, Greece and in some new entrant eastern countries (Kozép-Magyarorszàg: the region of Budapest; Praha).

When we exclude regions with capital cities, there appear to be some "country effects" in the spatial map of specialisation in business services. In fact all the Dutch regions and many UK (with some exception especially in the Western part of the country) and German regions appear to be highly specialised in these branches. On the other hand, none of the regions from new entrant countries, Portugal, Greece, and Finland (with the exception of regions with capital cities, as mentioned above) show a comparative advantage in business services. Regions in Spain, France and Italy show a more mixed pattern. In particular Italy shows a North-South divide, while French and Spanish regions, while being on average de-specialised, show relatively higher values of specialisation at their borders.

[Insert Figure 2 about here]

A clear clustering effect in the comparative advantage indicator mapped in Figure 2 emerges indicating that there are factors explaining the sectoral composition of regional employment in BS which seem to spread to neighbouring regions. We test this in a spatial econometric framework in the next section.

3.3 Econometric strategy

Due to the existence of spatial correlation in most of our variables, specialisation in business services is estimated using a Spatial Durbin model (SDM). This is a general model that includes amongst the regressors not only the spatial lagged dependent variable, but also the spatial lagged set of independent variables. In the context of panel data, it can be represented as follows[9]:

$$Y_t = \rho W Y_t + X_t \beta_1 + W X_t \beta_2 + \lambda_t e_N + v_t \qquad (1)$$

where Y_t denotes a Nx1 vector consisting of one observation for every spatial unit of the dependent variable in the th time period, X_t is a NxK matrix of independent variables, W is an NxN non negative spatial weights matrix with zeros on the diagonal. A vector or matrix premultiplied by W denotes its spatially lagged value, ρ, β_1 and β_2 are response parameters, and λ_t denotes a time specific effect, which is multiplied by a Nx1 vector of units elements and ν_t is a Nx1 vector of residuals for every spatial unit with zero mean and variance σ^2.

[9] Elhorst (2005) presents a more general panel model including also fixed effects and a dynamic specification. Due to the short time series available (1999-2003), we treat data as a repeated cross-section (pooled estimation).

Based on the hypotheses discussed in Section 3.1, *Y* is the regional share of employment in business services over total regional employment[10] (BUS) and *X* is a matrix of explanatory variables including: the share of population over the regional area (POP), dummies for regions where capital cities are located (CAPITAL), the weighted share of employment in manufacturing industries that are strong users of business services over total employment (INTDEM), Patents in ICT over population (ICT); public R&D expenditures over GDP (RD) and the share of population with tertiary education (HC). All variables are in logarithms and the model is estimated for a panel of 164 NUTS2 EU27 regions drawn from the Regio database pooled over the period 1999-2003[11].

LeSage and Fischer (2008) show that the Spatial Durbin model is appropriate, independently from economic considerations, when two circumstances are verified: i) spatial dependence occurs in the disturbances of a regression model and ii) there is an omitted explanatory variable (variables) that exhibits non zero covariance with a variable (variables) included in the model. Moreover it nests most models used in the regional literature. In particular, imposing the restriction that $\beta_2=0$ leads to a spatial autoregressive (SAR) model that includes a spatial lag of the dependent variable from related regions, but excludes these regions' characteristics. Imposing the restriction that $\beta_2=\rho\beta_1$ yields the spatial error model (SEM) that allows only for spatial dependence in the disturbances. Imposing the restriction that $\rho=0$ leads to a spatially lagged X regression model (SLX) that assumes independence between the regional dependent variables, but includes characteristics from related regions in the form of explanatory variables. Finally, imposing the restriction that $\rho=0$ and $\beta_2=0$ leads to a non-spatial regression model. We choose the appropriate model on the basis of hypotheses testing[12].

In our spatial regression that includes a spatial lag of the dependent and independent variables, a change in a single explanatory variable in region *i* has a *direct impact* on region *i* as well as an *indirect impact* on other regions (see LeSage and Fischer, 2008 for a discussion). This result arises from the spatial connectivity relationships that are incorporated in spatial regression models; it raises the difficulty of interpreting the resulting estimates. LeSage and Pace (2009) provide computationally feasible means of calculating scalar summary measures of these two types of impacts that arise from changes in the explanatory variables. These routines have been extended by Elhorst

[10] From now on we omit the explanation of the suffix i and t which refer respectively to the region and to the time period. All the regressors included in the equation specification refer to region i at time t.

[11] The regions belong to the following countries: Austria, Belgium, Czech Republic, Germany, Spain, Finland, France, Greece, Hungary, Italy, Netherlands, Poland, Portugal, Slovakia and United Kingdom. Only regions for which there were enough data in order to construct a balanced sample by interpolating missing values were included.

[12] Lagrange Multiplier tests and their robust versions are used to test the OLS versus the SAR and SEM; Wald tests are used for testing the SAR and SEM versus the SDM while the test of the SLX versus the SDM is a t-test on the coefficient of the spatial lag of the dependent variable.

(2010) to panel data model. In this paper we use the Elhorst (2010) Matlab routines that allow to compute direct and indirect effects.

3.3 Econometric results

Since all the restrictions were rejected (see tests at the end of the table) we report results based on the more general model (spatial Durbin). Coefficients, direct, indirect and total effects of each variable with their asymptotic t-values are reported in Table 4.

[Insert Table 4 about here]

Looking at the direct effects, all the coefficients have the expected signs and are significant with the exception of tertiary education. Agglomeration economies, manufacturing intermediate demand and technology are all relevant factors in explaining specialisation in business services as suggested by the literature.

Looking at the agglomeration variables, the dummy for regions with capital cities is highly positively related to BS specialisation as well as the variable of population density. These results highlight the important role played by urbanisation externalities for the regional specialisation in business services. It is interesting to observe that, even when included simultaneously, both population density and the dummy for regions with capital cities positively affect regional specialisation in BS, highlighting a specific role played by urban economies for the development of these services. High population density as well as the specific role of urban economies can also be interpreted as a (final) demand determinant of BS specialisation.

Intermediate demand (as captured by the index of intermediate demand from manufacturing industries) represents a major determinant of BS specialisation across regions. This is consistent with the important role of forward linkages for BS and also suggests the existence of complementarities between intermediate and final demand in fostering the increasing specialisation in BS across EU regions.

Finally, as suggested by the literature on innovation in services, both ICT, proxied by the ICT-related patents over population across regions, and public R&D have a positive and significant impact on BS specialisation. The lack of significance of the human capital variable is not expected on the basis of the empirical evidence found in the literature (Kox and Rubalcaba, 2007b). One possible explanation is that the share of people with tertiary education is a poor proxy of employees' abilities when we compare regions of different countries since the meaning of the variable can be different depending on the educational system. Moreover, due to lack of data on migration, we cannot assess in this context whether migration of high-skilled workers represents a factor of attractiveness for BS to localise in a particular region.

Overall, agglomeration, demand and technology factors favouring specialisation in BS within the region are well captured by the direct effects.

Turning to spatial dependence, the highly significant coefficient of the lagged dependent variable (and some lagged independent variables) suggests the presence of clustering effects behind the determinants of BS specialisation. The positive coefficient of the spatial lag confirms the descriptive picture provided by the Moran scatter plot discussed above and establishes the spatial dependence in BS specialisation.

However, in order to disentangle the contribution of each explanatory variable to spatial dependence we have to look at indirect effects.

The signs and significance of indirect effects in the spatial Durbin specification provide interesting insight into the different role of spatially lagged independent variables. There are two possible (equivalent) interpretations of these effects. One interpretation (the one that we adopt in our discussion) reflects how changing each explanatory variable of all neighbouring regions by some constant amount would affect the dependent variable of a typical region. Pace and LeSage (2009) label this as the average total impact on an observation. The second interpretation measures the cumulative impact of a change in each explanatory variable in region i over all neighbouring regions, which Pace LeSage (2009) label the average total impact from an observation (see also Le Sage and Fischer, 2008).

Interesting results come out from the indirect effects of agglomeration variables (capital cities and population density). In fact, while being surrounded by highly populated regions gives rise to positive spillovers (positive and significant indirect effect), being surrounded by regions with capital cities exerts a negative indirect effect on specialisation in business services. It appears that in the case of capital cities there is a strong 'displacing' effect with services' based activities moving away from surrounding areas to concentrate in urban centres.

When we look at the role of intermediate demand coming from neighbouring regions on one's region business services we find a negative but not significant indirect effect. This contrasts with the negative and highly significant coefficient of the lagged intermediate demand. It must be noted that the indirect effect takes into account the whole set of spatial interactions among regions as captured also by the positive spatial dependence in BS specialisation. A possible explanation of the lack of significance of the indirect effect is that the positive spillovers coming from intermediate demand in neighbouring regions are compensated by a possible crowding out effect (the presence of high intensive users of BS in neighbouring regions might tend to 'displace' the BS specialisation in one region). Alternatively, it is also possible that the extent of forward linkages and related externalities are geographically more concentrated and cannot be captured at our level of aggregation (the NUTS 2 level)[13].

Looking at the indirect effect of technology, we find mixed results. While the intensity of ICT in the close-by regions – proxied by the lagged patents in ICT over population – has a positive and significant impact on regional BS specialisation, the same does not occur for public R&D. This suggests the existence of ICT clusters (or ICT-related spillovers) that go beyond regional boundaries, while, surprisingly, these spillovers are not found for government R&D. A possible explanation could be the fact that knowledge spillovers of public R&D are not geographically confined. The finding of a positive direct effect but a not significant indirect effect also suggests the existence of complementarities between a region's public and private R&D (that is included in BS) but not between the same region's private R&D and neighbouring regions' public R&D. In this respect, the empirical literature has not provided a conclusive answer. Although more evidence supports the presence of positive spillovers of publicly funded R&D on private R&D investments, in some cases the opposite evidence has also been found, showing displacing effects (for a detailed review on the issue of complementarities/substitutability between public and private R&D see David et al., 2000).

Finally, it is interesting to underline that while the estimated coefficients of the SDM do not differ substantially from the direct effects, coefficients of spatially lagged variables are misleading (they point to a negative impact of lagged intermediate demand and to a lack of significance of lagged population density and ICT) because they do not take into account the whole set of connectivity relationships that are incorporated in the spatial regression model. These can only be assessed by looking at the size and significance of indirect effects.

4. Summary of the findings and conclusions

4.1 Determinants of BS specialisation

Our study aims at investigating the structural and spatial determinants of specialisation in business services at the regional level. We identify agglomeration economies, intermediate demand and technology as key explanatory variables.

[13] The results reported in Table 4 are based on a distance matrix with a cutoff distance of 2.5 (the minimum bandwidth allowing each region to have at least one neighbour) and where we take the inverse of the distance (see section 3.2). Results are qualitatively the same if we take the inverse of the square distance. All results are stable to doubling the cutoff with the exception of lack of significance of the ICT indirect effect. This is not surprising since our unit of analysis is already large (NUTS 2 regions) and, therefore, it is important to choose small distances if we want to capture spillover effects.

We find that knowledge intensive business services tend to concentrate in capitals and urbanised areas, that ensure high levels of final demand. This has important implications for the evolution of income disparities at the regional level and calls for regional policies. In fact, while the concentration of valued-added and knowledge intensive activities in cities may foster regional growth, it could also cause negative externalities in surrounding areas.

We also find that the composition of manufacturing activities affects specialisation in business services via inter-sectoral linkages. This result has important implications since it suggests that a region's ability to develop an efficient and dynamic service economy is linked to the structure of its manufacturing sector. In particular, we find that knowledge-intensive industries are the main users of business services. As a consequence, regions specialised in these industries are in a favourable position for developing a comparative advantage in business services.

We also find that technology (proxied by patents in ICT) has a positive and significant impact on specialisation in business services. Also, the intensity of regional public spending in R&D has a positive and significant effect on BS. This supports those theories that emphasise the role of technology in affecting specialisation and is consistent with the view that ICT plays a special role in the case of business services. It also suggests that technology policy focussing on the development and use of new technologies can positively affect regional specialisation in business services, an area that is becoming strategic for its high rate of growth and its linkages with the manufacturing sector. Surprisingly we do not find a role for human capital in affecting specialisation in business services. However this could depend on the fact that our proxy (the share of population with tertiary education) does not fully capture regional skill levels since it could be affected by national differences in education systems. Future studies might investigate whether other proxies measuring the availability of skilled workforce at the regional level (not available so far) could explain regional specialisation in business services better, as one would expect.

4.2 The spatial dependence of BS specialisation

Our results support the hypothesis of the presence of spatial dependence in the determinants of BS specialisation. At a descriptive level, a positive and significant Moran coefficient is found, which indicates that a regional sectoral specialisation (and de-specialisation) is affected – among other determinants – by that of neighbouring regions.

The estimation of the spatial specifications of equation (1) confirms that BS specialisation and some of its determinants are spatially dependent.

When looking at the role of spatially lagged explanatory variables we find interesting results: while being surrounded by highly populated areas leads to positive spillovers on services' specialisation (as suggested by the literature on clusters and industrial agglomeration), being surrounded by urban areas has a displacing effect (an indirect negative effect). This result has important implications since it suggests that urbanisation while favouring the rise of employment in services in cities might also lead to an increase in disparities between cities and surrounding areas. Moreover, among technology variables, while lagged ICT exerts a positive significant impact on BS specialisation, this is not the case for public R&D. This result supports the findings on the importance of ICT clusters or ICT spillovers while we did not find evidence of spillovers of public R&D to surrounding regions: it appears that the complementarity between public and private R&D, that is included in our service variable, is confined within the region.

All in all, this paper aims to adding to both the regional economic literature and the literature on structural change and tertiarisation, which have so far lacked a regional perspective. Providing a spatial picture of the determinants of BS specialisation contributes to understanding the underlying reasons behind employment productivity and growth divergences at the regional level, in line with recent contributions addressing these issues (Fagerberg et al., 1997; Guerrieri et al., 2005; Meliciani, 2006; Verspagen, 2007; Sterlacchini, 2008 among others), which are likely to become more important after the enlargement to Eastern EU countries.

Although a detailed discussion of this issue is outside the scope of this paper, the analysis presented is also aimed at informing European industrial and innovation policies, which are increasingly (and rightly so) designed at the regional level (Verspagen, 2007).

Our research agenda includes accounting for the dynamic specifications of the spatial econometric model presented in this work and defining a more refined set of variables measuring the innovation intensity, beyond the patents in ICT and the share of population with tertiary education, allowing also to account for migration of skilled workers.

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Appendix: Tables and Figures

Table 1 – A summary of the variables included in the econometric model

Theoretical constructs	**Operational variables**	**Proxy**
Agglomeration economies (Section 2.1)	*Localisation externalities*	BS: specialisation in Business Services
	Urbanisation externalities	AGGL: POP: Population density CAPITALS: regions with capital cities
	Hirschmann's forward linkages	INTDEM:Weighted share of employment in manufacturing industries that are high users of business services over total employment
Intermediate demand (Section 2.2)	*Structure of intermediate linkages*	INTDEM:Weighted share of employment in manufacturing industries that are high users of business services over total employment
Innovation in services (Section 2.3)	*Information and communication technology*	ICT: Patents in ICT over population
	Public expenditures in R&D	RD: Public R&D expenditures over regional GDP
	Human capital	HC: Share of population with tertiary education

Table 2 - Share of Business Services in total industry output in 2000, average across European countries

Above average manufacturing Industries	Share	Above average service industries	Share
Printed matter and recorded media	8.2%	Computer and related services	19.5%
Chemicals and chemical products	8.1%	Other business services	17.5%
Office machinery and computers	8.0%	Research and development services	13.9%
Tobacco products	7.6%		
Radio, television and communication equipment and apparatus	7.3%		
Medical, precision and optical instruments, watches and clocks	6.4%		
Average manufacturing Industries	**Share**	**Average service industries**	**Share**
Machinery and equipment n.e.c.	5.0%	Insurance and pension funding services, except compulsory social security services	10.5%
Electrical machinery and apparatus n.e.c.	4.8%	Services auxiliary to financial intermediation	9.0%
Other transport equipment	4.8%	Wholesale trade and commission trade, except of motor vehicles and motorcycles	8.9%
Rubber and plastic products	4.5%	Post and telecommunications services	8.1%
Food products and beverages	4.4%	Renting of machinery and equipment without operator and of personal and household goods	8.0%
Furniture; other manufactured goods n.e.c.	4.2%	Financial intermediation services, except insurance and pension funding services	7.7%
Wearing apparel; furs	4.1%	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	7.6%
Other non-metallic mineral products	4.0%	Retail trade services, except of motor vehicles and motorcycles; repair services of personal and household goods	6.7%
Below average manufacturing industries	**Share**	**Below average service industries**	**Share**
Motor vehicles, trailers and semi-trailers	3.9%	Supporting and auxiliary transport services; travel agency services	5.3%
Pulp, paper and paper products	3.7%	Water transport services	5.2%
Recovered secondary raw materials	3.5%	Air transport services	4.5%
Fabricated metal products, except machinery and equipment	3.4%	Hotels and restaurants services	4.1%
Textiles	3.3%	Real estate services	3.5%
Leather and leather products	3.0%	Land transport; transport via pipelines services	3.3%
Basic metals	2.8%		
Wood and of products of wood and cork (except furniture); articles of straw and plaiting materials	2.3%		
Coke, refined petroleum products and nuclear fuels	2.0%		
Average	*4.7*		*8.4*
Standard Deviation	*1.9*		*4.5*

Source: Eurostat Regio database
Notes: Industries are defined as above (below) average when the share is higher (lower) than the average plus (minus) (1/2)*standard deviation.

Table 3 - Correlation coefficients among all variables and their spatial lags

	BS	INTDEM	POP	ICT	HC	RD	CAPITAL	LBS	LINTDEM	LPOP	LICT	LHC	LRD	LCAPITAL
BS	1													
INTDEM	0.572 (0.000)	1												
POP	0.749 (0.000)	0.483 (0.000)	1											
ICT	0.521 (0.000)	0.532 (0.000)	0.395 (0.000)	1										
HC	0.213 (0.006)	0.108 (0.168)	0.302 (0.000)	-0.054 (0.489)	1									
RD	0.260 (0.001)	0.125 (0.111)	0.099 (0.206)	0.172 (0.027)	0.107 (0.174)	1								
CAPITAL	0.462 (0.000)	0.309 (0.000)	0.510 (0.000)	0.130 (0.097)	0.345 (0.000)	0.233 (0.003)	1							
LBS	0.451 (0.000)	0.312 (0.000)	0.344 (0.000)	0.442 (0.000)	-0.197 (0.011)	0.056 (0.475)	-0.154 (0.049)	1						
LINTDEM	0.262 (0.001)	0.553 (0.000)	0.206 (0.008)	0.403 (0.000)	-0.203 (0.009)	0.033 (0.675)	-0.086 (0.271)	0.636 (0.000)	1					
LPOP	0.361 (0.000)	0.246 (0.001)	0.443 (0.000)	0.303 (0.000)	-0.177 (0.023)	-0.018 (0.818)	-0.090 (0.226)	0.815 (0.000)	0.549 (0.000)	1				
LICT	0.367 (0.000)	0.374 (0.000)	0.252 (0.001)	0.672 (0.000)	-0.225 (0.004)	0.093 (0.235)	-0.095 (0.226)	0.658 (0.000)	0.640 (0.000)	0.518 (0.000)	1			
LHC	-0.247 (0.001)	-0.231 (0.003)	-0.208 (0.007)	-0.319 (0.000)	0.161 (0.039)	-0.148 (0.058)	-0.075 (0.341)	-0.031 (0.690)	-0.085 (0.278)	0.082 (0.294)	-0.231 (0.003)	1		
LRD	0.098 (0.212)	0.060 (0.442)	-0.006 (0.934)	0.178 (0.022)	-0.188 (0.016)	0.086 (0.274)	0.092 (0.240)	0.167 (0.032)	0.090 (0.252)	0.064 (0.404)	0.223 (0.004)	-0.170 (0.029)	1	
LCAPITAL	-0.131 (0.096)	-0.058 (0.463)	-0.085 (0.280)	-0.097 (0.216)	-0.102 (0.196)	0.083 (0.286)	0.001 (0.987)	0.288 (0.000)	0.255 (0.001)	0.338 (0.000)	0.066 (0.404)	0.314 (0.000)	0.208 (0.007)	1

Note: p-values in brackets

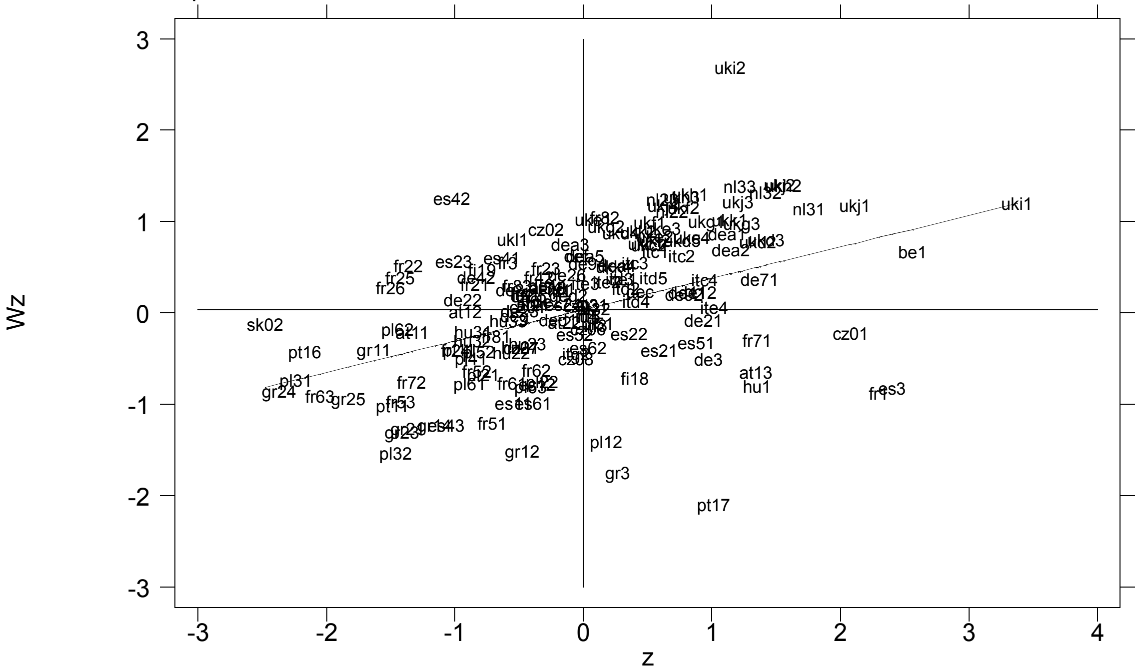
Table 4 – The determinants of specialisation in business services 1999-2003 – Spatial Durbin Model estimates

Variables	Coefficient	Direct effect	Indirect effect	Total effect
Intermediate demand	0.181 *** (7.238)	0.178 *** (7.194)	-0.063 (-1.075)	0.115 * (1.910)
Share of population with tertiary education	-0.000 (-0.036)	0.001 (0.112)	0.026 (0.634)	0.028 (0.569)
Patents in ICT over population	0.017 ** (2.248)	0.019 *** (2.592)	0.029 * (1.683)	0.048 *** (2.682)
Government R&D over GDP	0.034 *** (5.563)	0.035 *** (5.375)	0.012 (0.468)	0.047 (1.634)
Population density	0.178 *** (10.671)	0.185 *** (11.663)	0.088 *** (2.680)	0.273 *** (7.784)
Regions with capital cities	0.390 *** (7.362)	0.360 *** (6.509)	-0.435 *** (-2.770)	-0.074 (-0.415)
BS Specialisation in neighbours regions	0.487 *** (12.896)			
Lagged intermediate demand	-0.121 *** (-3.250)			
Lagged Share of population with tertiary education	0.015 (0.675)			
Lagged Patents in ICT over population	0.007 (0.690)			
Lagged government R&D over GDP	-0.010 (-0.742)			
Lagged population density	-0.038 (-1.585)			
Lagged regions with capital cities	-0.435 *** (-4.979)			
LM spatial lag	148.12 ***			
Robust LM spatial lag	6.268 ***			
LM spatial error	226.22 ***			
Robust LM spatial error	84.364 ***			
Wald spatial lag=70.23***				
Wald spatial error=21.30***				
R^2=0.697				
Log-likelihood=-237.72				
Observations=820				

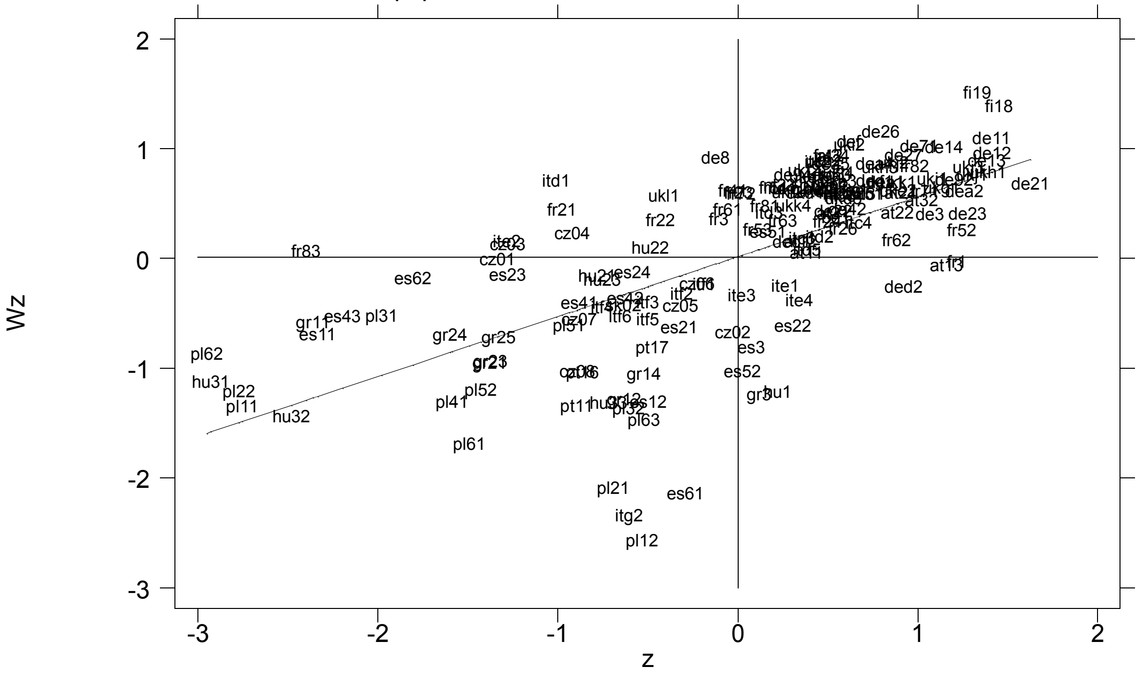
Notes: *, **, *** indicate significant at the 10%, 5% and 1% levels respectively. Time dummies are included.

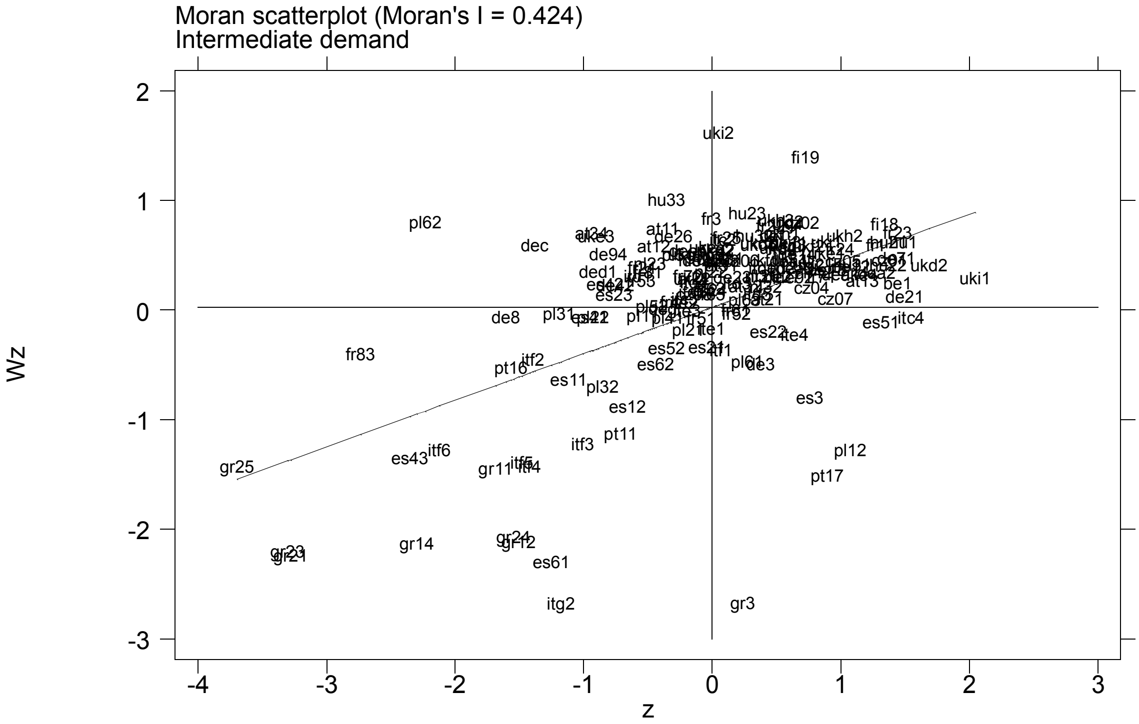
Figure 1: Moran scatterplot of dependent and explanatory variables

Moran scatterplot (Moran's I = 0.344)
Specialisation in business services

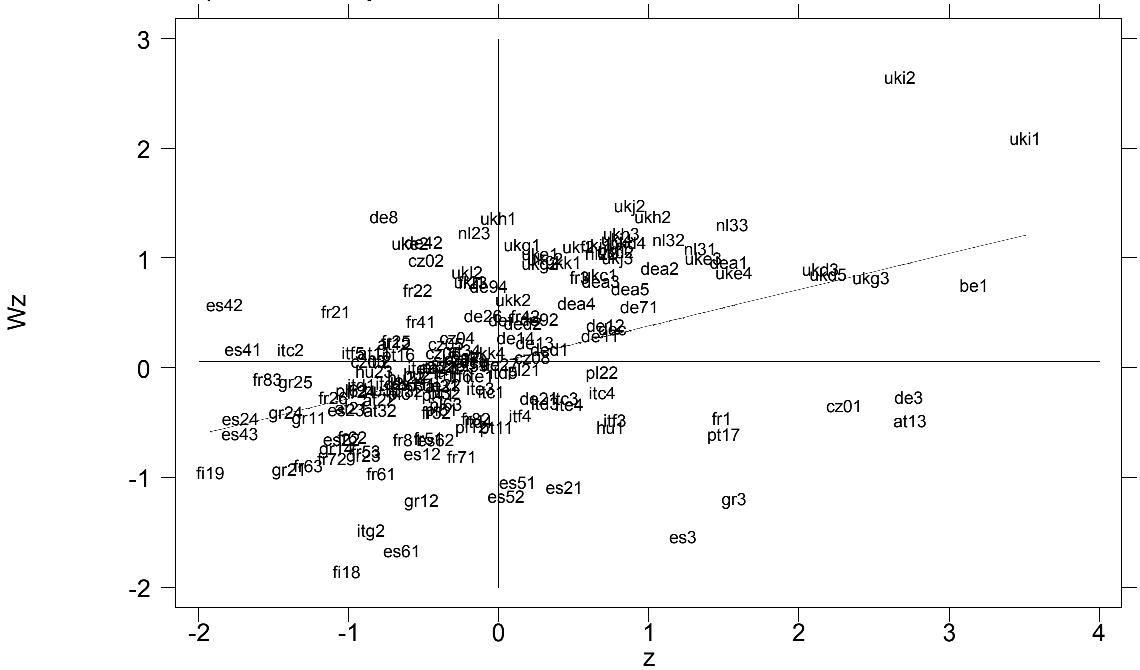


Moran scatterplot (Moran's I = 0.545)
Patents in ICT over population

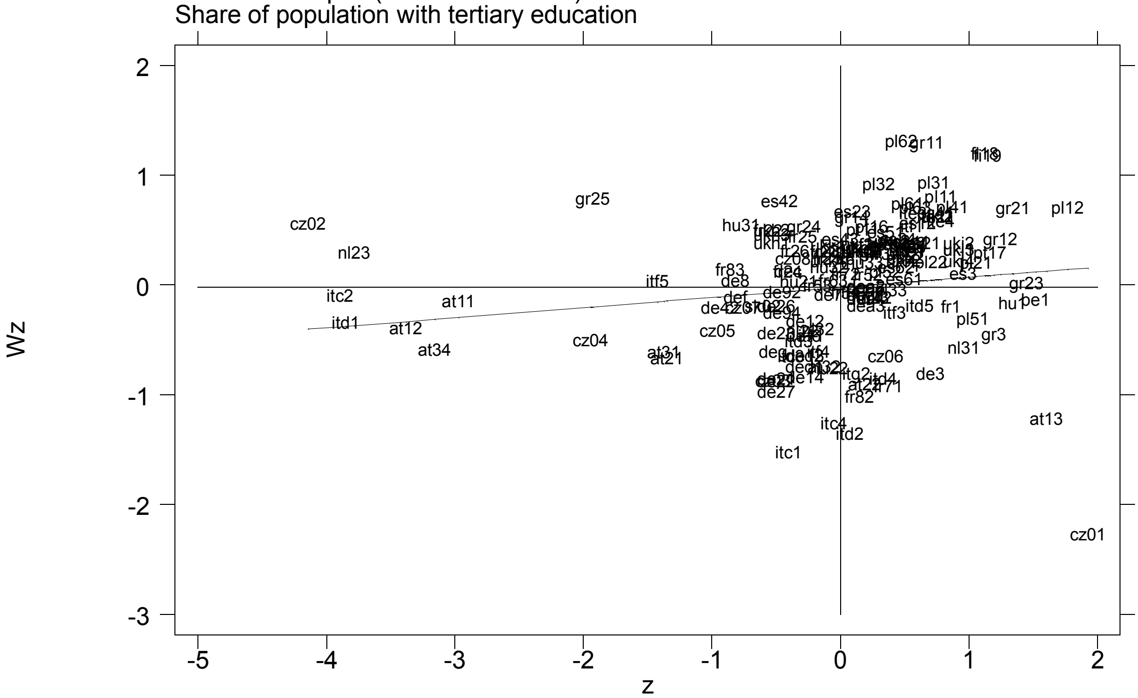


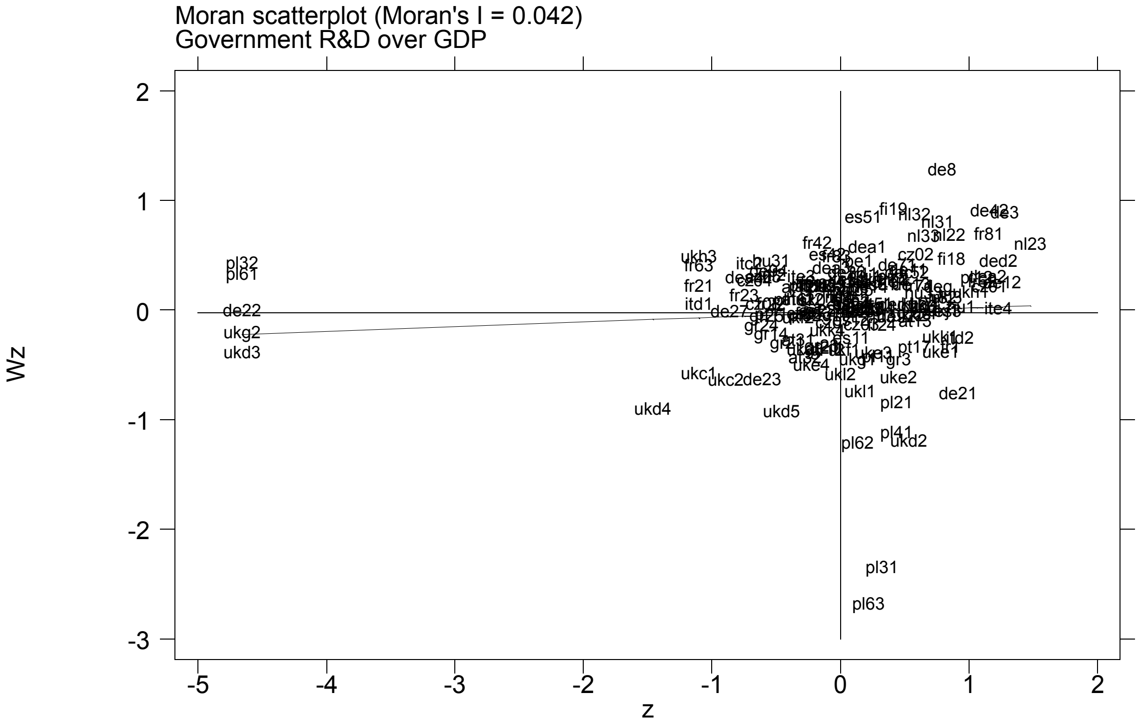

Moran scatterplot (Moran's I = 0.424)
Intermediate demand
Wz
z

Moran scatterplot (Moran's I = 0.330)
Population density



Moran scatterplot (Moran's I = 0.092)
Share of population with tertiary education





Source: EUROSTAT Regio database

Notes: Distance band between 0.0 and 2.5; z = vector of each the variable in deviation from the regional mean; Wz=vector of spatial lags

Figure 2 – Specialisation in Business Services in EU regions – comparative advantage in 2003