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Investigating Agglomeration Economies in a panel of European Cities and Regions

Michael Artis*

(m.artis@swansea.ac.uk)

Declan Curran**

(Declan.G.Curran@nuim.ie)

and

Marianne Sensier†

(marianne.sensier@manchester.ac.uk)

*School of Business and Economics, Swansea University, Wales

**National Institute for Regional and Spatial Analysis (NIRSA), National University of Ireland, Maynooth, Ireland

†Institute of Political and Economic Governance
School of Social Sciences, The University of Manchester, UK

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Abstract
This paper investigates agglomeration economies in an annual panel of NUTS 2 and 3 areas across France, Germany, Ireland, Italy, Spain and the UK over 1980-2006. We uncover evidence of long run agglomeration effects of 14% at the NUTS 2 level and 13% at the NUTS 3 level. We also find evidence of localisation and urbanisation agglomeration effects for the industry and service sectors in NUTS 3 areas. Furthering the analysis a study on highly populated NUTS 3 city areas is undertaken, but only for the most recent sub-sample are agglomeration effects significant at 10% showing bigger city regions to have performed better in the most recent past.

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Keywords: agglomeration, system dynamic panel data estimations.

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1. Introduction

Theories of agglomeration economies posit that the concentration of economic activities leads to the emergence of positive externalities, which are transmitted both within and between industries through channels such as technological spillovers, an increasingly skilled labour pool, and firm-supplier networks (Fujita et al., 1999; Fujita and Thisse, 2002). However, while empirical studies have generally confirmed the presence of a positive agglomeration effect, estimates of this positive externality have tended to vary in magnitude (Melo et al., 2009). Empirical research estimating the extent to which agglomeration economies influence the development of areas has tended to focus on how these positive externalities manifest themselves in a given region's labour productivity. The relationship is usually expressed in terms of how much a doubling of employment density would increase labour productivity (i.e. an estimate of elasticity). While US and EU estimates of this relationship have varied, most estimates have fallen within a range of 4.5% (Ciccone, 2002) to 13% (Brülhart and Mathys, 2008) for Europe.

In this quantitative analysis we aim to establish the presence and strength of agglomeration economies observed across European NUTS 2 and 3 areas, as well as across large NUTS 3 city-regions[1]. This comparison of agglomeration forces at play in NUTS administrative areas also allows us to assess the extent to which the choice of geographic unit of analysis affects the observed estimates of European agglomeration economies. We also investigate whether distinct agglomeration trends are present in the secondary and services sectors (localisation economies) and whether agglomeration economies operate across industries (urbanisation).

We estimate the effect of agglomeration economies by regressing employment density on labour productivity utilising system GMM dynamic panel data techniques. The countries we analyse include France, Germany, Ireland, Italy, Spain and the UK. We use a similar approach to Brülhart and Mathys (2008), who use a dataset that covers the majority of Europe's NUTS 2 areas and they transform their data into three year averages. While our analysis focuses on a smaller group of Western European countries, we include the countries that Ciccone (2002) studied in cross-section at the NUTS 3 area level. Our analysis departs from both these studies in that we investigate the data at an annual frequency over the sample 1980-2006 and three

[1] We define large city regions as those Nuts 3 regions with population greater than 500,000.

further sub-samples which are close to the decade split (1981-1989, 1990-1998 and 1999-2006) this allows us to assess whether the observed agglomeration effects are changing over time. At the NUTS 2 level we also include a Eurostat variable capturing the amount of human resources in science and technology (HRST) in a region to proxy an education control.

To preview our results we find a greater agglomeration effect for total labour productivity at the NUTS 2 region level with a 14% estimated long-run elasticity compared to 13% at the NUTS 3 level. When the HRST variable is added we find an important positive contribution for productivity. We uncover evidence of localisation agglomeration economies for financial intermediation at the NUTS 2 level and services at the NUTS 3 level with some evidence of urbanisation economies over the full sample for the manufacturing and industry sectors. We find that large NUTS 3 city regions exhibit stronger agglomeration effects over the recent past.

In the next section we review the literature on agglomeration economies. In Section 3 we detail the methodology used in this study, Section 4 presents the datasets used in our estimations and some summary statistics. Section 5 discusses the results from our panel data estimation. Finally, Section 6 offers some conclusions.

2. Agglomeration Literature Review

The economics of agglomeration, whose origins can be traced back to the work Marshall (1898; 1919; 1930), tend to be summarised into a triad of external economies – a pooled market for workers with specialised skills, a growing number of increasingly specialised input suppliers and technological spillovers. The local pool of labour can provide an efficiency gain for both workers and firms by maximising job-matching opportunities and thus reducing search costs (Gordon and McCann, 2000; Simpson, 1992), while the associated accumulation of human capital can enhance both labour skills (Arrow, 1962) and firm productivity (Romer, 1987; Scott, 1988). As regards input relations, a localised industry can support more suppliers, which increases the level of specialisation and efficiency of the supply base, which, in turn, presents an efficiency gain for the customers (Harrison, 1992). The actual driver for geographical proximity between firms is the desire to reduce the costs of transactions across space (Krugman, 1991). This may involve transport/logistics costs and/or the cost of intentional information exchange between the two firms (van Egeraat and Jacobson, 2006). The third advantage that is commonly distilled from Marshall's work, technological spillovers, involves informational or knowledge externalities which result from the concentration of (both vertically and horizontally) related firms, facilitating processes of learning and innovation in the locality (Malmberg and Maskell, 1997 and 2002). Technological spillovers are believed to be intensified by proximity in "untraded interdependencies" (Storper, 1995) and independent of the degree of intentional interaction. Knowledge tends to become embedded in the local milieu (Malmberg, 1996) – "the mysteries of trade (…) are in the air" (Marshall, 1898, p.350). This unintentional interaction (Oerlemans and Meeus, 2005) within a group of firms involves the acts of observation and comparison by firms (Malmberg and Maskell, 2002) which are facilitated by non-geographical forms of proximity, notably social, cultural and institutional proximity (although these other forms of proximity can indirectly be augmented by geographical proximity) (Boschma, 2005).

Hoover (1937) further refined the theory of agglomeration economies by dividing such economies into two distinct types: localisation and urbanisation economies. Localisation economies, as identified by Marshall (1890), are advantages that firms in a single industry (or set of closely related industries) gain from being located in the same location while urbanisation economies are advantages gained by all firms, regardless of sector, from being located together. Urbanisation economies are partially based on economies of scope and are related to the phenomenon that people and economic activity in general tend to concentrate in cities or core industrial areas (Malmberg and Maskell, 2002). Urbanisation economies, in particular, offer agents located in densely populated markets the opportunity to take advantage of positive externalities, such as those associated with knowledge spillovers across firms both within and between industries the presence of a more extensive division of labour or increasing returns owing to firm-level economies of scale and improved firm-worker matching (Wheeler, 2001), as well as improved access to inter-industry information flows, better access to specialised services, and access to general public infrastructure and facilities (see Melo et al., 2009; Fujita and Thisse, 2002; Fujita et al., 1999). Of course, negative externalities such as congestion may also arise, though Ciccone and Hall (1996) find that for densely populated areas in the US agglomeration effects more than offset the associated congestion effects.

Empirical research estimating the extent to which agglomeration economies influence labour productivity generally find a positive relationship, though the estimates tend to vary in magnitude; Melo, et al. (2009). Ciccone (2002) estimates agglomeration effects in a cross-section of NUTS 3 areas in France, Germany, Italy, Spain and the UK. Ciccone (2002) finds that a doubling of employment density increases labour productivity by 4.5% - compared to a corresponding elasticity of 5% estimated for the United States (Ciccone and Hall, 1996). Ciccone (2002) also finds that agglomeration effects, education, and country-dummies explain 64 percent of the variation in productivity across European regions; agglomeration effects do not appear to differ significantly between France, Germany, Italy, Spain, and the UK; and production in neighbouring NUTS 3 areas has a significant effect on regional productivity. Further European estimates come from Cingano and Schivardi (2004), who estimate a long-run elasticity of plant productivity to Italian city employment of 6.7%, and Rice et al. (2006), who estimate the effect of proximity to economic mass (controlling for occupational composition) on regional productivity to yield an elasticity of 3.5% for the UK. However, when Brülhart and Mathys (2008) employ a panel data approach estimating the effect of employment density on productivity across the majority of European countries they find elasticity estimates in the region as high as 13%. The wide range of agglomeration-productivity elasticity estimates is greatly influenced by the estimation techniques employed and how these techniques tackle the potential sources of endogeneity or reverse causality in empirical studies of agglomeration effects. The problem of endogeneity, and the empirical approaches utilised to handle it, are now discussed.

It has been well documented in empirical studies of agglomeration effects that, when regressing regional productivity on a measure of regional agglomeration, there is a risk of causality running from productivity to the agglomeration measure i.e. reverse causality. A range of different estimation procedures have been employed to account for this possible source of endogeneity. The general approach is to replace the agglomeration variable (be it employment density or employment mass) with an instrumental variable that is correlated with the agglomeration variable but not correlated with productivity. In a cross-sectional study Ciccone (2002) instruments employment density with regional land area. The underlying idea is that regional boundaries drawn mostly in the 19th century are correlated with 19th century population (and with current population and employment) but not with current productivity. Artis, Miguelez and Moreno (2009) incorporate both a spatial component and instrumental variables into a cross-sectional 2 stage least squares approach. Two external instruments are used: (i) the population in 1801 for regions whose centre is within two travel time bands as per Rice et al. (2006) and (ii) total land area of regions as per Ciccone (2002). Brülhart and Mathys (2008) exemplify the movement away from this type of "external" instrument by using past levels and past changes of the agglomeration variable ("internal instruments") in a dynamic panel setting which is the methodology used in this study and discussed in the next section.

3. Methodology

We outline the estimation approach of Brülhart and Mathys (2008) who utilise dynamic panel techniques to quantify the effect of agglomeration. While the Arellano and Bond (1991) differenced Generalised Method of Moments (DIFF-GMM) estimator uses first differences as instruments, this was found to behave poorly in small samples (Windmeijer, 2005). The system GMM estimator (SYS-GMM) of Arellano and Bover (1995) uses both lagged levels and first differences as instruments and is seen to perform better in small samples. Brülhart and Mathys (2008, p353) outline a number of useful methods for testing whether the instrument strategy is performing well. Their dependent variable is log of labour productivity defined as constant GVA per employee in the region. Employment density of each region is calculated as number of employees divided by area and this is used as an explanatory variable along with the log of employment and the lag of log labour productivity. They compare a number of different estimation methodologies: OLS, fixed effects, DIFF-GMM and SYS-GMM (with the latter giving preferred results as it suffers less from small sample bias). Brülhart and Mathys (2008) note that along with its ability to control for reverse causality, the SYS-GMM estimation approach is also more robust to error than cross-sectional approaches as time-invariant additive measurement error is absorbed into the region-specific effects of the panel specification.

In our case we are analysing NUTS 2 or 3 region's productivity which depends on lagged productivity, present and lagged employment density and further control variables as follows:

$$P_{nt} = \alpha P_{n,t-1} + \beta_0 D_{nt} + \beta_1 D_{n,t-1} + \gamma_0' X_{nt} + \varepsilon_n + \rho_{ct} + v_{nt} \qquad (1)$$

Where X_{nt} is a column vector of $k \in (1....K)$ control variables; α, β and γ are coefficients to estimated; ε_n is a region-specific effect; ρ_{ct} is a period-specific effect which varies with country, c, and v_{nt} is a stochastic error term. X_{nt} contains the HRST variable representing human resources in science and technology of each NUTS 2 region n. It could also contain variables reflecting the time-varying component of the regional business climate or the political environment.

The effects of agglomeration are quantified by testing the long-run equilibrium relationship between employment density and productivity in equation (1) given by the elasticity $\beta_{LR} = \frac{\beta_0 + \beta_1}{1-\alpha}$. We compute this nonlinear combination and the linear restriction $\beta_0 + \beta_1 = 0$ with a Wald test. If the restriction is rejected we can conclude that density has a statistically significant long-run effect on region/city productivity. If the restriction is not rejected but the parameters are individually statistically significantly different from zero, the interpretation is that changes in density have short-run effects on region/city productivity without impacting on the long-run productivity level.

We compare a number of different estimators when computing our results, but we only present output for the system GMM model. We utilise Stata 11 to estimate our models and compute two diagnostic tests: (1) the Arellano and Bond (1991) test for zero autocorrelation in first-differenced errors and (2) the cross-sectional dependence test of Pesaran (2004) which is written as a Stata routine by De Hoyos and Sarafidis (2006) to follow a fixed effects panel regression and is suitable in dynamic panels when T<N (with T the number of years in the time series and N the number of regions). This tests the null hypothesis of no cross-sectional dependence which if rejected could indicate spatial dependencies present. We also test different cross-section years with the Moran's *i* statistic for spatial autocorrelation (see Appendix B).

To get a handle on whether it is localisation or urbanisation agglomeration effects that are important we analyse different sectors and estimate own and other sector effects by testing the long-run relationship in the same way as described above.

4. Data and Summary Statistics

We investigate NUTS 2 and 3 areas in France, Germany (excluding East German regions), Ireland, Italy, Spain and the UK (we eliminate extremes from our dataset by excluding less productive small island regions and highly productive Aberdeen, NUTS 2 region ukm5, due to North Sea oil revenues) for a sample from 1980 to 2006. The dataset we use in this study has been purchased from Cambridge Econometrics[2]. In Chapter 4 of their manual detailing the European regional economic model and the data they describe how "the data completion process for NUTS 2 areas involves deflation, interpolation and summation constraints to ensure consistency across different levels of aggregation", p.4-4. The Eurostat REGIO database is the prime source for the European data produced by Cambridge Econometrics. They are able to produce deflated GVA series for areas by utilising sectoral price deflators from AMECO.

We analyse a total of 122 NUTS 2 areas (see Appendix Table A.1 for full list) and 691 NUTS 3 areas (see Table A.2). For the group we refer to as large NUTS 3 city regions we include 172 NUTS 3 areas that have a population greater than 500 thousand (we use Cambridge Econometrics Nuts 3 region population estimates in 2006 to decide which areas to include) these areas are highlighted in bold in the Appendix Table A.2.

We transform constant price GVA (in millions of Euros with 2000 as the base year) and divide it by employment for the areas to arrive at our dependent variable of labour productivity (GVA per worker). To calculate our employment density variable we divide employment by total land area for each region (in square kilometres). The land areas are downloaded from Eurostat's Regional Statistics Database[3], within regional demographics we can access area tables.

The variable for human resources in science and technology (HRST) as a share of the economically active population in the age group 15-74 is also downloaded from Eurostat's Regional Statistics Database within regional science and technology statistics. This indicator gives the percentage of the total labour force in the age group 15-74, that is classified as HRST, i.e. having either successfully

[2] See: http://www.camecon.com/AboutUs/Economic_Intelligence_Services/European_forecasts_by_city_region_and_sector/european_forecasts_city_reg_sector.aspx.

[3] See: http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/regional_statistics/data/database.

completed an education at the third level or is employed in an occupation where such an education is normally required. HRST are measured mainly using the concepts and definitions laid down in the Canberra Manual, OECD, Paris, 1995. We use this in our regression with total productivity in NUTS 2 areas.

When checking for localisation or urbanisation agglomeration effects we use the sector breakdown prepared by Cambridge Econometrics in their European regional dataset. At the NUTS3 region level three sectors are reported: agriculture, industry and services. At the NUTS 2 region level we can get a finer sector breakdown and we focus on manufacturing and energy production within the industry sector and financial intermediation within the services sector.

Table 1 reports the summary statistics for the NUTS 2 areas over the full sample 1980-2006, with the HRST series reported over a shorter sub-sample of 1999-2006. Table 2 contains the summary statistics for the NUTS 3 areas. In Tables 1 and 2 we present the mean, median and coefficient of variation (calculated as the standard deviation/ mean which gives and indication of the variables degree of dispersion) for total productivity, density and HRST (only available for NUTS 2 areas) over all countries and then by individual country. Within each country we also present the region with the sample average maximum and minimum productivity and density.

From Tables 1 and 2 we can see that the NUTS 2 and 3 areas of Ireland have the greatest dispersion for productivity. The UK has the greatest dispersion of employment density at the NUTS 2 level but France has greater density dispersion at the NUTS 3 level. Over all countries the NUTS 2 region with maximum average productivity of 61.03 is Île de France within this the Haut-de-Seine region has the greatest productivity for the NUTS 3 areas at 72.55. At the other end of the spectrum Spain has the lowest reported productivity with the NUTS 3 region of Orense having an average of 22.80 over the full sample. The UK has the greatest dispersion of employment density at the NUTS 2 level with the densest region being Inner London, also having the highest level of human resources in science and technology. At the NUTS 3 level the highest coefficient of variation for employment density is found for France which has the greatest extreme between Paris and Lozère. Spain has the smallest average employment density at the NUTS 3 level at 38.96 and the smallest employment density region of Soria at 3.59.

5. Agglomeration Effect at Differing Regional Levels

Next we will present the results from our SYS-GMM panel regression models and we will discuss each different geographical grouping in separate sections.

5.1 Results of NUTS 2 Panel Regression Model

The results of the panel data estimations are for total productivity in 122 NUTS 2 areas is shown in Table 3 these include year*country dummies to account for the differences in productivity between countries. We report the SYS-GMM one-step coefficients with robust standard errors (the two-step method is more suited to a larger group so is used for NUTS 3 region results in Section 5.2). Here we see that all short-run parameters are significant for the full sample and sub-samples. In our last sub-sample 1999 to 2006 we are able to include the human resources in science and technology variable (proxy to education controls) and find this to be significantly contributing to productivity. We test the long-run elasticity restrictions with a Wald test which uses the "delta method" approximation in Stata. Over the full sample we have a positive agglomeration effect of 14% - so doubling employment density would increase productivity by 14% (slightly greater than the 13% found by Brülhart and Mathys, 2008). However our results from the Pesaran (2004) test with null of no cross-sectional dependence is rejected over the full sample which could indicate that we have problems with spatial dependence, but this test is not rejected for the sub-samples. The issue of autocorrelation in the labour productivity and employment density variables is also explored using global and local Moran's i statistics and maps (presented in Appendix B). While the global Moran's i statistic identify the presence of spatial autocorrelation in the dataset, the local Moran's i statistic and maps are not indicative of strong spatial dependence in the underlying data.

When we analyse the agglomeration effect over time we find that it was lower in the 1980s decade at 8% and then is estimated to be negative and insignificant for the 1990s at -2%. During this decade all countries experienced recessions in the early 1990s and Germany had a prolonged recession due to reunification. Over the latest sub-sample 1999 to 2006 we again estimate a positive and significant agglomeration effect at 10%, this falls to 8% when the HRST variable is included which contributes a positive effect to productivity of 9%.

The results for manufacturing productivity are presented in Table 4 and those for the financial intermediation sector are in Table 5, we regress the productivity variable on own sector employment density and then in a separate regression on other sector density. From Table 4 we see that over the full sample manufacturing productivity exhibits negative own sector congestion agglomeration economies at the NUTS 2 level but when regressed against other sector employment density instead we get a positive urbanisation agglomeration effect of 14%. Again the cross-sectional independence test is rejected over the full sample but this is accepted for the sub-samples. When analysing the sub-samples we find no significant manufacturing sector localisation effects but do find an urbanisation agglomeration effect of 9% in the 1990s though the short run parameters in this model are not significant. The 1980s and 1990s were decades that witnessed industrial decline across Western Europe which is apparent in the negative effect density has on manufacturing productivity over these sub-samples.

The financial intermediation results of Table 5 present a sector which has grown over the last three decades. This is evident in the positive and significant localisation agglomeration effect of 11% over the full sample (but with evidence of cross-sectional dependence). The localisation effect for financial services is negative in the 1980s but emerges in the 1990s at 19%. This effect has increased in the last decade and has been joined by an urbanisation effect of 25% (though short-run coefficients are not significant and the AR2 test is rejected at just below 5%).

5.2 Results of NUTS 3 Panel Regression Model

The results of the panel data estimations for total productivity in our group of 691 NUTS 3 areas are shown in Table 6. We use the two-step method for the SYS-GMM model with this large group of areas and find the short-run parameters are significant for most but not for employment density in the 1980s. Here we also find positive long-run elasticity at 13% over the full sample, slightly weaker than the 14% NUTS 2 region result but larger than the 4.5% reported by Ciccone (2002) for 1980s cross-sections. Here the cross-sectional independence and error autocorrelation tests are rejected over the full sample but accepted for the sub-samples. When we analyse the sub-samples the agglomeration effect is only significant in the latest sample 1999 to 2006 at 7%.

The results for industry productivity are presented in Table 7 and we see the estimated own sector localisation agglomeration effect is 14% and significant for the full sample (compared to -10% for the manufacturing sector at the NUTS 2 level). Here the diagnostic tests are satisfactory for most models apart from own sector density in the 1980s when there is some evidence of cross-sectional dependence. When looking at the individual sub-samples the short-run parameters are significant but the long-run elasticity is insignificant for own and other sector employment density. The industry urbanisation effect is 19% and significant for other sector density over the full sample, stronger than 14% found for NUTS 2 manufacturing.

Table 8 shows the service sector results which are much stronger than those for financial intermediation for NUTS 2 areas. Over the full sample we estimate a significant localisation effect of 34% for services and 39% urbanisation effect (the diagnostic tests are passed for the own sector density but failed for other sector density). When looking at these effects over time the AR2 diagnostic is signalling problems of autocorrelation in the first difference errors and the cross-sectional dependence test is failed in the 1990s sub-sample.

5.3 Results of Large NUTS 3 City Panel Regression Model

Table 9 presents the results of the panel of 172 NUTS 3 large city regions (with populations greater than 500,000) for total productivity. All short-run parameters are significant for the full sample and sub-samples and the diagnostic tests are satisfactory for the sub-sample models. The long-run elasticity is not significant for the full sample, 1980s or 1990s. For the most recent sample over 1999 to 2006 our estimations show a positive agglomeration effect of 10% so larger city regions have only appeared to have benefited from agglomeration in the recent past.

The industry productivity results for the large NUTS 3 areas are presented in Table 10 and we now loose significance for own sector localisation agglomeration effect and estimate a negative effect for each sub-sample (though the short-run coefficients are significant). Here the diagnostic tests are satisfactory for most models apart cross-sectional dependence for the full sample. The industry urbanisation effect is 20% for large NUTS 3 areas but the short-run parameters are not significant for the full sample and 1980s or last sub-sample. The strongest evidence of urbanisation for industry other sector density in large city regions is found in the 1990s with significant long-run elasticity of 12%, falling to 7% in the latest sub-sample.

Finally Table 11 shows the service sector results for large city regions which are lower than those for the full group of NUTS 3 areas. Over the full sample we estimate a significant localisation effect of 12% for services and 18% urbanisation effect (but there is evidence of cross-sectional dependence). When looking at these effects over time the diagnostic tests are more satisfactory than those reported in Table 8. Significant short and long-run effects are found for the 1990s and most recent sub-samples at 12% and 17%, respectively, for own sector density (suggesting localisation economies are present) and 17% and 19%, respectively, for other sector density indicating urbanisation agglomeration effects for these large city regions.

6. Conclusions

This paper investigates agglomeration economies in European NUTS 2, 3 areas and large city regions across France, Germany, Ireland, Italy, Spain and the UK. The effect of agglomeration economies across these European areas over the period 1980-2006 is estimated utilising system GMM panel data techniques. While our analysis focuses on a smaller group of Western European countries than Brülhart and Mathys (2008) the dataset used in this study includes the countries contained in the Ciccone (2002) cross-sectional study of European NUTS 3 areas. In this way, our method and results can be situated in terms of existing empirical research in this area but have contributed to the literature in investigating agglomeration economies at an annual frequency in a dynamic panel, observing how these results change over time and monitoring for spatial dependence in our models.

In the quantitative analysis undertaken in this study we uncover evidence of strong long run agglomeration effects over all countries of 14% at the NUTS 2 level and 13% at the NUTS 3 level (though we find evidence of cross-sectional dependence). These estimated long-run elasticity coefficients reside at the upper end of the range of existing empirical estimates.

When we split our sample period into decade-long sub-samples we find that the agglomeration effect for total productivity is significant at the NUTS 2 region level in 1980s at 8%. However, this agglomeration effect becomes negative and insignificant in the 1990s, coinciding with a period in the early part of this decade when most countries experienced economic downturns. Notably, the most recent sub-sample 1999 to 2006 has witnessed positive agglomeration effect of 8% for NUTS 2 areas and 7% for the NUTS 3 areas. It is also found that highly populated NUTS 3 city regions (with populations in excess of 500,000) appear to enjoy greater agglomeration effects at 10%, indicating the denser employment of city regions has contributed to the generation of stronger agglomeration effects in recent years. This result is reinforced by Curran and Sensier (2010) in a study of large urban zones.

We investigated if localisation (own sector) or urbanisation (other sector) agglomeration economies were important by analysing sector data at the broad level of industry and services for NUTS 3 areas and for manufacturing and financial intermediation for NUTS 2 areas. Our results are consistent with claims that the last thirty years has seen a significant shift from the late industrial period, in which manufacturing industries benefited from localisation economies, to a period in which knowledge based economic activities, dominated by service industries in terms of employment, have benefited more from urbanisation economies.

Taken as a whole, the findings of our quantitative analysis reiterate the presence of agglomeration economies across European NUTS 2 and NUTS 3 areas in recent decades, and indicate that previous empirical studies may actually have underestimated the strength of these forces in the European context.

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Table 1: Summary Statistics for NUTS 2 Areas in Ireland, Spain, France, the UK, Italy and Germany

Variables Country (# regions)	Mean	Median	Coefficient of Variation	Max.	Region with maximum of average 1980-2006	Min.	Region with minimum of average 1980-2006
Labour Productivity (122)	40.76	40.71	0.1900				
Ireland (2)	42.17	38.60	0.3058	48.57	Southern and Eastern (ie02)	35.77	Border, Midlands and Western (ie01)
Spain (15)	31.51	31.91	0.1451	37.46	Comunidad de Madrid (es3)	24.98	Extremadura (es43)
France (21)	44.26	44.77	0.1590	61.03	Île de France (fr1)	39.47	Limousin (fr63)
UK (35)	39.54	38.86	0.1749	53.14	Inner London (uki1)	30.89	Cornwall and Isles of Scilly (ukk3)
Italy (19)	40.31	40.21	0.1625	49.54	Valle d'Aosta/Vallée d'Aoste (itc2)	32.61	Calabria (itf6)
Germany (30)	44.56	44.14	0.1372	57.28	Hamburg (de6)	39.81	Trier (deb2)
Employment Density	209.19	73.88	3.3295				
Ireland	19.50	18.91	0.5238	28.32	Southern and Eastern (ie02)	10.68	Border, Midlands and Western (ie01)
Spain	50.50	31.31	1.3007	261.5	Madrid (es3)	7.31	Castilla-la Mancha (es42)
France	55.61	30.98	1.5172	419.0	Île de France (fr1)	16.61	Limousin (fr63)
UK	466.16	147.76	2.6424	7322.5	Inner London (uki1)	34.76	Cumbria (ukd1)
Italy	72.36	66.36	0.6199	182.26	Lombardia (itc4)	16.97	Valle d'Aosta/Vallée d'Aoste (itc2)
Germany	195.54	104.01	1.4000	1336.3	Hamburg (de6)	38.93	Lüneburg (de93)
HRST average 1999-2006	0.342	0.338	0.1786		**Maximum value**		**Minimum value**
Ireland	0.315	0.315	0.1720	0.387	Southern and Eastern (ie02)	0.22	B., M. & Western (ie01)
Spain	0.340	0.331	0.2087	0.549	Pais Vasco (es21)	0.211	Extremadura (es43)
France	0.329	0.309	0.1637	0.54	Île de France (fr1)	0.248	Champagne-Ard. (fr21)
UK	0.345	0.332	0.1650	0.582	Inner London (uki1)	0.248	E.Yorks &N.Lincs (uke1)
Italy	0.287	0.287	0.1313	0.396	Liguria (itc3)	0.199	Basilicata (itf5)
Germany	0.387	0.383	0.1046	0.518	Oberbayern (de21)	0.283	Niederbayern (de22)

Table 2: Summary Statistics for NUTS 3 Areas in Ireland, Spain, France, the UK, Italy and Germany average for 1980-2006

Variables Country (# regions)	Mean	Median	Coefficient of Variation	Maximum	Region with maximum of average 1980-2006	Minimum	Region with minimum of average 1980-2006
Labour Productivity (691)	41.53	41.85	0.2059				
Ireland (8)	41.25	37.98	0.3467	56.42	Dublin (ie021)	33.95	Midlands (ie012)
Spain (47)	30.74	31.36	0.1628	38.80	Álava (es211)	22.80	Orense (es113)
France (94)	43.90	43.64	0.1886	72.55	Hauts-de-Seine (fr105)	34.00	Lozère (fr814)
UK (126)	39.56	39.66	0.2065	55.37	Inner London - West (uki11)	29.8	Isle of Wight (ukj34)
Italy (90)	40.36	40.86	0.1666	49.54	Milano (itc45)	30.38	Crotone (itf62)
Germany (326)	43.50	43.46	0.1843	70.81	München, Landkreis (de21h)	34.04	Cloppenburg (de948)
Employment Density	329.06	73.07	2.8656				
Ireland	73.31	13.89	2.223	487.64	Dublin (ie021)	9.49	West (ie013)
Spain	38.96	17.51	1.4973	261.5	Madrid (es3)	3.59	Soria (es417)
France	304.19	28.35	5.7238	16257.24	Paris (fr101)	5.38	Lozère (fr814)
UK	674.6	198.5	2.0365	13418.5	Inner London - West (uki11)	10.22	Scottish Borders (ukm24)
Italy	106.96	69.54	1.3069	973.01	Milano (itc45)	16.72	Grosseto (ite1a)
Germany	312.10	88.77	1.4370	2878.77	München, Kreisfreie Stadt (de212)	15.63	Lüchow-Dannenberg (de934)

Table 3: Total Productivity Agglomeration Estimates for Nuts 2 Areas in France, Germany Ireland, Italy, Spain and the UK

Dependent variable = Log labour productivity(*t*)	Full Sample	1980s	1990s	2000s	2000s +HRST
Sample Period for annual data	1981-2006	1981-1989	1990-1998	1999-2006	1999-2006
Short-run parameters					
Log labour productivity(*t-1*)	0.9455*** (0.0140)	0.7334*** (0.0653)	0.8615*** (0.0483)	0.7893*** (0.0768)	0.7933*** (0.0744)
Log employment density(*t*)	-0.6549*** (0.0438)	-0.6699*** (0.1993)	-0.4845*** (0.1181)	-0.5556*** (0.0964)	-0.5554*** (0.0994)
Log employment density(*t-1*)	0.6623*** (0.0438)	0.6922*** (0.1966)	0.4818*** (0.1184)	0.5772*** (0.0911)	0.5726*** (0.0949)
Human Resources in Science and Technology (HRST)					0.0888** (0.0380)
Constant	0.2221*** (0.0442)	0.8935*** (0.2190)	0.6107*** (0.1774)	0.8370*** (0.2992)	0.7867*** (0.2684)
Long-run elasticity					
$(\beta_0 + \beta_1)/(1-\alpha)$	0.1357** (0.0534)	0.0834** (0.0352)	-0.0199 (0.0601)	0.1026*** (0.0372)	0.0832** (0.0335)
$\beta_0 + \beta_1$	0.0074** (0.003)	0.0222** (0.0104)	-0.0027 (0.0080)	0.0216** (0.0108)	0.0172* (0.0100)
Cross-section Dependence test	0.0010	0.0853	0.0684	0.0808	0.1163
AR2	0.5443	0.8877	0.7381	0.4266	0.5195
Number of Regions	122	122	122	122	122
Observations	3172	1098	1098	976	976

Notes: the short-run coefficients are from a one-step SYS-GMM with robust standard errors in brackets. Long-run elasticity reports the point estimate from a Wald test of the parameter restriction calculated by the "delta method" approximation in Stata. The probability values are reported for Pesaran's test of cross-section independence and the AR2 which is the Arellano-Bond test for zero autocorrelation in first differenced errors. All regressions include year * country dummy variables.

Table 4: Manufacturing Sector Agglomeration Estimates for Nuts 2 Areas in France, Germany Ireland, Italy, Spain and the UK

Dependent variable = Log labour productivity(*t*)	Full Sample		1980s		1990s		2000s	
Sample Period for annual data	1981-2006		1981-1989		1990-1998		1999-2006	
Sector:	**Own**	**Other**	**Own**	**Other**	**Own**	**Other**	**Own**	**Other**
Short-run parameters								
Log labour productivity(*t-1*)	0.8666*** (0.0166)	0.8142*** (0.0218)	0.8617*** (0.0419)	0.8276*** (0.0464)	0.8828*** (0.0534)	0.5675*** (0.0690)	0.7320*** (0.0662)	0.6536*** (0.0800)
Log employment density(*t*)	-0.536*** (0.0607)	-0.2234* (0.1293)	-0.705*** (0.1964)	-0.0790 (0.3220)	-0.653*** (0.1179)	0.3456 (0.3548)	-0.262*** (0.0987)	-0.793*** (0.2138)
Log employment density(*t-1*)	0.5221*** (0.0587)	0.2497* (0.1294)	0.6967*** (0.1823)	0.1537 (0.3230)	0.6427*** (0.1165)	-0.3051 (0.3551)	0.2779*** (0.0976)	0.8068*** (0.2644)
Constant	0.5381*** (0.0612)	0.8991*** (0.1225)	0.4847** (0.1952)	0.3164 (0.2709)	0.4854** (0.2105)	1.6623*** (0.2562)	1.3045*** (0.3199)	1.7418*** (0.3981)
Long-run elasticity								
$(\beta_0 + \beta_1)/(1-\alpha)$	-0.1015** (0.0514)	0.1415*** (0.0418)	-0.0578 (0.1663)	0.4330 (0.3088)	-0.0843 (0.0908)	0.0937** (0.0460)	0.0604 (0.0669)	0.0408 (0.0527)
$\beta_0 + \beta_1$	-0.0135** (0.0066)	0.0263*** (0.0085)	-0.0080 (0.0234)	0.0747 (0.0486)	-0.0099 (0.0095)	0.0405* (0.0227)	0.0162 (0.0188)	0.0141 (0.0190)
Cross-section Dependence test	0.0022	0.0047	0.1671	0.1911	0.0487	0.0763	0.1435	0.1486
AR2	0.2430	0.5179	0.0488	0.1628	0.1891	0.2092	0.7396	0.6241
Number of Regions	122	122	122	122	122	122	122	122
Observations	3172	3172	1098	1098	1098	1098	976	976

Notes: see Table 3.

Table 5: Financial Intermediation Agglomeration Estimates for Nuts 2 Areas in France, Germany Ireland, Italy, Spain and the UK

Dependent variable = Log labour productivity(*t*)	Full Sample		1980s		1990s		2000s	
Sample Period for annual data	1981-2006		1981-1989		1990-1998		1999-2006	
Sector:	**Own**	**Other**	**Own**	**Other**	**Own**	**Other**	**Own**	**Other**
Short-run parameters								
Log labour productivity(*t-1*)	0.8869*** (0.0204)	0.8594*** (0.0218)	0.8092*** (0.0618)	0.8268*** (0.0630)	0.8962*** (0.0532)	0.8038*** (0.0696)	0.5797*** (0.0955)	0.4343*** (0.0858)
Log employment density(*t*)	-0.484*** (0.0618)	-0.505*** (0.1134)	-0.653*** (0.1494)	-0.5765** (0.2596)	-0.747*** (0.0987)	-0.912*** (0.3320)	-0.407*** (0.1022)	-0.1846 (0.2392)
Log employment density(*t-1*)	0.4964*** (0.0607)	0.5002*** (0.1103)	0.6456*** (0.1482)	0.5603** (0.2555)	0.7666*** (0.0975)	0.8776*** (0.3265)	0.4993*** (0.0967)	0.3240 (0.2545)
Constant	0.5626*** (0.1156)	0.7649*** (0.1192)	0.8018*** (0.2857)	0.7543*** (0.2946)	0.5097* (0.2656)	1.0137*** (0.3189)	1.7996*** (0.5208)	1.5166*** (0.6227)
Long-run elasticity								
$(\beta_0 + \beta_1)/(1-\alpha)$	0.1061* (0.0663)	-0.0366 (0.0652)	-0.0395 (0.0670)	-0.0932 (0.0803)	0.1866* (0.1015)	-0.1748 (0.1182)	0.2187*** (0.0781)	0.2466*** (0.0912)
$\beta_0 + \beta_1$	0.0120* (0.0073)	-0.0051 (0.0091)	-0.0075 (0.0124)	-0.0162 (0.0128)	0.0194** (0.0103)	-0.0343 (0.0163)	0.0919*** (0.0349)	0.1395*** (0.0560)
Cross-section Dependence test	0.0035	0.0081	0.0757	0.1319	0.2228	0.4973	0.1137	0.1030
AR2	0.5876	0.2638	0.0122	0.0068	0.6666	0.2290	0.1153	0.0437
Number of Regions	122	122	122	122	122	122	122	122
Observations	3172	3172	1098	1098	1098	1098	976	976

Notes: see Table 3.

Table 6: Total Productivity Agglomeration Estimates for Nuts 3 Areas in France, Germany Ireland, Italy, Spain and the UK

Dependent variable = Log labour productivity(*t*)	Full Sample	1980s	1990s	2000s
Sample Period for annual data	1981-2006	1981-1989	1990-1998	1999-2006
Short-run parameters				
Log labour productivity(*t-1*)	0.9412*** (0.0047)	0.9262*** (0.0942)	0.9535*** (0.3559)	0.4790*** (0.1067)
Log employment density(*t*)	-0.7513*** (0.0321)	-0.7674 (0.7396)	-0.9074** (0.4291)	-0.3087*** (0.1112)
Log employment density(*t-1*)	0.7587*** (0.0317)	0.7712 (0.7097)	0.9042** (0.4031)	0.3441*** (0.1047)
Constant	-0.0000 (0.0005)	0.2162 (0.2063)	0.3950 (1.2667)	2.1898*** (0.4052)
Long-run elasticity				
$(\beta_0 + \beta_1)/(1-\alpha)$	0.1254*** (0.0326)	0.0505 (0.3508)	-0.0677 (1.1219)	0.0680* (0.0416)
$\beta_0 + \beta_1$	0.0074*** (0.0018)	0.0037 (0.0305)	-0.0031 (0.0285)	0.0354** (0.0177)
Cross-section Dependence test	0.0361	0.7774	0.3349	0.0549
AR2	0.0270	0.3413	0.2668	0.1825
Number of Regions	691	691	691	691
Observations	17966	6219	6219	5552

Notes: the short-run coefficients are from a two-step SYS-GMM with robust standard errors in brackets. Long-run elasticity reports the point estimate from a Wald test of the parameter restriction calculated by the “delta method” approximation in Stata. The probability values are reported for Pesaran’s test of cross-section independence and the AR2 which is the Arellano-Bond test for zero autocorrelation in first differenced errors. The constant is zero in the full sample regression because it is estimated on the country-year mean transformed data, other regressions include year * country dummy variables.

Table 7: Industry Sector Agglomeration Estimates for Nuts 3 Areas in France, Germany Ireland, Italy, Spain and the UK

Dependent variable = Log labour productivity(*t*)	Full Sample		1980s		1990s		2000s	
Sample Period for annual data	1981-2006		1981-1989		1990-1998		1999-2006	
Sector:	**Own**	**Other**	**Own**	**Other**	**Own**	**Other**	**Own**	**Other**
Short-run parameters								
Log labour productivity(*t-1*)	0.9385*** (0.0035)	0.9269*** (0.0040)	0.9410*** (0.0125)	0.9372*** (0.2372)	0.9453*** (0.3462)	0.8764*** (0.2756)	0.7097*** (0.0459)	0.5385*** (0.1485)
Log employment density(*t*)	-0.759*** (0.0297)	0.2525*** (0.0704)	-1.144*** (0.1194)	-0.4302 (0.4099)	-0.807*** (0.2584)	0.4177 (0.5184)	-1.355*** (0.2326)	0.1268 (0.2227)
Log employment density(*t-1*)	0.7674*** (0.0297)	-0.238*** (0.0702)	1.1519*** (0.1174)	0.4348 (0.4926)	0.8192*** (0.2310)	-0.4973 (0.3983)	1.3578*** (0.2364)	-0.1201 (0.2236)
Constant	-0.0001 (0.0007)	-0.0001 (0.0007)	0.2247** (0.0988)	0.1264 (1.1725)	0.5902 (0.7521)	1.1267** (0.5597)	1.5410*** (0.2642)	2.1250*** (0.6605)
Long-run elasticity								
$(\beta_0 + \beta_1)/(1-\alpha)$	0.1433*** (0.0459)	0.1914** (0.0885)	0.1305 (0.2007)	0.0728 (1.6973)	0.2243 (0.9090)	-0.6439 (2.4498)	0.0099 (0.0886)	0.0145 (0.0921)
$\beta_0 + \beta_1$	0.0088*** (0.0026)	0.0140** (0.0061)	0.0077 (0.0108)	0.0046 (0.0892)	0.0123 (0.0295)	-0.0796 (0.1297)	0.0029 (0.0256)	0.0067 (0.0420)
Cross-section Dependence test	0.0808	0.0527	0.0007	0.9280	0.9432	0.3985	0.1002	0.0997
AR2	0.2526	0.1650	0.3438	0.6707	0.2983	0.5176	0.5711	0.2611
Number of Regions	691	691	691	691	691	691	691	691
Observations	17966	17966	6219	6219	6219	6219	5528	5528

Notes: see Table 6.

Table 8: Service Sector Agglomeration Estimates for Nuts 3 Areas in France, Germany Ireland, Italy, Spain and the UK

Dependent variable = Log labour productivity(*t*)	Full Sample		1980s		1990s		2000s	
Sample Period for annual data	1981-2006		1981-1989		1990-1998		1999-2006	
Sector:	**Own**	**Other**	**Own**	**Other**	**Own**	**Other**	**Own**	**Other**
Short-run parameters								
Log labour productivity(*t-1*)	0.9564*** (0.0038)	0.9636*** (0.0035)	0.9546*** (0.0192)	0.9747*** (0.0098)	0.9662*** (0.0323)	0.9030*** (0.0234)	0.9604** (0.0312)	0.9553*** (0.0203)
Log employment density(*t*)	-0.738*** (0.0635)	-0.222*** (0.0586)	-0.634*** (0.1237)	0.0127 (0.0953)	-1.041*** (0.1769)	-0.2665 (0.1721)	-0.2595* (0.1555)	-0.1511 (0.1030)
Log employment density(*t-1*)	0.7527*** (0.0631)	0.2363*** (0.0584)	0.6677*** (0.1268)	0.0146 (0.0947)	1.0444*** (0.1568)	0.3192* (0.1669)	0.2941** (0.1477)	0.1605 (0.1010)
Constant	-0.00 (0.0011)	0.0001 (0.0009)	0.0909 (0.0792)	0.1387** (0.0653)	0.1480** (0.0629)	0.1980 (0.1271)	0.1022* (0.0577)	0.1769** (0.0872)
Long-run elasticity								
$(\beta_0+\beta_1)/(1-\alpha)$	0.3355*** (0.0626)	0.3864*** (0.0842)	0.7412* (0.4260)	1.0771* (0.6367)	0.1056 (0.7470)	0.5435*** (0.1609)	0.8751*** (0.2880)	0.2113 (0.2031)
$\beta_0+\beta_1$	0.0146*** (0.0033)	0.0141*** (0.0032)	0.0337*** (0.0103)	0.0273*** (0.0105)	0.0036 (0.0286)	0.0527** (0.0220)	0.0346* (0.0204)	0.0094 (0.0098)
Cross-section Dependence test	0.4472	0.0000	0.4741	0.1103	0.0001	0.0000	0.0950	0.1015
AR2	0.0519	0.0014	0.0005	0.0496	0.0081	0.0033	0.0196	0.0025
Number of Regions	691	691	691	691	691	691	691	691
Observations	17966	17966	6219	6219	6219	6219	5528	5528

Notes: see Table 6.

Table 9: Total Productivity Agglomeration Estimates for LARGE Nuts 3 Areas in France, Germany Ireland, Italy, Spain and the UK

Dependent variable = Log labour productivity(*t*)	Full Sample	1980s	1990s	2000s
Sample Period for annual data	1981-2006	1981-1989	1990-1998	1999-2006
Short-run parameters				
Log labour productivity(*t-1*)	0.9492*** (0.0071)	0.9529*** (0.0171)	0.9075*** (0.0233)	0.6393*** (0.1141)
Log employment density(*t*)	-0.6620*** (0.0430)	-0.6850*** (0.1404)	-0.7936*** (0.0822)	-0.5931*** (0.1166)
Log employment density(*t-1*)	0.6642*** (0.0430)	0.6867*** (0.1395)	0.7919*** (0.0821)	0.6308*** (0.1123)
Constant	0.2656 (0.0492)	0.1975** (0.0878)	0.5973*** (0.1271)	1.5836*** (0.5306)
Long-run elasticity				
$(\beta_0 + \beta_1)/(1-\alpha)$	0.0419 (0.0415)	0.0352 (0.0839)	-0.0182 (0.0577)	0.1046*** (0.0315)
$\beta_0 + \beta_1$	0.0021 (0.0021)	0.0017 (0.0038)	-0.0017 (0.0053)	0.0377*** (0.0140)
Cross-section Dependence test	0.0043	0.0740	0.2154	0.1286
AR2	0.2540	0.4811	0.0693	0.1816
Number of Regions	172	172	172	172
Observations	4472	1548	1548	1376

Notes: Large Nuts 3 Regions with population > 500K (apart from Cardiff, Edinburgh and Belfast slightly less but still included). For further details see Notes for Table 3.

Table 10: Industry Sector Agglomeration Estimates for Large Nuts 3 Areas in France, Germany Ireland, Italy, Spain and the UK

Dependent variable = Log labour productivity(*t*)	Full Sample		1980s		1990s		2000s	
Sample Period for annual data	1981-2006		1981-1989		1990-1998		1999-2006	
Sector:	**Own**	**Other**	**Own**	**Other**	**Own**	**Other**	**Own**	**Other**
Short-run parameters								
Log labour productivity(*t-1*)	0.9344*** (0.0063)	0.9159*** (0.0084)	0.9591*** (0.0171)	0.9405*** (0.0227)	0.9567*** (0.0354)	0.8261*** (0.0424)	0.6727*** (0.0692)	0.5741*** (0.0544)
Log employment density(*t*)	-0.649*** (0.0417)	0.0476 (0.0941)	-0.512*** (0.1860)	0.1448 (0.2104)	-0.840*** (0.0739)	0.6622** (0.2700)	-0.737*** (0.1409)	0.0820 (0.2914)
Log employment density(*t-1*)	0.6499*** (0.0414)	-0.0306 (0.0933)	0.5068*** (0.1860)	-0.1356 (0.2097)	0.8233*** (0.0722)	-0.6415** (0.2658)	0.7280*** (0.1341)	-0.0508 (0.2873)
Constant	0.4080*** (0.0506)	0.3939*** (0.0724)	0.1932 (0.1496)	0.1745 (0.1484)	0.5055*** (0.1515)	0.9109*** (0.2304)	1.8800*** (0.4566)	1.9977*** (0.3429)
Long-run elasticity								
$(\beta_0 + \beta_1)/(1-\alpha)$	0.0185 (0.0470)	0.2019*** (0.0550)	-0.1143 (0.1704)	0.1552 (0.1761)	-0.3832 (0.3834)	0.1193* (0.0721)	-0.0275 (0.0652)	0.0731** (0.0353)
$\beta_0 + \beta_1$	0.0012 (0.0031)	0.0170*** (0.0047)	-0.0047 (0.0064)	0.0092 (0.0096)	-0.0166 (0.0106)	0.0207* (0.0124)	-0.0090 (0.0212)	0.0311 (0.0149)
Cross-section Dependence test	0.0188	0.0094	0.7846	0.5587	0.5005	0.4606	0.0683	0.0528
AR2	0.2105	0.4654	0.0256	0.0760	0.2036	0.0704	0.8618	0.7319
Number of Regions	172	172	172	172	172	172	172	172
Observations	4472	4472	1548	1548	1548	1548	1376	1376

Notes: see Table 9.

Table 11: Service Sector Agglomeration Estimates for Large Nuts 3 Areas in France, Germany Ireland, Italy, Spain and the UK

Dependent variable = Log labour productivity(*t*)	Full Sample		1980s		1990s		2000s	
Sample Period for annual data	1981-2006		1981-1989		1990-1998		1999-2006	
Sector:	**Own**	**Other**	**Own**	**Other**	**Own**	**Other**	**Own**	**Other**
Short-run parameters								
Log labour productivity(*t-1*)	0.9375*** (0.0075)	0.9391*** (0.0091)	0.9429*** (0.0167)	0.9706*** (0.0195)	0.9247*** (0.0221)	0.8990*** (0.0326)	0.8435*** (0.0714)	0.8326*** (0.0841)
Log employment density(*t*)	-0.646*** (0.0388)	-0.0492 (0.0384)	-0.880*** (0.0884)	-0.310*** (0.1062)	-0.699*** (0.1190)	0.2466*** (0.0900)	-0.784*** (0.1332)	-0.295** (0.1216)
Log employment density(*t-1*)	0.6532*** (0.0385)	0.0603 (0.0384)	0.8885*** (0.0888)	0.3191*** (0.1060)	0.7077*** (0.1178)	-0.230*** (0.1669)	0.8109*** (0.1321)	0.3263*** (0.1187)
Constant	0.2615*** (0.0400)	0.1617*** (0.0472)	0.3771*** (0.1047)	0.2022** (0.0898)	0.2860** (0.0766)	0.0885 (0.1789)	0.5953** (0.2713)	0.5798** (0.2978)
Long-run elasticity								
$(\beta_0 + \beta_1)/(1-\alpha)$	0.1187*** (0.0317)	0.1816*** (0.0486)	0.1466 (0.1457)	0.2992 (0.2683)	0.1193** (0.0489)	0.1655*** (0.0642)	0.1723*** (0.0478)	0.1891*** (0.0668)
$\beta_0 + \beta_1$	0.0074*** (0.0019)	0.0111*** (0.0026)	0.0084 (0.0075)	0.0088* (0.0051)	0.0090** (0.0040)	0.0167** (0.0070)	0.0270** (0.0121)	0.0317* (0.0164)
Cross-section Dependence test	0.0029	0.0036	0.0902	0.0536	0.0957	0.0725	0.1369	0.1409
AR2	0.5359	0.5534	0.4986	0.8300	0.0141	0.7336	0.1769	0.0836
Number of Regions	172	172	172	172	172	172	172	172
Observations	4472	4472	1548	1548	1548	1548	1376	1376

Notes: see Table 9.

Appendix A: Listing of Nuts Areas used in analysis

Appendix Table A1: List of 122 Nuts 2Areas

Code	**Ireland (2)**	Code	Region
ie01	Border, Midlands and Western	ie02	Southern and Eastern
	Spain (15)		
es11	Galicia	es41	Castilla y León
es12	Principado de Asturias	es42	Castilla-la Mancha
es13	Cantabria	es43	Extremadura
es21	Pais Vasco	es51	Cataluña
es22	Comunidad Foral de Navarra	es52	Comunidad Valenciana
es23	La Rioja	es61	Andalucia
es24	Aragón	es62	Región de Murcia
es30	Comunidad de Madrid		
	France (21)		
fr10	Île de France	fr51	Pays de la Loire
fr21	Champagne-Ardenne	fr52	Bretagne
fr22	Picardie	fr53	Poitou-Charentes
fr23	Haute-Normandie	fr61	Aquitaine
fr24	Centre	fr62	Midi-Pyrénées
fr25	Basse-Normandie	fr63	Limousin
fr26	Bourgogne	fr71	Rhône-Alpes
fr30	Nord - Pas-de-Calais	fr72	Auvergne
fr41	Lorraine	fr81	Languedoc-Roussillon
fr42	Alsace	fr82	Provence-Alpes-Côte d'Azur
fr43	Franche-Comté		
	UK (35)		
ukc1	Tees Valley and Durham	ukh2	Bedfordshire, Hertfordshire
ukc2	Northumberland, Tyne and Wear	ukh3	Essex
ukd1	Cumbria	uki1	Inner London
ukd2	Cheshire	uki2	Outer London
ukd3	Greater Manchester	ukj1	Berkshire, Bucks and Oxfordshire
ukd4	Lancashire	ukj2	Surrey, East and West Sussex
ukd5	Merseyside	ukj3	Hampshire and Isle of Wight
uke1	East Yorkshire and Northern Lincolnshire	ukj4	Kent
uke2	North Yorkshire	ukk1	Gloucestershire, Wiltshire and Bristol/Bath area
uke3	South Yorkshire	ukk2	Dorset and Somerset
uke4	West Yorkshire	ukk3	Cornwall and Isles of Scilly
ukf1	Derbyshire and Nottinghamshire	ukk4	Devon
ukf2	Leicestershire, Rutland and Nrthnts	ukl1	West Wales and The Valleys
ukf3	Lincolnshire	ukl2	East Wales
ukg1	Herefordshire, Worcs and Warks	ukm2	Eastern Scotland
ukg2	Shropshire and Staffordshire	ukm3	South Western Scotland
ukg3	West Midlands	ukn	Northern Ireland
ukh1	East Anglia		
	Italy (19)		
itc1	Piemonte	ite2	Umbria
itc2	Valle d'Aosta/Vallée d'Aoste	ite3	Marche
itc3	Liguria	ite4	Lazio
itc4	Lombardia	itf1	Abruzzo
itd1	Provincia Autonoma Bolzano-	itf2	Molise

	Bozen		
itd2	Provincia Autonoma Trento	itf3	Campania
itd3	Veneto	itf4	Puglia
itd4	Friuli-Venezia Giulia	itf5	Basilicata
itd5	Emilia-Romagna	itf6	Calabria
ite1	Toscana		
	Germany (30)		
de11	Stuttgart	de73	Kassel
de12	Karlsruhe	de91	Braunschweig
de13	Freiburg	de92	Hannover
de14	Tübingen	de93	Lüneburg
de21	Oberbayern	de94	Weser-Ems
de22	Niederbayern	dea1	Düsseldorf
de23	Oberpfalz	dea2	Köln
de24	Oberfranken	dea3	Münster
de25	Mittelfranken	dea4	Detmold
de26	Unterfranken	dea5	Arnsberg
de27	Schwaben	deb1	Koblenz
de5	Bremen	deb2	Trier
de6	Hamburg	deb3	Rheinhessen-Pfalz
de71	Darmstadt	dec	Saarland
de72	Gießen	def	Schleswig-Holstein

Appendix Table A2: List of 691 Nuts 3 Areas (bold font signifies large region with population > 500,000 used in Table 9)

Code	**Ireland (8)**	Population	Code	Region	Population
ie011	Border	469.18	ie022	Mid-East	472.52
ie012	Midlands	252.03	ie023	Midwest	361.92
ie013	West	418.93	ie024	South-East (IE)	465.90
ie021	**Dublin**	**1193.72**	**ie025**	**South-West (IE)**	**626.57**
	Spain (47)				
es111	**La Coruña**	**1113.11**	es421	Albacete	387.45
es112	Lugo	349.76	es422	**Ciudad Real**	**502.23**
es113	Orense	330.93	es423	Cuenca	209.50
es114	**Pontevedra**	**927.40**	es424	Guadalajara	208.34
es12	**Principado de Asturias**	**1058.20**	es425	**Toledo**	**603.79**
es13	**Cantabria**	**560.42**	es431	**Badajoz**	**664.80**
es211	Álava	300.70	es432	Cáceres	408.08
es212	**Guipúzcoa**	**685.43**	es511	**Barcelona**	**5225.82**
es213	**Vizcaya**	**1132.51**	es512	**Gerona**	**665.93**
es22	**Comunidad Foral de Navarra**	**592.27**	es513	Lérida	403.13
es23	La Rioja	303.54	es514	**Tarragona**	**715.85**
es241	Huesca	216.72	es521	**Alicante**	**1735.84**
es242	Teruel	141.37	es522	**Castellón de la Plana**	**548.75**
es243	**Zaragoza**	**909.29**	es523	**Valencia**	**2415.67**
es3	**Comunidad de Madrid**	**5995.49**	es611	**Almería**	**617.65**
es411	Avila	164.96	es612	**Cadiz**	**1177.97**
es412	Burgos	357.60	es613	**Córdoba**	**783.50**
es413	León	484.85	es614	**Granada**	**874.34**

es414	Palencia	172.15	es615	Huelva	485.05
es415	Salamanca	347.49	es616	**Jaén**	**655.78**
es416	Segovia	154.75	**es617**	**Málaga**	**1450.98**
es417	Soria	91.93	**es618**	**Sevilla**	**1810.50**
es418	**Valladolid**	**511.86**	**es62**	**Región de Murcia**	**1353.08**
es419	Zamora	196.06			
	France (94)				
fr101	**Paris**	**2155.29**	**fr521**	**Côte-du-Nord**	**568.09**
fr102	**Seine-et-Marne**	**1282.47**	**fr522**	**Finistère**	**878.27**
fr103	**Yvelines**	**1404.72**	**fr523**	**Ille-et-Vilaine**	**940.74**
fr104	**Essonne**	**1198.61**	**fr524**	**Morbihan**	**693.91**
fr105	**Hauts-de-Seine**	**1526.81**	fr531	Charente	343.98
fr106	**Seine-Saint-Denis**	**1475.45**	**fr532**	**Charente-Maritime**	**597.09**
fr107	**Val-de-Marne**	**1287.19**	fr533	Deux-Sèvres	352.74
fr108	**Val-d'Oise**	**1160.46**	fr534	Vienne	419.19
fr211	Ardennes	286.12	fr611	Dordogne	401.66
fr212	Aube	299.50	**fr612**	**Gironde**	**1388.89**
fr213	**Marne**	**567.37**	fr613	Landes	359.58
fr214	Haute-Marne	186.02	fr614	Lot-et-Garonne	318.16
fr221	**Aisne**	**535.04**	**fr615**	**Pyrénées-Atlantiques**	**630.71**
fr222	**Oise**	**792.41**	fr621	Ariège	146.45
fr223	**Somme**	**558.55**	fr622	Aveyron	270.07
fr231	**Eure**	**567.50**	**fr623**	**Haute-Garonne**	**1175.14**
fr232	**Seine-Maritime**	**1243.50**	fr624	Gers	179.32
fr241	Cher	313.88	fr625	Lot	168.29
fr242	Eure-et-Loir	419.48	fr626	Hautes-Pyrénées	229.42
fr243	Indre	230.79	fr627	Tarn	363.50
fr244	**Indre-et-Loire**	**571.76**	fr628	Tarn-et-Garonne	222.80
fr245	Loir-et-Cher	322.47	fr631	Corrèze	237.53
fr246	**Loiret**	**646.62**	fr632	Creuse	122.25
fr251	**Calvados**	**667.52**	fr633	Haute-Vienne	365.22
fr252	Manche	489.18	**fr711**	**Ain**	**567.17**
fr253	Orne	292.30	fr712	Ardèche	303.42
fr261	**Côte-d'Or**	**515.12**	fr713	Drôme	466.61
fr262	Nièvre	220.94	**fr714**	**Isère**	**1173.50**
fr263	**Saône-et-Loire**	**544.68**	**fr715**	**Loire**	**729.32**
fr264	Yonne	343.26	**fr716**	**Rhône**	**1663.76**
fr301	**Nord**	**2583.03**	fr717	Savoie	404.04
fr302	**Pas-de-Calais**	**1459.97**	**fr718**	**Haute-Savoie**	**697.18**
fr411	**Meurthe-et-Moselle**	**723.88**	fr721	Allier	341.22
fr412	Meuse	192.32	fr722	Cantal	150.29
fr413	**Moselle**	**1040.24**	fr723	Haute-Loire	218.37
fr414	Vosges	382.56	**fr724**	**Puy-de-Dôme**	**624.12**
fr421	**Bas-Rhin**	**1077.62**	fr811	Aude	338.48
fr422	**Haut-Rhin**	**739.38**	**fr812**	**Gard**	**684.36**
fr431	**Doubs**	**515.48**	**fr813**	**Hérault**	**994.86**
fr432	Jura	255.80	fr814	Lozère	76.77
fr433	Haute-Saône	234.64	fr815	Pyrénées-Orientales	425.53
fr434	Territoire de Belfort	140.08	fr821	Alpes-de-Haute-Provence	154.77
fr511	**Loire-Atlantique**	**1220.84**	fr822	Hautes-Alpes	133.03
fr512	**Maine-et-Loire**	**758.76**	**fr823**	**Alpes-Maritimes**	**1070.50**
fr513	Mayenne	299.02	**fr824**	**Bouches-du-Rhône**	**1910.18**

fr514	**Sarthe**	**554.00**	**fr825**	**Var**	**979.15**
fr515	**Vendée**	**593.39**	**fr826**	**Vaucluse**	**533.38**
	UK (126)				
ukc11	Hartlepool and Stockton	279.69	**uki21**	**Outer London - East and North East**	**1620.41**
ukc12	South Teeside	277.06	**uki22**	**Outer London - South**	**1192.27**
ukc13	Darlington	98.71	**uki23**	**Outer London - West and North West**	**1798.29**
ukc14	Durham CC	498.62	**ukj11**	**Berkshire**	**810.54**
ukc21	Northumberland	314.60	ukj12	Milton Keynes	224.32
ukc22	**Tyneside**	**812.96**	ukj13	Buckinghamshire CC	483.72
ukc23	Sunderland	283.79	**ukj14**	**Oxfordshire**	**629.08**
ukd11	West Cumbria	238.36	ukj21	Brighton and Hove	250.09
ukd12	East Cumbria	263.05	**ukj22**	**East Sussex CC**	**506.69**
ukd21	Halton and Warrington	311.10	**ukj23**	**Surrey**	**1077.60**
ukd22	**Cheshire CC**	**682.26**	ukj24	**West Sussex**	**771.21**
ukd31	**Greater Manchester South**	**1370.25**	ukj31	Portsmouth	193.63
ukd32	**Greater Manchester North**	**1179.81**	ukj32	Southampton	226.87
ukd41	Blackburn with Darwen	140.67	**ukj33**	**Hampshire CC**	**1259.65**
ukd42	Blackpool	141.46	ukj34	Isle of Wight	137.92
ukd43	**Lancashire CC**	**1159.40**	ukj41	Medway Towns	252.76
ukd51	East Merseyside	331.65	**ukj42**	**Kent CC**	**1379.47**
ukd52	Liverpool	438.63	ukk11	City of Bristol	401.92
ukd53	Sefton	281.18	**ukk12**	**Bath and NE Somerset, North Somerset and South Gloucestershire**	**626.09**
ukd54	Wirral	314.00	**ukk13**	**Gloucestershire**	**575.01**
uke11	City of Kingston upon Hull	251.13	ukk14	Swindon	184.35
uke12	East Riding of Yorkshire	329.07	ukk15	Wiltshire CC	447.68
uke13	North and North East Lincolnshire	314.93	ukk21	Bournemouth and Poole	298.91
uke21	York	189.42	ukk22	Dorset CC	404.87
uke22	**North Yorkshire CC**	**586.30**	**ukk23**	**Somerset**	**520.92**
uke31	**Barnsley, Doncaster and Rotherham**	**766.17**	**ukk3**	**Cornwall and Isles of Scilly**	**523.23**
uke32	**Sheffield**	**521.99**	ukk41	Plymouth	245.63
uke41	Bradford	485.30	ukk42	Torbay	134.59
uke42	**Leeds**	**736.41**	**ukk43**	**Devon CC**	**741.83**
uke43	**Calderdale, Kirklees and Wakefield**	**909.89**	ukl11	Isle of Anglesey	68.89
ukf11	Derby	234.56	ukl12	Gwynedd	118.51
ukf12	East Derbyshire	270.07	ukl13	Conwy and Denbighshire	208.40
ukf13	South and West Derbyshire	478.83	ukl14	South West Wales	374.36
ukf14	Nottingham	280.55	ukl15	Central Valleys	289.08

ukf15	North Nottinghamshire	435.36	ukl16	Gwent Valleys	332.04
ukf16	South Nottinghamshire	328.42	ukl17	Bridgend and Neath Port Talbot	269.11
ukf21	Leicester City	284.78	ukl18	Swansea	226.62
ukf22	**Leicester CC and Rutland**	**667.39**	ukl21	Monmouthshire and Newport	229.60
ukf23	**Northamptonshire**	**662.28**	**ukl22**	**Cardiff and Vale of Glamorgan**	**440.91**
ukf3	**Lincolnshire**	**685.49**	ukl23	Flintshire and Wrexham	283.35
ukg11	Herefordshire	182.71	ukl24	Powys	132.05
ukg12	**Worcestershire**	**564.73**	ukm21	Angus and Dundee City	255.00
ukg13	**Warwickshire**	**532.05**	ukm22	Clackmannanshire and Fife	413.61
ukg21	The Wrekin	163.30	ukm23	East Lothian and Midlothian	175.03
ukg22	Shropshire CC	289.27	ukm24	Scottish Borders	112.21
ukg23	Stoke-on-Trent	237.59	**ukm25**	**City of Edinburgh**	**467.60**
ukg24	**Staffordshire CC**	**820.28**	ukm26	Falkirk	151.95
ukg31	**Birmingham**	**1003.65**	ukm27	Perth and Kinross and Stirling	231.09
ukg32	Solihull	202.89	ukm28	West Lothian	168.40
ukg33	Coventry	306.27	ukm31	East Dunbartonshire, West Dunbarton-shire and Helensburgh and Lomond	227.71
ukg34	**Dudley and Sandwell**	**592.50**	ukm32	Dumfries and Galloway	151.14
ukg35	Walsall and Wolverhampton	491.15	ukm33	East Ayrshire & North Ayrshire mainland	252.89
ukh11	Peterborough	163.13	**ukm34**	**Glasgow City**	**584.99**
ukh12	**Cambridgeshire CC**	**587.97**	ukm35	Inverclyde, East Renfrewshire and Renfrewshire	347.24
ukh13	**Norfolk**	**832.16**	ukm36	North Lanarkshire	328.75
ukh14	**Suffolk**	**699.92**	ukm37	South Ayrshire	113.84
ukh21	Luton	186.19	ukm38	South Lanarkshire	312.16
ukh22	Bedfordshire CC	401.24	**ukn01**	**Belfast**	**265.20**
ukh23	**Hertfordshire**	**1051.37**	ukn02	Outer Belfast	376.52
ukh31	Southend-on-Sea	157.85	ukn03	East of Northern Ireland	416.03
ukh32	Thurrock	148.13	ukn04	North of Northern Ireland	282.76
ukh33	**Essex CC**	**1348.77**	ukn05	West and South of Northern Ireland	385.52
uki11	**Inner London - West**	**1099.11**			
uki12	**Inner London - East**	**1890.00**			
	Italy (90)				
itc11	**Torino**	**2245.89**	itd59	Rimini	292.01
itc12	Vercelli	176.90	ite11	Massa-Carrara	200.80
itc13	Biella	187.30	ite12	Lucca	381.50
itc14	Verbano-Cusio-Ossola	161.60	ite13	Pistoia	280.20
itc15	Novara	356.50	**ite14**	**Firenze**	**968.91**
itc16	**Cuneo**	**572.70**	ite15	Prato	243.80

itc17	Asti	214.60	ite16	Livorno	336.60
itc18	Alessandria	431.80	ite17	Pisa	398.31
itc2	Valle d'Aosta/Vallée d'Aoste	124.40	ite18	Arezzo	336.40
itc31	Imperia	217.20	ite19	Siena	262.40
itc32	Savona	282.90	ite1a	Grosseto	220.10
itc33	**Genova**	**889.00**	**ite21**	**Perugia**	**642.64**
itc34	La Spezia	219.90	ite22	Terni	227.78
itc41	**Varese**	**851.99**	ite31	Pesaro e Urbino	369.51
itc42	**Como**	**569.60**	ite32	Ancona	465.62
itc43	Lecco	326.30	ite33	Macerata	315.61
itc44	Sondrio	180.10	ite34	Ascoli Piceno	381.71
itc45	**Milano**	**3876.77**	ite41	Viterbo	303.80
itc46	**Bergamo**	**1039.29**	ite42	Rieti	154.70
itc47	**Brescia**	**1189.09**	**ite43**	**Roma**	**3922.53**
itc48	**Pavia**	**518.50**	**ite44**	**Latina**	**526.60**
itc49	Lodi	213.70	ite45	Frosinone	491.40
itc4a	Cremona	349.40	itf11	L'Aquila	305.29
itc4b	Mantova	395.60	itf12	Teramo	299.99
itd1	Provincia Autonoma Bolzano-Bozen	485.16	itf13	Pescara	310.89
itd2	**Provincia Autonoma Trento**	**504.75**	itf14	Chieti	391.39
itd31	**Verona**	**875.19**	itf21	Isernia	89.30
itd32	**Vicenza**	**841.39**	itf22	Campobasso	231.19
itd33	Belluno	212.30	itf31	**Caserta**	**889.11**
itd34	**Treviso**	**853.39**	itf32	Benevento	288.90
itd35	**Venezia**	**834.49**	itf33	**Napoli**	**3084.73**
itd36	**Padova**	**894.39**	itf34	Avellino	437.50
itd37	Rovigo	244.80	itf35	**Salerno**	**1090.31**
itd41	Pordenone	301.71	itf41	**Foggia**	**682.90**
itd42	**Udine**	**530.72**	itf42	**Bari**	**1595.90**
itd43	Gorizia	141.21	itf43	**Taranto**	**580.40**
itd44	Trieste	236.81	itf44	Brindisi	403.30
itd51	Piacenza	277.01	itf45	**Lecce**	**808.20**
itd52	Parma	418.41	itf51	Potenza	388.91
itd53	Reggio nell'Emilia	497.81	itf52	Matera	203.80
itd54	**Modena**	**667.72**	itf61	**Cosenza**	**729.01**
itd55	**Bologna**	**952.33**	itf62	Crotone	172.30
itd56	Ferrara	352.41	itf63	Catanzaro	367.11
itd57	Ravenna	371.41	itf64	Vibo Valentia	168.10
itd58	Forlì-Cesena	376.31	itf65	**Reggio di Calabria**	**564.71**
	Germany (326)			18 large regions only	
de111	**Stuttgart**	**593.18**	**de929**	**Region Hannover**	**1128.69**
de113	**Esslingen**	**514.18**	**dea11**	**Düsseldorf, Kreisfreie Stadt**	**576.01**
de115	**Ludwigsburg**	**513.68**	**dea12**	**Duisburg, Kreisfreie Stadt**	**500.31**
de128	**Rhein-Neckar-Kreis**	**534.11**	**dea13**	**Essen, Kreisfreie Stadt**	**584.31**
de212	**München, Kreisfreie Stadt**	**1277.09**	**dea1c**	**Mettmann**	**504.21**
de254	**Nürnberg, Kreisfreie Stadt**	**500.04**	**dea23**	**Köln, Kreisfreie Stadt**	**986.59**

de501	**Bremen, Kreisfreie Stadt**	**547.42**	**dea2c**	**Rhein-Sieg-Kreis**	**598.29**
de6	**Hamburg**	**1748.91**	**dea36**	**Recklinghausen**	**645.00**
de712	**Frankfurt am Main, Kreisfreie Stadt**	**652.30**	**dea52**	**Dortmund, Kreisfreie Stadt**	**587.90**

Appendix B: Global Moran's *i* measure of spatial autocorrelation

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

$$I_t = \left(\frac{n}{s}\right) \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij} y_{it} y_{jt}}{\sum_{i=1}^{n}\sum_{j=1}^{n} y_{ij} y_{jt}} \qquad \text{(B1)}$$

where w_{ij} represents the elements of the spatial weighting matrix *W*, *n* and *s* denote the total number of sub-regions and the summation of w_{ij} respectively. The results of this diagnostic test for spatial autocorrelation on NUTS 2 labour productivity and employment density in 1980, 1992, and 2006 are reported in Table B1. The test has been carried out using an inverse distance spatial weighting matrix, where w_{ij} denotes the row standardised reciprocal distance between sub-regions *i* and *j*.

Table B1: Moran's* I *Global Spatial Autocorrelation Statistic

	1980	**1992**	**2006**
Labour Productivity	0.129***	0.133***	0.105***
Employment Density	0.148***	0.129***	0.149***

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

Table B1 suggests that labour productivity and employment density do indeed exhibit spatial autocorrelation across NUTS 2 areas in 1980, 1992, and 2006. However, in order to gain a fuller understanding of the spatial patterns inherent in the NUTS 2 labour productivity and employment density data, we calculate local Moran's *i* statistics. These are presented in colour-coded maps (Figures B1 and B2). Unlike its global counterpart, the local Moran's *i* statistic describes the association between the value of the variable at a given location and that of its neighbours, and between the value within the neighbourhood set and that for the sample as a whole; Patacchini and Rice (2007).

The local Moran's *i* maps presented in Figures B1 and B2 shows the NUTS 2 areas for which the local statistics are significant at the 0.05 level. The four colour-coded categories of the local Moran's *i* maps correspond to the four types of local spatial association between a location and its neighbours: HH (upper right), contains areas with a high value surrounded by areas with high values; HL (lower right) consists of high value areas with relatively low value neighbours; LL (lower left) consists of low value areas surrounded by other areas with low values; and LH (upper left) contains low value areas with high value neighbours.

The local Moran's i statistics illustrated by in Figures B1 and B2 indicate that spatial autocorrelation may be less of an issue in the underlying data than the global measure would suggest. [4] In the labour productivity maps, there are two clear clusters of spatial correlation: one in and around the Netherlands (HH) and another in Spain (LL). While the LL cluster is present throughout the 1980-2006 time period, the HH cluster diminishes considerably by the end of the time period. In the maps of employment density, the spatial autocorrelation detected appears to be driven by the Greater London NUTS 2 area.[5]

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[4] Ord and Getis (1995) have shown that the local statistics for any pair of locations, i and j, are correlated whenever their neighbourhood sets contain common elements Given this, Ord and Getis suggest using a Bonferroni bounds procedure to assess significance such that for an overall significance level of α, the individual significance level for each observation is taken as α /n, where n is the number of observations in the sample. In this particular study with a sample of 156 observations, an overall significance level of 0.05 implies an individual significance level for each observation of just 0.00032. However, Patacchini and Rice (2007) note that in practice, for any given location the number of other locations in the sample with correlated local statistics is likely to be considerably small than n, and so this procedure is expected to be overly conservative. Using such a procedure in Figures A1and A2 above would result in less NUTS 2 areas exhibiting spatial correlation. For example, in Figure A1 the number of NUTS 2 areas exhibiting HH spatial autocorrelation in 2006 labour productivity would fall from 8 to 5, while LL regions would fall from 15 to 6.

[5] A further issue with local measures of autocorrelation statistics is that they are affected by the presence of global spatial association, and hence inference based on the normal approximation (as is the case in Figures A1 and A2 above) is likely to be hindered; Anselin (1995). See Patacchini and Rice (2007) for a detailed discussion of limitations associated with local autocorrelation statistics.

Figure B1: Local Moran's *i* measure of spatial autocorrelation - labour productivity of NUTS 2 areas 1980 (top left), 1992 (top right) and 2006 (bottom right)

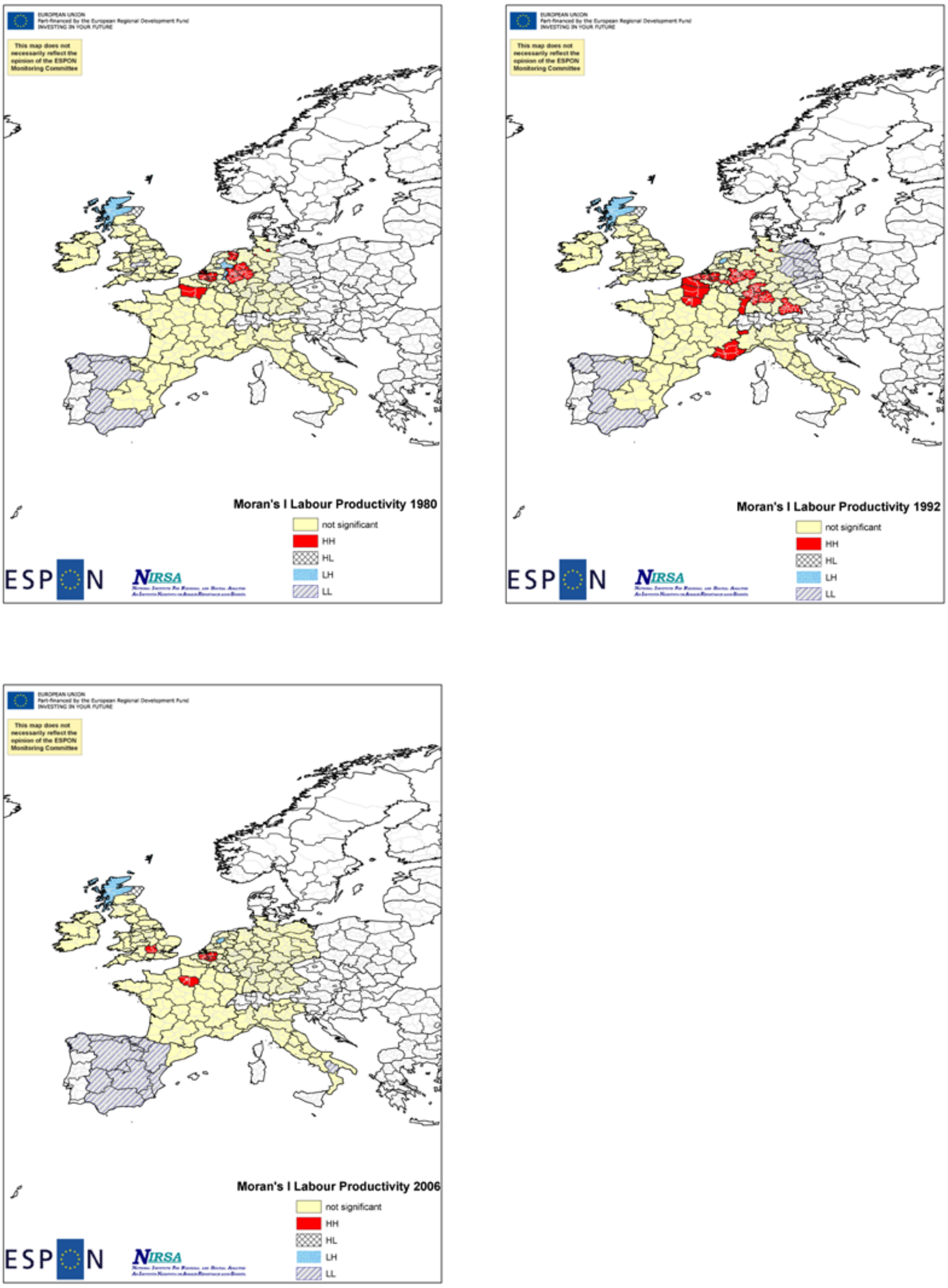

Figure B2: Local Moran's *i* measure of spatial autocorrelation – employment density of NUTS 2 areas, 1980 (top left), 1992 (top right) and 2006 (bottom right)

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