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# "Assessing agglomeration economies in a spatial framework with endogenous regressors"

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## *Abstract*

This paper is concerned with the influence of agglomeration economies on economic outcomes across British regions. The concentration of economic activity in one place can foster economic performance due to the reduction in transportation costs, the ready availability of customers and suppliers, and knowledge spillovers. However, the concentration of several types of intangible assets can boost productivity as well. Thus, using an interesting dataset which proxies regional productivity, we will assess the relative importance of agglomeration and other assets, controlling for endogeneity, spatial autocorrelation and heteroscedasticity at the same time. Our results suggest that agglomeration has a definite positive influence on productivity, although our estimates of its effect are dramatically reduced when spatial dependence and other hitherto omitted variables proxying intangible assets are controlled for.

***JEL classification***: C21, J24, R10, R11, R12
***Keywords*: agglomeration economies, intangible assets, endogeneity, spatial autocorrelation, spatial HAC estimation**

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# 1. Introduction

Within the well-established research program of the New Economic Geography (Fujita (1988), Krugman (1991), Fujita et al. (1999)), the seminal studies by Ciccone and Hall (1996) and Ciccone (2002) stand out as focussing on the measurement of agglomeration economies.

In this paper, we attempt to analyze this effect on labour productivity in the NUTS3[1] regions of Great Britain. Our investigation includes several novelties. First of all, it uses a new dataset to measure economic outcomes and productivity, that is, GVA per job filled (Wosnitza and Walker, 2008). It has the advantage of avoiding a number of the measurement errors that have afflicted other productivity data sets. Second, as a proxy for the agglomeration of economic activity, our study uses a concept elaborated by Rice et al. (2006), that of "economic mass". Thirdly, we rely on the hypothesis that the mere location of individuals and firms within a specific space cannot be the only source of aggregated increasing returns. Thus, we think that the qualitative characteristics of each region are also important in explaining economic outcomes. Hence, departing from the model by Ciccone (2002) and partially following Bode's (2004) suggestions, we have included several modifications in order to control for a wider range of private returns beyond individuals' location and to allow for a broader variety of social returns or externalities within the region as well. Finally, we take account of the effect of externalities that take place across regions: that is, we take very full account of spatial autocorrelation.

The way in which we have chosen to go about our study is basically as follows: we will start by estimating our model by OLS, both with and without including sources of private and social returns within regions, in addition to agglomeration *per se*. However, several sources of endogeneity could arise from these first estimates. It could be the case that the concentration of employees leads to better economic outcomes or, on the contrary, that better economic outcomes attract more workers to live in a given region due to higher wages. If the latter occurs, estimation by OLS will yield inconsistent estimates. To deal with this problem, we will conduct our estimation using

[1] NUTS corresponds to the French acronym for "*nomenclature d'unités territoriales statistiques*", and refers to administrative divisions within Europe for statistical purposes.

GMM. The existence of externalities *across* regions would in any case lead to the OLS estimates being biased and inconsistent. To our knowledge, there are few papers which have estimated the agglomeration effect taking account at the same time of these two sources of inconsistency. In fact, as stressed by Fingleton and Le Gallo (2008), applied spatial econometrics has almost neglected the effects of other endogenous variables, although their presence is common in every empirical work.

We will therefore explore stage by stage which of these three features –and to what extent - is a source of bias in the agglomeration elasticity if not controlled for.

Another novelty of our study refers to spatial econometrics techniques. We do not only consider a spatial lag of our dependent variable as an explanatory variable, but also check for residual autocorrelation once this spatial lag has been included. If necessary, we can estimate our model by feasible generalized spatial two-stages least squares (FGS2SLS), as suggested in Kelejian and Prucha (K-P) (1998). Indeed, if there are significant spatially autocorrelated explanatory variables aside from the spatial lag and their effects are not fully controlled by means of its inclusion, their absence would tend to induce a spatially non-random pattern of residuals which has to be taken into account. We have modified the K-P estimator in order to include the possibility of controlling for other sources of endogeneity (in our case, the reverse causality between agglomeration and economic outcomes). Besides, we have also performed spatial heteroscedasticity and autocorrelation consistent estimations (SHAC) of the variance-covariance (VC) matrix of the first stage of the K-P estimator, as suggested in Kelejian and Prucha (2007). Since there is no reason to assume homoscedasticity in our data even when controlling for spatial dependence, this non-parametric HAC estimator will allow us to control for heteroscedasticity and spatial autocorrelation of an unspecified nature. As far as we know, no papers exist which deal with the estimation of the agglomeration effect, taking into account both two-way causation and spatial autocorrelation neither by means of a spatial lag and a spatially autocorrelated error term, nor by means of a spatial lag and the spatial HAC estimation of the VC matrix, and to do this will be, therefore, one of the main contributions of the paper.

Our results do suggest that agglomeration economies are significant in determining productivity, although our estimates of their size is somewhat reduced when the intangible asset endowments which characterize the knowledge-based economy are introduced, and are dramatically diminished when spatial dependence is controlled for. The paper is organized as follows: section 2 reviews the theoretical and empirical literature on agglomeration economies; section 3 presents our model and some data issues; section 4 outlines the OLS estimates of our baseline specification, while section 5 deals with GMM and 2SLS estimations to cope with endogeneity problems, and also includes some robustness checks. Finally, section 6 concludes.

## 2. Background

Broadly understood, the study by Ciccone and Hall (1996) highlights the idea that density of economic activity is a source of enhanced productivity gains due to the effect of spatial externalities leading to increasing returns within regions. Three main sources have been put forward to understand why improved aggregated economic results may come about from the agglomeration of economic activity. On the one hand, easier access to suppliers and customers, in the presence of transportation costs that rise with distance, will surely lead to better outcomes for the firm, holding input endowments and technology constant – since, quite simply, "the ratio of output to input will rise with density" (Ciccone and Hall, 1996, p. 54). Secondly, the concentration of economic activity would imply thicker and larger input markets, so ones that are more efficient in terms of market matching. Thus, the concentration of producers in one location would bring about a large and diverse provision of certain inputs (Rosenthal and Strange, 2004), which could be characterized by strong scale economies in input production. Finally, the concentration of economic activity results in more intensive and frequent knowledge spillovers, given that firms can learn from others when they are sharing a common space. More recently, other important sources of agglomeration economies have been put forward as well, such as natural advantages, home market effects (Hanson, 2005), consumption opportunities (Glaeser et al., 2001), and rent-seeking (Ades and Glaeser, 1995).

According to the seminal study by Ciccone and Hall (1996), density is crucial for explaining the variation of productivity. Indeed, a doubling of employment density will lead to a 6% increase of average labour productivity. Ciccone (2002) enlarged the scope of his previous work by estimating agglomeration effects for the NUTS3 regions of France, Germany, Italy, Spain, and the UK with a model in which the concentration of production is the main source of agglomeration economies. This study suggests substantial agglomeration effects in Europe, with estimated elasticities of around 4.5%, which do not differ significantly across countries.

The empirical literature concerned with the effect of agglomeration economies on economic performance has grown enormously since the seminal paper by Ciccone and Hall (1996) for the US and some useful surveys (Rosenthal and Strange, 2004; Duranton, 2007) already exist. In broad terms, the majority of studies obtain elasticities between 0.01 and 0.20, using different proxies for agglomeration and for economic outputs and both at an aggregate level or at plant level – although results under 0.10 are preponderant - so a doubling of city or region size leads to an increase in productivity between 1% and 10% (Graham, 2007)[2]. Although somewhat later than for the US case, a growing literature estimating agglomeration effects for Europe has sprung up as well – in addition to Ciccone (2002).

Hence, Cingano and Schivardi (2004) and Combes et al. (2008) stress the importance of human capital –the latter focusing their attention on the endogenous nature of human capital. Panel data techniques and dynamics are suggested in Blien et al. (2006), Brülhart and Mathys (2008) and Brülhart and Sbergami (2009). Stressing the role of diseconomies when dealing with agglomeration effects on economic outcomes are Graham (2007) and Brülhart and Sbergami (2009), whilst the former study highlights large differences in the estimated agglomeration effect dependent upon the economic sector analysed – from elasticities around 0.04 for manufacturing sectors up to values of 0.18 for certain service sectors. Finally, Baptista (2003), Fingleton (2003) or Rice et al. (2006) are interesting references for the British case.

## 3. Methodology and some data issues

### 3.1. The model

[2] For the case of the US, the review by Rosenthal and Strange (2004) supports a range of agglomeration economies estimates of between 3% and 8%.

For our purposes, we start from the approach by Ciccone (2002), who develops a fruitful theoretical model to be empirically tested, of a production function in region s of the form:

$$y = Q_s f(l \cdot H, k; Y_s, A_s) = Q_s((l \cdot H)^{\beta} k^{1-\beta})^{\alpha} \left( \frac{Y_s}{A_s} \right)^{(\lambda-1)/\lambda} \tag{1}$$

where $y$ is the output per hectare, $l$ the number of workers per hectare, $H$ the average level of human capital, $k$ the amount of physical capital per hectare; $Q_s$ is the index of TFP in the region; and $Y_s$ and $A_s$ denote total production and total hectares of the region respectively; $\alpha$ captures returns to capital and labour per hectare, $\beta$ is a distribution parameter, and $(\lambda - 1)/\lambda$ is the parameter which captures spatial externalities arising from the concentration of economic activity - in this case, density of production $(Y_s/A_s)$. Here, based on our theoretical considerations, we will introduce a few modifications to be empirically tested. Basically, we consider that this specification fails to represent a great variety of individual returns that might foster economic outcomes as well, leading to an omitted variables problem. Further, it does not resolve the question of what kind of externalities affect output and, therefore, labour productivity (Bode, 2004). Our main hypothesis is that the mere concentration of economic activity cannot be the sole determinant of productivity differentials across regions.

Our theoretical model, therefore, will include several kinds of intangible endowments, which will allow us to control for a wider variety of private returns which derive from the accumulation of these intangible inputs. At the same time, it will let us control for a broader range of social returns or externalities which follow from the accumulation of endowments – however, we are concerned about the difficulty of empirically differentiating at an aggregate level between these two sources of increasing returns, that is, private and social returns. Here, we limit our inputs to those of human capital, knowledge, and entrepreneurial culture[3]. Where these sources of productivity are not controlled for, the estimation of the agglomeration effect could be biased upward.

The literature has widely stressed the role played by human skills in determining regional economic outcomes (Moretti, 2004; Ciccone and Cingano, 2003; Combes et al., 2008). The hypothesis behind these contributions is twofold. On the one hand, it relies on the assumption that, even given equal technologies among regions, there exist differences between areas concerning the ability of individuals to make that technology productive (Fingleton, 2003). On the other hand, human capital spillovers increase aggregate productivity beyond the effect of this capital on individuals' productivity. Thus, an increase of the overall level of human capital of each region leads to higher levels of productivity (Moretti, 2004)[4]. However, human capital could be acquired both in the educational system and while working. Therefore, the occupational composition of the region is important too (Ciccone and Cingano, 2003) and may well bias the density parameter upward if not controlled for appropriately.

In a similar way as human capital endowments, differential access of each region to knowledge could explain productivity differentials across regions as well, *ceteris paribus* (Fingleton, 2003). Actually, the access to innovation and new technologies, and to the processes and individuals that generate them –in broad terms, knowledge capital - is rooted in the so-called theories of endogenous economic growth. We hypothesize that private returns of knowledge and knowledge externalities arise both from knowledge inputs – that is, R&D efforts and the number of employees working in high-technology industrial sectors, and from knowledge outputs, that is to say, patents.

In addition, as Audretsch (2002), Rosenthal and Strange (2004) or Acs et al. (2005) suggest, the entrepreneurial or business culture of a region could boost economic performance as well. Indeed in HM Treasury (2001), we find that entrepreneurial activity is regarded as a key driver of productivity growth in the economy. The creation

[3] We are concerned about the omission of other kinds of intangible asset, such as relational capital, social capital, territorial capital, cognitive capital, intellectual capital, and the like. We assume, however, that our 3 types of intangible assets are taking into account to a certain extent the possible effects of these unidentified intangible assets on productivity.

[4] See Moretti (2004) for a detailed review of theories and empirical studies on human capital and human capital externalities.

and enlargement of firms is associated with the introduction of new technologies, innovative production processes, and increased competitive pressure on the other firms in a given market, providing them with strong incentives to further innovate and adopt new technologies (Glaeser et al., 1992). Thus, we will include both the amount of new entrepreneurial projects set up in a given region, and the overall growth of firms during the whole period, in order to take account not only of the business culture of the region, but also its success.

Given all the former arguments, we should assume, contrary to Ciccone's (2002) model, that this set of intangible assets enters the production function affecting directly the total factor productivity index -$Q_s$- of each region, in order to capture a greater variety of private returns and externalities. These considerations lead us to a new TFP measure like

$$Q_s = Q_s(Q, H_s, O_s, RD_s, MAN_s, PAT_s, E_s, S_s) \tag{2}$$

where $Q$ are the determinants of TFP which do not differ at a NUTS3 level. $H_s$ and $O_s$ are educational and occupational human capital indicators respectively, $RD_s$ an indicator of knowledge efforts, $MAN_s$ an indicator of high-tech manufacturing knowledge, and $PAT_s$ an indicator of knowledge outputs; $E_s$ is an entrepreneurship capital indicator, and $S_s$ an entrepreneurship success indicator, all of them within the region s (see Appendix for a description of the variables). So going back to equation (1), the final model would be

$$y = Q_s(Q, H_s, O_s, RD_s, MAN_s, PAT_s, E_s, S_s) \cdot f(l, k, Y_s, A_s) \tag{3}$$

which actually follows the form of

$$y = Q_s(\cdot) \cdot (l^{\beta} k^{1-\beta})^{\alpha} \left( \frac{Y_s}{A_s} \right)^{(\lambda-1)/\lambda} \tag{4}$$

where $Q_s(\cdot)$ is the total factor productivity index affected for a wider range of private and social returns aside from those derived from the agglomeration of the economic activity. In order to make this function estimable, we can turn it into an aggregate regional production function of the form:

$$Y_s = y \cdot A_s = A_s Q_s(\cdot) \left( \left( \frac{L_s}{A_s} \right)^{\beta} \left( \frac{K_s}{A_s} \right)^{1-\beta} \right)^{\alpha} \left( \frac{Y_s}{A_s} \right)^{(\lambda-1)/\lambda} \tag{5}$$

where output, labour and capital $(Y_s, L_s, K_s)$ correspond to their quantity in each region instead of in each hectare. Rearranging and solving for labour productivity, yields:

$$Y_s = A_s^{1-\alpha\lambda} Q_s(\cdot)^{\lambda} L_s^{\alpha\lambda} \left( \left( \frac{K_s}{L_s} \right)^{1-\beta} \right)^{\alpha\lambda} \tag{6}$$

$$\frac{Y_s}{L_s} = \left( \frac{L_s}{A_s} \right)^{\alpha\lambda-1} Q_s(\cdot)^{\lambda} \left( \left( \frac{K_s}{L_s} \right)^{1-\beta} \right)^{\alpha\lambda} \tag{7}$$

As stressed by Ciccone (2002), at low levels of regional disaggregation, data on the quantity of physical capital do not exist. To cope with this disadvantage, we will follow Ciccone (2002) and we will assume that the rental price of capital is the same within every NUTS1 region. Hence, from equation (1) can be derived the capital-demand function, $K_s = \frac{\alpha(1-\beta)}{r} Y_s$, where r is the rental price of capital in each larger region. Thus, the developments carry on in the following way:

$$\frac{Y_s}{L_s} = \left( \frac{L_s}{A_s} \right)^{\alpha\lambda-1} Q_s(\cdot)^{\lambda} \left( \left( \frac{\alpha(1-\beta)}{r} Y_s \right)^{1-\beta} L_s^{-(1-\beta)} \right)^{\alpha\lambda} \tag{8}$$

$$\left(\frac{Y_s}{L_s}\right) = \left(\frac{L_s}{A_s}\right)^{\theta} \Omega_s Q_s(\cdot)^{\omega} \tag{9}$$

where $\theta_i = \dfrac{\alpha\lambda - 1}{1-\alpha\lambda(1-\beta)}$ and measures the net effect of regional employment density on regional productivity – that is to say, higher outcomes minus the detrimental effect on productivity due to congestion, contamination, pollution and resources squandering, crime rates, higher house rents, and so on; $\Omega_s = \left(\dfrac{\alpha(1-\beta)}{r}\right)^{\frac{1}{1-(1-\beta)\alpha\lambda}}$ and is a constant which only depends on the rental price of capital in a larger region, and $\omega = \dfrac{\lambda}{1-\alpha\lambda(1-\beta)}$. Taking logs, and assuming that the productivity term, $Q_s(\cdot)$, enters in a logarithmic form, yields:

$$\begin{aligned}\log\left(Y_s/L_s\right) &= \log\Omega + \theta_1(\log Agglomeration_{s1}) + \theta_2(\log Agglomeration_{s2}) + \\ &+ \phi_0 \log Q + \phi_1 \log H_s + \phi_2 \log O_s + \phi_3 \log RD_s + \phi_4 \log MAN_s + \phi_5 \log PAT_s + \\ &+ \phi_6 \log E_s + \phi_7 \log S_s + \varepsilon_s\end{aligned} \tag{10}$$

where $\varepsilon_s$ is a random error term[5]. Likewise we will allow the model to include among its covariates two measures of agglomeration to explore, to some extent, the spatial scope of this effect –see in the next section the description of the variables used. Regional dummies will be included also to capture both differences in exogenous TFP not explained in the model $(\phi_0 \log Q)$ -which are assumed to be marginal- and specially $\log\Omega$, because differences in physical capital or its rental price could be captured by allowing for spatial fixed effects for larger regions (Ciccone, 2002). Thus, a dummy for large regions (NUTS1) will replace $\phi_0 \log Q + \log\Omega$. Next, $\phi_j = \omega{\cdot}\delta_j$, and $\delta_j$ are the elasticities of TFP with respect to its determinants, where $j = 1,...7$ for the coefficients of the 7 indicators for intangible assets.

[5] We will relax this assumption in section 5.

### 3.2. Data

Productivity is defined as GVA per filled job for the period 2001 to 2005 and, as local data are prone to exhibit lumpiness from year to year, we compensate for this by using the average of the five years' productivity figures –the same applies for the explanatory variables. The literature has widely used either wages and earnings, or GVA per head or employee, to proxy regional productivity. However, productivity measures should include more than wages or salaries, but also allow for profits, for instance. Thus, Wosnitza and Walker (2008) decompose GVA per head in British regions, following the OECD methodology, into four elements, that is, productivity –actually GVA per job filled, which is calculated on a workplace basis instead of on a residence basis- employment rate, commuting rate, and activity rate. Taking as a measure of productivity this GVA per job on a workplace basis allows us to avoid some of the potential distortions of GVA per head or employee, particularly in cities that receive a significant number of commuters, or have low economic activity rates[6].

To proxy the concentration of economic activity in order to explain the effect of agglomeration on productivity, we will use the concept of "economic mass", due to Rice et al. (2006). This measure is based on the total employment of a given area which is located within a series of driving time bands around the centre of each NUTS3 area[7]. Thus, we do not understand agglomeration as population per hectare within a given

[6] Variables like GVA or GDP, for instance, are usually estimated at workplaces while people are counted where they born, so GVA per capita tend to be overestimated if the region excludes dormitory areas (Chesire and Magrini, 2009). This is precisely why this dataset is extremely valuable.

[7] Data on travel times (and distances as well) were calculated using Microsoft Autoroute 2002. We are very grateful to Patricia Rice and Anthony Venables for providing us with these data. To adapt our data to travel time data provided by Rice and Venables, the regions of Eilean Siar (Western Isles), Orkney Islands, and Shetland Islands have been excluded. Moreover, the following areas have been aggregated: East Cumbria and West Cumbria; South and West Derbyshire and East Derbyshire; North Nottinghamshire and South Nottinghamshire; Isle of Anglesey and Gwynedd; Caithness, Sutherland and Ross and Cromarty, Inverness and Nairn and Moray, Badenoch and Strathspey, Lochaber, Sky, Lochalsh and Argyll and the Islands.

administrative region, but as employment in a band or isochrone of certain minutes' travel by car. According to the authors, this measure is an economically more meaningful proxy for agglomeration than the more traditional measure of employment density in the own or neighbouring regions. British NUTS3 areas are small enough, with boundaries determined administratively rather than economically, that travel time bands will capture the effective potential employment (or jobs filled in our case) available for each area. Further, by including more than one travel time band, we will capture not only own area effects, but also cross-region effects, so we will be able to assess the scope of the agglomeration effect as well[8].

It is worth noting that intangible assets are hard to define and measure, basically due to a lack of consensus on what they exactly are. What is more, they tend to be a multidimensional concept, which we will try to take account in our proxies and, therefore, in our estimations. Information about the construction of each variable and the data sources are given in the appendix. We will assume that these variables will be completely exogenous, since they will pre-date our period of analysis, 2001-2005 –data for these variables will pertain to the period 1996-2000.

Table 1 sets out the variables used in this study with information on their variation across the regions of the UK. It is easy to see that differences across regions are important, as for the case of our dependent variable, which varies from £22,761 per filled job in the Scottish Borders region up to the value for Inner London – West, of £46,594. Differences among regions are high for the explanatory variables as well, especially for the concentration of population and employment, applied patents, and employment in R&D.

[Insert table 1 about here]

[8] As Rice et al. (2006) mention, the ideal situation would be to include several time bands of no more than 20 minutes each one, although it would introduce serious collinearity problems in the estimation. In our study, then, we have introduced two travel time bands of 60 minutes each, so two parameters, $\theta_{0-60}$ and $\theta_{60-120}$, will be included in our regressions.

## 4. Baseline results

The aim of this section is to explore the extent to which the parameter estimates for the effect of agglomeration on productivity, proxied by total employment within each isochrone, are modified when other sources of private returns and externalities within each region are taken into account. In Table 2 we display the OLS estimates. We have reported, in a first stage (column (i)), estimates of the effect of agglomeration on productivity, using only the educational human capital location quotient as a control, as is done in much of the literature reviewed in section 2. In the next column we show the effects of including the additional variables suggested by the model discussed in Section 3 (column (ii)).

Following Ciccone's (2002) article, we assume that the capital income share, $\alpha(1-\beta)$, equals 0.3, whilst the income share of land, $(1-\alpha)$, equals 0.015. The agglomeration parameter within the first 60 minutes travel time band, $\theta_{0-60}$, is, according to our estimates of the restricted model, 0.059. To get an approximation of the elasticity of production density on total output, we use the fact that $\frac{\lambda-1}{\lambda}=1-\frac{\alpha+\alpha(1-\beta)\theta_i}{1+\theta_i}$, so the estimated parameter implies results for the coefficient which captures spatial externalities in Ciccone's (2002) model of 5.3% for our sample.

When the full extended model is estimated (column (ii)) the adjusted R-square increases by 0.12, so that the specification explains a larger proportion of variance than the restricted one. Moreover, the implied elasticity of the density of production is 4.07%, about 77% of that in column (i). For the case of the second travel time band, 60-120 minutes, the parameter is also dramatically reduced.

Interestingly enough, the majority of the variables included in our model are significant and with the expected sign. Educational human capital has a significant and positive impact on productivity, while knowledge inputs –that is, R&D and high-tech manufacturing employment- positively affect outcomes as well. The business culture of a region –i.e., entrepreneurship capital- has a significant effect on productivity, whilst its success has a strongly significant and positive impact. On the other hand, the occupational human capital indicator does not have a significant impact on productivity, although this situation could be partially explained due to social and institutional factors, and to labour market segmentations within high performing regions, since people in those regions may demand low-productivity services to be located inside. Knowledge outputs, that is to say, applied patents according to their inventor region of residence, are not significant either[9]. Likewise, an F-test for the joint significance of the parameters accompanying the intangible proxies clearly rejects the null hypothesis.

In short, although the estimated agglomeration effect, $\theta$, and the implied production density parameter are somewhat smaller when intangible assets are included in the model, agglomeration economies still matter, although their impact – in quantitative terms- and their scope –in terms of distances- are estimated to be lower and shorter respectively.

[Insert table 2 about here]

At this point we should be aware of several sources of endogeneity and omitted variables in our model which could bias our estimates and make them inconsistent. On the one hand, the concentration of economic activity and employment could suffer from reverse causality with productivity, since workers could tend to concentrate where economic outcomes, and consequently wages, are higher. Moreover, other sources of externalities aside from those related to the concentration of employment may arise not only within a given region, but also across neighbouring regions. Their omission could lead us to make biased and inconsistent estimates. In the next section, we will take all these considerations into account.

## 5. Endogeneity and spatial correlation

[9] Former versions of this study included among the covariates interactions between educational human capital and the three dimensions of knowledge capital, although they were avoided in the final draft to save space (results can be provided from the authors upon request). When the total elasticities evaluated at the sample mean were calculated and also the standard errors through the Delta method (Serfling, 1980), we encountered a strong complementarity relationship between educational human capital and applied patents. The later variable not only increased considerably its value, but also became strongly significant.

### 5.1. Endogeneity

A principal concern when assessing the robustness of the relationship between the concentration of economic activity and productivity is with the issue of possible "two-way causation" -are cities highly productive because they are big and dense, or are cities big because they are highly productive? To cope with this concern, we will use GMM estimation techniques. To do so, we will use two instruments, so we will be able to perform overidentification tests as well. Thus, just as in Rice et al. (2006), we will use as one instrument the population in 1801 in regions whose centre is within two travel time bands. As the authors noted, the validity of this instrument lies in the assumption that the patterns that determined the settlement at the beginning of the XIXth century are not correlated with current levels of productivity, aside from its influence through current population and employment concentration. Further, following Ciccone´s (2002) suggestions, we will use total land area of the regions the centre of which is located within each of our two isochrones as a second instrument. As stressed by Ciccone, current administrative boundaries were often drawn in order to make equal the level of population of each region, so it can be used as an instrument if the original sources of population concentration (mainly geographical explanations) affect productivity only through agglomeration.

In columns (iii) and (iv) of Table 2 we repeat the estimations of columns (i) and (ii) respectively, but instrumenting our main explanatory variables – i.e., employment within each isochrone - using the aforementioned instruments. The first stage F-statistics for the joint significance of the instruments are larger than 10, which is usually considered a good threshold not to judge the instruments as weak ones, whilst partial R-squares of the first regression are high – both statistics are provided at the bottom of the table. Moreover, Shea partial R-squares (which take account of the collinearity among instruments –see Shea, 1997) are shown as well, since in models with multiple endogenous variables the first stage F-statistic and usual partial R-squares of the first stage are not sufficiently informative. In the case that the partial R-squared were large values and the Shea R-squared small ones, the instruments would lack sufficient relevance to explain all the endogenous regressors (Baum et al., 2003). As can be seen, the differences between the two measures are almost negligible.

The results and conclusions arising from these estimations are similar to those of the former ones: there is a reduction (both in quantitative and distance terms) of the agglomeration effect when controlling for intangible capital assets; and that these assets are important in fostering productivity –both jointly and individually. It is worth noting that the estimated coefficient of the agglomeration effect is somewhat lower when instrumented, suggesting that the parameter was somewhat upward biased in the OLS estimation and that the GMM estimation was necessary.

### 5.2. Spatial structure of productivity

Externalities or social returns could arise both from intangible capitals and from physical endowments. When the sender and the receiver of these externalities are not in the same region, we should expect a correlation between explanatory variables in one region and the dependent variable of its neighbouring regions. Concretely, we assume that if our dependent variable shows some degree of spatial dependence, it would mean that this spatial autocorrelation summarizes a wide range of externalities across regions. If so, we should take account of this dependence in the estimation of our model. Otherwise, the estimates of the relationship between agglomeration (both of employees and intangible endowments) and GVA per job filled will be biased.

To check for spatial dependence we need to define a measure of proximity[10], which will be summarized in a $nxn$ matrix of spatial weights, where $W = \{w_{ij}\}$. We will define here $w_{ij} = \exp(-0.01 d_{ij})$, $d_{ij}$ being the travel time by car between the centres of region i and region j[11]. As Pattacchini and Rice (2007) stress, travel times between

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[10] The most common definition of proximity is that of first order physical contiguity, that is, if two regions share the same administrative border $w_{ij} = 1$, and $w_{ij} = 0$ otherwise. Other contiguity criteria have been defined in the literature, such as commercial exchanges (Cabrer-Borràs and Serrano-Domingo, 2007) or technological proximity (Moreno et al., 2005). We will focus our attention in another definition of contiguity, somewhat more relevant for our purposes.

[11] We have used a distance decay of 0.01 among several options, since it shows the highest pseudo-$R^2$ after the FGS2SLS estimations (p.-$R^2$ 0.856 for 0.01; p.-$R^2$ 0.804 for 0.02; p.-$R^2$ 0.774 for 0.03; p.-$R^2$ 0.792 for 0.04; p.-$R^2$ 0.643 for 0.05; p.-$R^2$ 0.733 for 0.08; p.-$R^2$ 0.765 for 0.1).

regions are a more economically meaningful measure of proximity than physical contiguity or physical distance. What is more, this measure should suffer less from some kind of reverse causality than other economically meaningful measures like technological proximity or commercial exchanges. A cut-off of 120 minutes is introduced, since interdependencies beyond 2 hours' travel time should be negligible. Table 3 shows the values of Moran's I and Geary's c-statistics for GVA per job filled using various definitions of proximity, including contiguity, physical distance and variations of time-travel-dependent measures. Whilst there is some variation across the various measures, it is clear that spatial correlation is significant.

[Insert table 3 about here]

Further, as can be seen from Table 2, Moran's I test for spatially autocorrelated residuals after the OLS estimates seems to indicate that spatial autocorrelation remains. However, Robust Lagrange multiplier tests do not clearly discriminate where the spatial process is allocated, either as a spatial lag of the endogenous variable or in the error term. The first one is known as substantive spatial autocorrelation; its omission would imply an error term being spatially correlated, and its solution comes from the inclusion of the spatial lag of the dependent variable. On the other hand, when the spatial autocorrelation is not caused by the omission of a spatial lag of the dependent variable, we are confronted with residual or nuisance spatial autocorrelation, which may arise from the omission of relevant variables or from measurement errors (Anselin, 1988). The first type of spatial dependence can be interpreted as arising from economically meaningful spillovers, whilst the second one is merely due to noise (Bode, 2004).

In such a setting, we theoretically hypothesize that when the sender and the receiver of social returns are not in the same region, spatial autocorrelation arises and summarizes a wide range of externalities across regions which could be taken into account with the inclusion of a spatial lag of the dependent variable. However, even when a spatial lag is included, residual spatial autocorrelation may remain, and in this case we should also include a spatially autoregressive error term. Indeed, if there are significant spatially autocorrelated explanatory variables, aside from the spatial lag and not accounted for by means of its inclusion, their absence would tend to induce a spatially non-random pattern of residuals. To the best of our knowledge no other paper has hitherto sought to estimate agglomeration economies whilst at the same time dealing with reverse causality and spatial autocorrelation both in the dependent variable and in the error term. Equation (11) shows the mixture model, say a SARAR(1,1) – a spatial autoregressive model with autoregressive disturbances of order 1, where both types of spatial autocorrelation are included:

$$\begin{aligned} y &= \rho W y + X\beta + \varepsilon \\ \varepsilon &= \lambda W \varepsilon + u \end{aligned} \tag{11}$$

where $u$ is an *iid* disturbance term. At this point is necessary to choose the appropriate estimation method[12]. Most of the literature has used Maximum Likelihood (ML) procedures, the work by Rice et al. (2006) being an example. However, its reliability and feasibility requires specific distributional assumptions (K-P, 1998). Moreover, such procedures are not available for models with substantive and residual autocorrelation at the same time, and this procedure when other endogenous variables in the right hand side of the model exist would be difficult to implement, if not impossible (Fingleton and Le Gallo, 2008).

Thus, we first adopt the feasible generalized spatial two-stages least squares estimator (FGS2SLS) proposed by K-P (1998), which will be somewhat modified in order to control for endogeneity problems arising from reverse causality of the agglomeration variable. Hence, in a first step the model in (10) is estimated by 2SLS, but including a spatial lag of the dependent variable. In matrix notation, the estimator will be

$$\hat{\delta} = (Z' P_X Z)^{-1} Z P_X y_1 \tag{12}$$

where $Z$ stands for the matrix of regressors, that is, the exogenous and the endogenous ones –both the spatial and non-spatial endogenous regressors; $P_X$ is a projection matrix, $P_X = X(X'X)^{-1}X'$, with $X = (X_1, X_2, X_3)$ the matrix of included and

[12] Ordinary least squares would not be an appropriate technique, leading to unsatisfactory consequences if used, dependent upon the kind of spatial autocorrelation in question.

excluded instruments, where $X_1$ stands for the matrix of original exogenous regressors, $X_2$ for the historical instruments discussed in the former section, and $X_3$ the excluded instruments chosen for the spatial lag of the dependent variable. The choice of appropriate instruments is again one of the main concerns of this procedure. Given that the best instrument of a variable is its own mean, it is straightforward to note, in matrix notation, that

$$\begin{aligned} E(WY) &= W(I-\rho W)^{-1}X_1B = W[I+\rho W+\rho^2W^2+\ldots]X_1B = \\ &= WX_1B + W^2X_1(\rho^2B) + W^3X_1(\rho^3B) + \ldots + W^nX_1(\rho^nB) \end{aligned} \tag{13}$$

where $I$ is an identity matrix and $B$ the vector of parameters to estimate. We will set $n=2$ since it has been shown in Kelejian et al. (2003) as appropriate[13]. We have, however, additional very good candidates available as instruments, *i.e.* the spatial lags of the historical instruments, $WX_2$ and $W^2X_2$. This is the procedure implemented in Fingleton (2003) when estimating agglomeration economies for Great Britain[14]. This procedure is consistent, but not efficient in case that additional spatial correlation would remain in the disturbance term. We would then estimate the autoregressive parameter $\lambda$ in equation (11). To do so, we would follow K-P (1999), obtaining the residuals and the estimated $\hat{B}$ and $\hat{\rho}$ from the first stage; and we would also obtain three residual vectors, say $\tilde{\varepsilon} = Y - X_1\hat{B} - \hat{\rho}WY$, $\bar{\tilde{\varepsilon}} = W\tilde{\varepsilon}$ and $\bar{\bar{\tilde{\varepsilon}}} = W^2\tilde{\varepsilon}$, which are suggested in K-P (1999) to obtain the generalized moments estimator of $\lambda$. In the final step, our model with the spatial lag would be reestimated by 2SLS, in the same manner as in the first step, but having transformed it using $\hat{\lambda}$ through a spatial Cochrane-Orcutt type transformation to account for the spatial autocorrelation of the error term.

The results for the estimation of model (10) with a spatial lag of the endogenous variable – not reported here to save space - indicate that this spatial lag matters,

[13] The use of n higher than 2 could be dangerous in finite samples since the 2SLS procedure will be closer and closer to OLS, which will not be consistent therefore.

[14] Although in Fingleton (2003) n=1, which could mean an efficiency loss in the estimations.

although its value is small. Moreover, Moran's I test for 2SLS[15] indicates that some residual spatial autocorrelation remains - results reported at the bottom of column (i) in table 4. So, in that column we show the results with the inclusion of a spatial lag both in the dependent variable and in the error term.

The most striking aspects of that estimation are, basically, that the parameters accompanying proxies for intangible capital assets remain significant – the majority of them - and with similar values as in table 2. Additionally, the spatial lag is significant at 5% and with a value of 0.001. Likewise, the elasticity of the agglomeration effect falls to 0.024, from values around 0.042 and 0.039 in former estimations when spatial autocorrelation is taken into account. Moreover, the parameter for the second isochrone is not significant anymore.

In the following columns of the table we will go one step beyond. Since there is no reason to assume homoscedasticity in our model even when spatial correlation is taken into account, we will present estimates that allow for heteroscedasticity of unspecified form. Specifically, we will implement the recent results of Kelejian and Prucha (2007) which, additionally and contrary to earlier work, do not impose a specific functional form of the error term spatial correlation[16], *i.e.* the spatial HAC estimator of the V-C matrix. The rationale behind this technique comes from the time-series results, and basically is a non-parametric technique to estimate the V-C matrix using averages of cross-products of residuals, the range of which is determined by a kernel function. This kernel function takes the form of $K(d_{ij}/d)$, with $d_{ij}$ the distance between regions

[15] A Moran's I test for 2SLS residuals (distributed as a standard normal) proposed by Anselin and Kelejian (1997) is performed, since the usual Moran's I based on OLS residuals, where all the explanatory variables are exogenous, is not appropriate. The test has been performed using a row-standardized binary matrix where w=1 if a centre of a region is within a 0-60 minutes travel time band, and w=0 otherwise.

[16] Although the inclusion of a spatial lag of the dependent variable as summarising a broader set of externalities is theoretically straightforward, the *a priori* functional form of the spatial process in the disturbance term is less clear and that is why we are convinced about the value of the approach by K-P (2007) used in the present study.

i and j, and $d$ the bandwidth[17] - $K(d_{ij}/d)$ equals 0 when $d_{ij} \geq d$. Similarly to Anselin and Lozano-Garcia (2008), we will use here three different kernels: triangular, Epanechnikov, and bisquare, respectively $K(d_{ij}/d) = 1-(d_{ij}/d)$, $K(d_{ij}/d) = 1-(d_{ij}/d)^2$, and $K(d_{ij}/d) = (1-(d_{ij}/d)^2)^2$.

Basically, the procedure consists of repeating the first stage of the FGS2SLS and estimating the V-C matrix through the use of the residuals and the kernel functions based on distances between regions. Results (columns (ii) to (iv) for, respectively, triangular, Epanechnikov, and bisquare kernels) are quite similar to those of the FGS2SLS procedure. A few details should be noted: the decrease of the estimated parameter accompanying the first isochrone (from 0.024 to 0.021); the relative increase of the parameter of the second isochrone; and, especially, the strong significance of both parameters (significant at 1%). Note also that the differences of the standard errors are negligible irrespective of the chosen kernel function.

To sum up, from column (i) of table 4 we should conclude that externalities arising from neighbouring regions –summarized through a spatial lag of the dependent variable- matter, although their values are very small (0.1%). Besides, increasing returns arising from agglomeration economies are markedly reduced when spatial autocorrelation is allowed for and are significant only for distances below 60 minutes' travelling by car. However, the small value of the coefficient of the spatial lag and the residual spatial autocorrelation that remains after the first step of the FGS2SLS lead us to think that the spatial lag does not account for all the externalities across regions. Thus, several externalities across regions, not summarized in the spatial lag, matter as well in explaining productivity levels, though the particular sources behind them are left for future research.

However, when the V-C matrix is estimated following K-P (2007) suggestions (SHAC), the significance of both isochrones increases notably. We interpret these results as follows: although agglomeration economies are less important when spatial correlation is taken into account, we found they are still very significant, especially

[17] In our empirical approach, we will use a variable bandwidth with Euclidean distances to the 12 nearest neighbours. Results using other distances or different number of neighbours do not change to a large extent.

when we allow for heteroscedasticity and spatial correlation across spatial units without specifying *a priori* their functional form. Since both heteroscedasticity and the form of the spatial process in the disturbances term are important concerns, we are convinced about the validity of our final specifications and results. However, we will perform in the following section some robustness checks.

[Insert table 4 about here]

### 5.3. Robustness tests

This section includes some robustness checks to validate the results encountered throughout our study. We first repeat some of the specifications but instrumenting also the proxies for the intangibles (columns (i) and (v) of table 5). Although we are convinced that our former estimations are already consistent because these variables are pre-dating the dependent one, we acknowledge that given the time-persistent feature of the productivity measure, it is worthwhile to ensure that endogeneity problems do not remain. To do so, we will use the three-group method, already used in Fingleton (2003). Although it was thought to cope with measurement error (Kennedy, 1992), we assume that instrumenting these already lagged variables, any endogeneity problem should be solved. The three-groups method consists of sorting all the variables and splitting them into three equal-sized groups, taking the value 1 if the observation is in the highest third of the variable, 0 if it is in the middle, and -1 if the value is in the lowest third of the regressor. Column (i) of table 5 repeats the GMM estimations, but instrumenting all the covariates. It is worthwhile noting that few changes are found, aside from an increase in the estimated parameter for occupational human capital –although not enough to make it significant. Additionally, proxies for entrepreneurship capital are not significant anymore. We interpret these results as revealing some kind of measurement error in such variables, since this is a relatively new concept in the literature, which has received less attention than human capital or knowledge, and good proxies are difficult to find. Additionally, tests for the joint significance of the intangibles reject the null. Instruments validity measures –not reported- like partial $R^2$ and F-tests of the first stage are both quite high, although, contrary to what is shown in Table 2, differences between partial $R^2$ and Shea $R^2$ are markedly increased for some of the variables. We acknowledge, therefore, that the instruments chosen are not the best ones and the results (especially in column (v) of table 5) should be taken with caution.

Another interesting check relates to the space. We have used for the spatial lag of the dependent variable and for the agglomeration proxies measures of neighbourhood which relate each region with the ones surrounding it. We acknowledge, however, that the spatial distribution of economic activity in the Great Britain is driven by London and the relationships of each region with this metropolis. Thus, we have included in specifications (ii) to (v) measures of distances to Inner London-West (the richest region) in terms of miles and minutes travelling by car –a negative and significant sign is expected for both measures. None of these variables stands out as significant. Moreover, the spatial lag of the dependent variable remains strongly significant. However, the second isochrone is not significant anymore when *"minutes"* is introduced, in line with the FGS2SLS estimates[18]. However, given that the parameters for the "distance-to-London" variables are far from being significant, these later results should be interpreted with caution and deserve further research.

Additionally, in line with former studies (Rice et al., 2006), we have split up the isochrones into three bands of 40 minutes travelling by car each –jointly with the "Minutes to Inner London-West" variable (columns (iv) and (v)). The second and third travel time bands are not significant, again in line with the FGS2SLS. However, we should be aware that some collinearity problems could arise when splitting up the "economic mass" variable into three isochrones. In column (v), in addition to the three isochrones and the SHAC estimator of the V-C matrix, the intangibles are again instrumented using the three-group method. In this case, all the variables are significant apart from the second and third isochrones.

[Insert table 5 about here]

## 6. Conclusions

[18] In columns (iv) and (v) of table 5 we only include the variable "Minutes to Inner London-West" since it appears from column (iii) to have a slightly stronger effect on the spatial lag.

Throughout previous pages, the aim of this paper was to analyse whether agglomeration economies, understood as the concentration of production, and therefore employment, in a given region still matter once several qualitative features of each region aside from merely the typical inputs of the production process – land, capital, and labour - are taken into account. Specifically, departing from Ciccone's (2002) model, we entertained the hypothesis that regions are endowed with certain kinds of intangible asset which characterize the knowledge-based economy, beyond purely the location of individuals, and which are sources of private and social returns at the same time. Unlike previous works, we have taken account of these qualitative features when estimating the aggregate effect of agglomeration economies on economic performances of regions in order not to bias upward our parameter estimations. Further, we have hypothesised that strong social returns arising from several sources – tangible and intangible, will affect regions from one to another and can be summarised in a process of spatial dependence of our dependent variable, *i.e.* labour productivity.

The main conclusions arising from our methodological approach and datasets available are as follows: agglomeration economies – as we have measured them - matter in explaining differences in economic performance across regions although their importance in quantitative terms and their extension, are somewhat constrained when several variables proxying intangible assets – knowledge, human capital, and entrepreneurial culture - are included in our estimations. Specifically, the majority of the variables proxying intangible assets are significant and with the expected sign. The results are consistent even when treating explicitly "two-way causation" problems between productivity and agglomeration.

What is more, the explanatory power of intangible assets in our framework is mostly not reduced when externalities across regions are taken into account in the model. However, the coefficients for agglomeration economies are somewhat reduced, though significant. Therefore, we can conclude that inter-regional externalities arising from physical and intangible endowments do, indeed, exist.

Regarding some policy implications, our results suggests that, to some extent, local/regional transportation system improvements – especially public ones - which reduce the length of business and commuting journeys might boost labour productivity by means of increasing returns derived from transportation costs reductions, sharing inputs, and knowledge spillovers, so investments in this kind of infrastructure should be carried out, as has been stressed before (Graham, 2007). However, the accumulation of certain kinds of intangible endowments in a given region is extremely important as well, so low-density, non-metropolitan areas could also profit from the concentration of these intangible assets. Policies concerned with this issue are correspondingly relevant.

# Tables

## Table 1. Statistics

| | Observations | Mean | Coefficient of variation | Min | Max |
|---|---|---|---|---|---|
| GVA filled job | 119 | 29785 | 0.136 | 22761 | 46594 |
| Employment within 60 mn | 119 | 1251878 | 0.965 | 51342 | 6120282 |
| Employment within 60-120 mn | 119 | 4827812 | 0.704 | 0 | 1.26e+07 |
| Educational human capital | 119 | 0.96 | 0.162 | 0.66 | 1.48 |
| Occupational human capital | 119 | 24.24 | 0.184 | 11.53 | 39.63 |
| Employment in RD and computers | 119 | 0.79 | 0.846 | 0.2 | 4.3 |
| High tech manufacturing employment | 119 | 1.17 | 0.501 | 0.08 | 2.84 |
| Applied patents | 119 | 407 | 1.107 | 25 | 3247 |
| VAT registrations | 119 | 2.73 | 0.430 | 1.23 | 12.37 |
| CAGR VAT registrations | 119 | 1.64 | 0.623 | -0.34 | 4.92 |

**Table 2. White-robust OLS and GMM estimates. Dep. Var.: lnGVA per job filled**

| | (i) | (ii) | (iii) | (iv) |
|---|---|---|---|---|
| | OLS | OLS | GMM | GMM |
| ln(employment within 0-60 minutes) | 0.059*** | 0.042*** | 0.056*** | 0.039*** |
| | *(0.008)* | *(0.008)* | *(0.010)* | *(0.008)* |
| ln(employment within 60-120 minutes) | 0.015*** | 0.009*** | 0.017*** | 0.010*** |
| | *(0.004)* | *(0.003)* | *(0.004)* | *(0.002)* |
| Educational HK | 0.333*** | 0.167** | 0.334*** | 0.166** |
| | *(0.065)* | *(0.080)* | *(0.063)* | *(0.073)* |
| Occupational HK | | -0.002 | | -0.001 |
| | | *(0.003)* | | *(0.003)* |
| Empl. RD&IT | | 0.048*** | | 0.050*** |
| | | *(0.014)* | | *(0.013)* |
| High tech manuf. employment | | 0.056*** | | 0.056*** |
| | | *(0.013)* | | *(0.012)* |
| ln(Applied patents by inventor) | | 0.015 | | 0.013 |
| | | *(0.011)* | | *(0.010)* |
| ln(VAT registrations) | | 0.079* | | 0.078** |
| | | *(0.044)* | | *(0.040)* |
| CAGR VAT registrations | | 0.020* | | 0.021** |
| | | *(0.011)* | | *((0.010)* |
| Constant | 8.950*** | 9.203*** | 8.965*** | 9.231*** |
| | *(0.121)* | *(0.117)* | *((0.115)* | *(0.108)* |

| | | | | |
|---|---|---|---|---|
| NUTS1 dummies | Yes | Yes | Yes | Yes |
| Sample size | 119 | 119 | 119 | 119 |
| Adj. $R^2$ | 0.616 | 0.739 | 0.615 | 0.748 |
| Joint test for intangibles (F-test$_{7, 99}$ and Wald test$_{Chi2(7)}$) | | 14.61 | | 121.18 |
| *p-value* | | *0.000* | | *0.000* |
| Moran's I | 3.801 | 3.550 | | |
| *p-value* | *0.000* | *0.000* | | |
| Robust LM (error) | 0.316 | 0.859 | | |
| *p-value* | *0.574* | *0.354* | | |
| Robust LM (lag) | 8.997 | 2.068 | | |
| *p-value* | *0.003* | *0.150* | | |
| Hansen J statistic | | | 0.803 | 0.858 |
| *p-value* | | | *0.669* | *0.651* |
| ln(Empl. 60 mn) - *Partial $R^2$* | | | *0.778* | *0.751* |
| ln(Empl. 60 mn) - *Shea $R^2$* | | | *0.734* | *0.732* |
| ln(Empl. 60 mn) - *First stage F-stat* | | | *53.43* | *49.13* |
| ln(Empl. 60-120 mn) - *Partial $R^2$* | | | *0.973* | *0.968* |
| ln(Empl. 60-120 mn) - *Shea $R^2$* | | | *0.917* | *0.944* |
| ln(Empl. 60-120 mn) - *First stage F-stat* | | | *1804.41* | *1402.15* |

**Notes:** OLS and GMM estimates with several levels of significance: 1%***, 5%**, 10%*. White-robust standard errors are presented in italics and parenthesis below each associated parameter. Moran's I test for the residuals of the OLS estimations is provided, indicating that they remain spatially autocorrelated. Robust Lagrange multiplier tests are provided as well, in order to choose which kind of spatial dependence arises. However, the results are not conclusive. Each test presents its p-value in italics below. The variables expressed in percentages and location quotients are not log-transformed in order to facilitate the interpretation of their coefficient. Hansen J statistics for mutual consistency of the available instruments are provided (columns (iii) and (iv)) and we cannot reject the null hypothesis that the excluded instruments are valid and uncorrelated with the error term, so there are no overidentification problems.

## Table 3. Global spatial autocorrelation tests

| | W1 | W2 | W3 | W4 | W5 | W6 |
|---|---|---|---|---|---|---|
| *Moran's I* | | | | | | |
| ln(GVA filled job) | 12.994 | 6.598 | 5.800 | 6.858 | 7.318 | 11.117 |
| *p-value* | *0.000* | *0.000* | *0.000* | *0.000* | *0.000* | *0.000* |
| *Geary's c* | | | | | | |
| ln(GVA filled job) | -3.337 | -5.721 | -4.598 | -5.933 | -6.191 | -3.020 |
| *p-value* | *0.000* | *0.000* | *0.000* | *0.000* | *0.000* | *0.001* |

**Notes:** W1: main matrix ($w_{ij}$=exp(-0.01$d_{ij}$), $d_{ij}$ being the travel time by car between the centres of region i and region j); W2: row-standardized contiguity binary matrix; W3: row-standardized binary matrix where w=1 if a centre of a region is within a 0-60 minutes travel time band, and w=0 otherwise; W4: row-standardized binary matrix where w=1 if a centre of a region is within a 0-90 minutes travel time band, and w=0 otherwise; W5: row-standardized binary matrix where w=1 if a centre of a region is within a 0-120 minutes travel time band, and w=0 otherwise; W6: w=1/m, where m=miles between each regional centre.

## Table 4. FGS2SLS and SHAC estimates. Dep. Var.: lnGVA j.f.

| | (i) | (ii) | (iii) | (iv) |
|---|---|---|---|---|
| | FGS2SLS | SHAC-tr | SHAC-ep | SHAC-bi |
| W·lnGVA filled job | 0.001*** | 0.001*** | 0.001*** | 0.001*** |
| | *(0.000)* | *(0.000)* | *(0.000)* | *(0.000)* |
| ln(employment within 0-60 minutes) | 0.024* | 0.021*** | 0.021*** | 0.021*** |
| | *(0.012)* | *(0.007)* | *(0.007)* | *(0.007)* |
| ln(employment within 60-120 minutes) | 0.003 | 0.008*** | 0.008*** | 0.008*** |
| | *(0.006)* | *(0.002)* | *(0.002)* | *(0.002)* |
| Educational human capital | 0.144** | 0.178** | 0.178** | 0.178*** |
| | *(0.067)* | *(0.072)* | *(0.070)* | *(0.072)* |

| | | | | |
|---|---|---|---|---|
| Occupational human capital | 0.003 | -0.002 | -0.002 | -0.002 |
| | *(0.003)* | *(0.003)* | *(0.003)* | *(0.003)* |
| Employment in RD and computers | 0.042*** | 0.044*** | 0.044*** | 0.044*** |
| | *(0.013)* | *(0.012)* | *(0.012)* | *(0.012)* |
| High tech manufacturing employment | 0.038*** | 0.054*** | 0.054*** | 0.054*** |
| | *(0.012)* | *(0.011)* | *(0.012)* | *(0.012)* |
| ln(Applied patents by inventor) | 0.010 | 0.016 | 0.016 | 0.016 |
| | *(0.009)* | *(0.010)* | *(0.010)* | *(0.010)* |
| ln(VAT registrations) | 0.037 | 0.070* | 0.070* | 0.070* |
| | *(0.035)* | *(0.040)* | *(0.040)* | *(0.041)* |
| CAGR VAT registrations | 0.021** | 0.019* | 0.019* | 0.019* |
| | *(0.009)* | *(0.010)* | *(0.010)* | *(0.010)* |
| Constant | 9.491*** | 9.474*** | 9.474*** | 9.474*** |
| | *(0.178)* | *(0.112)* | *(0.112)* | *(0.111)* |
| NUTS1 dummies | Yes | Yes | Yes | Yes |
| Sample size | 119 | 119 | 119 | 119 |
| Pseudo-$R^2$ | 0.856 | 0.777 | 0.777 | 0.777 |
| Joint test for intangibles (Wald test$_{Chi2(7)}$) | 90.54 | 100.41 | 100.41 | 100.41 |
| *p-value* | *0.000* | *0.000* | *0.000* | *0.000* |
| Sargan statistic | 25.538 | 24.757 | 24.757 | 24.757 |
| *p-value* | *0.323* | *0.363* | *0.363* | *0.363* |
| \| Moran's I z statistic \| | 1.68 | 1.68 | 1.68 | 1.68 |
| *p-value* | *0.095* | *0.047* | *0.047* | *0.047* |
| Lambda | 0.561 | | | |

**Notes:** FGS22SLS and SHAC (using different Kernels) estimates with several levels of significance: 1%***, 5%**, 10%*. Standard errors are presented in italics and parenthesis below each associated parameter. Sargan statistics for mutual consistence of the available instruments are provided and we cannot reject the null hypothesis that the excluded instruments are valid and uncorrelated with the error term, so there are not overidentification problems –they correspond to the first stage of the procedure for columns (ii), (iii), and (iv). Instruments validity are not reported to save space, although can be provided upon request from the authors. The Pseudo-$R^2$ is calculated as the ratio of the variance of the fitted values of the dependent variable over the variance of the dependent variable.

## Table 5. Robustness checks. Dep. Var.: lnGVA j.f.

| | (i) | (ii) | (iii) | (iv) | (v) |
|---|---|---|---|---|---|
| | GMM | SHAC-tr | SHAC-tr | SHAC-tr | SHAC-tr |
| W·lnGVA filled job | | 0.001*** | 0.001** | 0.001*** | 0.001*** |
| | | *(0.000)* | *(0.000)* | *(0.000)* | *(0.000)* |
| First Isochrone | 0.039*** | 0.025*** | 0.026*** | 0.015** | 0.013* |
| | *(0.009)* | *(0.007)* | *(0.007)* | *(0.008)* | *(0.008)* |
| Second Isochrone | 0.009*** | 0.008** | 0.008 | -0.003 | -0.003 |
| | *(0.003)* | *(0.004)* | *(0.006)* | *(0.003)* | *(0.003)* |
| Third Isochrone | | | | 0.008 | 0.009 |
| | | | | *(0.007)* | *(0.007)* |
| Educational human capital | 0.236** | 0.176** | 0.178** | 0.180** | 0.234*** |
| | *(0.095)* | *(0.073)* | *(0.077)* | *(0.078)* | *(0.058)* |
| Occupational human capital | 0.002 | -0.002 | -0.002 | -0.002 | -0.005* |
| | *(0.002)* | *(0.003)* | *(0.003)* | *(0.004)* | *(0.003)* |
| Employment in RD and computers | 0.050*** | 0.044*** | 0.044*** | 0.044*** | 0.041*** |
| | *(0.016)* | *(0.012)* | *(0.012)* | *(0.013)* | *(0.012)* |
| High tech manufacturing employment | 0.066*** | 0.054*** | 0.054*** | 0.052*** | 0.052*** |
| | *(0.014)* | *(0.012)* | *(0.012)* | *(0.012)* | *(0.011)* |
| ln(Applied patents by inventor) | 0.007 | 0.016 | 0.016 | 0.016 | 0.018** |
| | *(0.013)* | *(0.010)* | *(0.010)* | *(0.010)* | *(0.008)* |
| ln(VAT registrations) | 0.041 | 0.072 | 0.072* | 0.057 | 0.076*** |
| | *(0.068)* | *(0.042)* | *(0.041)* | *(0.037)* | *(0.027)* |
| CAGR VAT registrations | 0.016 | 0.019* | 0.019** | 0.022** | 0.019* |
| | *(0.014)* | *(0.010)* | *(0.010)* | *(0.010)* | *(0.010)* |

| | | | | | |
|---|---|---|---|---|---|
| Miles to Inner London-West | | 0.000 | | | |
| | | *(0.000)* | | | |
| Minutes to Inner London-West | | | 0.000 | -0.000 | -0.000 |
| | | | *(0.000)* | *(0.000)* | *(0.000)* |
| Constant | 9.175*** | 9.402*** | 9.381*** | 9.629*** | 9.576*** |
| | *(0.119)* | *(0.229)* | *(0.306)* | *(0.263)* | *(0.257)* |
| NUTS1 dummies | Yes | Yes | Yes | Yes | Yes |
| Sample size | 119 | 119 | 119 | 119 | 119 |
| Pseudo-$R^2$ | 0.728[(1)] | 0.780 | 0.780 | 0.778 | 0.791 |
| Joint test for intangibles (Wald test$_{Chi2(7)}$) | 128.30 | 100.60 | 100.71 | 93.26 | 82.17 |
| *p-value* | *0.000* | *0.000* | *0.000* | *0.000* | *0.000* |
| Sargan statistic | 1.097[(2)] | 32.477 | 35.540 | 40.481 | 46.623 |
| *p-value* | *0.578* | *0.145* | *0.079* | *0.096* | *0.027* |

**Notes:** GMM and 2SLS with SHAC (only using the triangular Kernel) estimates with several levels of significance: 1%***, 5%**, 10%*. Standard errors are presented in italics and parenthesis below each associated parameter. Sargan statistics for mutual consistence of the available instruments are provided and we cannot reject the null hypothesis that the excluded instruments are valid and uncorrelated with the error term, so there are not overidentification problems. The intangibles proxies are instrumented in columns (i) and (v) using the three-group method. The isochrones are of 60 minutes each in columns (i), (ii), and (iii), and of 40 minutes each in columns (iv) and (v). The Pseudo-$R^2$ is calculated as the ratio of the variance of the fitted values of the dependent variable over the variance of the dependent variable. (1) This is not a pseudo-$R^2$ but an adjusted-$R^2$. (2) This corresponds to the Hansen J statistic.

# Appendix

## A1. Variables and data construction

| Variable | Proxy | Dates | Source |
|---|---|---|---|
| Productivity | GVA per job filled | Average 2001-2005 | Wosnitza and Walker (2008). |
| "Economic mass" | Sum of the jobs filled within all the regions which centre is located within two travel-time bands of 60 minutes each starting from the centre of each region. | Average 2001-2005 | Wosnitza and Walker (2008) for the jobs data and data acknowledged to Patricia Rice and Anthony Venables. |
| Educational human capital | Location quotient[(1)] of the percentage of economically active population with first and higher degree; nursing and teaching qualifications (NVQ4) or with A-level; GNVQ Higher level, or Advanced certificate of Vocational Education (NVQ3) | Average 1999-2001 | NOMIS database, collected by the Office of National Statistics (ONS) |
| Occupational human capital | Percentage of economically active population who are enrolled in occupations like corporate managers, managers/proprietors in agriculture/services, science and technology professionals, health professionals, teaching and research professionals, and business and public service professionals | Average 1999-2001 | NOMIS database, collected by the Office of National Statistics (ONS) |
| Employment in RD and IT | Location quotient for each area giving the workforce specialisation in computing and related activities and in research and | Average 1996-2000 | NOMIS database |

| | | | |
|---|---|---|---|
| | development | | |
| High tech manuf. employment | Location quotient for each area giving the workforce specialisation in chemicals and man-made fibres; machinery and equipment; optical and electrical equipment; and transport equipment | Average 1996-2000 | NOMIS database |
| Applied patents by inventor | Patents applied in a given region, regionalising them according to the household of the inventor who has registered the patent to the European Patent Office, using the OECD database(2) | Average 1996-2000 | OECD REGPAT database, May 2008 |
| Entrepreneurship culture | VAT registrations per head | Average 1996-2000 | NOMIS database |
| Entrepreneurship success | Cumulative Annual Growth Rate (CAGR) of VAT registrations | Average 1996-2000 | NOMIS database |
| Area | Sum of the squared kilometres within all the regions which centre is located within two travel-time bands of 60 minutes each starting from the centre of each region. | | ONS |
| Population in 1801 | Sum of the 1801 population within all the regions which centre is located within two travel-time bands of 60 minutes each starting from the centre of each region. | 1801 | *"Britain through time"*. Great Britain Historical Geographical Information System. University of Portsmouth. Department of Geography. |

(1) The regional share over the national share
(2) Collecting data on applied patents in this way we try to avoid the bias introduced by the accumulation of patents in regions where the headquarters of several firms are located.

# References

Ades, A. F. and Glaeser, E. L. (1995) Trade and Circuses: Explaining Urban Giants. *Quarterly Journal of Economics*, 110

Acs, Z., Audretsch, D., Braunerhjelm, P. Carlsson, B. (2005) The Knowledge Spillover Theory of Entrepreneurship. CEPR Discussion Paper 5326

Anselin, L. (1988) *Spatial Econometrics: Methods and Models*. The Netherlands: Kluwer Academic Publishers.

Anselin, L. and Kelejian, H. H. (1997) Testing for spatial error autocorrelation in the presence of endogenous regressors. *International Regional Science Review*, 20: 153-182.

Anselin, L. and Lozano-Garcia, N. (2008): Errors in variables and spatial effects in hedonic house price models of ambient air quality. *Empirical Economics*, 34: 5-34.

Audretsch, D. B. (2002): Entrepreneurship: A Survey of the literature, Prepared for the European Commission, Enterprise Directorate General

Baptista, R. (2003): Productivity and the density of regional clusters, in J. Bröcker; D. Dohse and R. Soltwedel (eds) *Innovation clusters and interregional competition*. Berlin: Springer.

Baum, C., Schaffer, M., Stillman, S. (2003): Instrumental variables and GMM: Estimation and testing. *The Stata Journal*, 3 (1): 1-31

Blien, U., Suedekum, J., Wolf, K. (2006): Local employment growth in West Germany: A dynamic panel approach. *Labour Economics*, 13: 445–458

Bode, E. (2004) Agglomeration Externalities in Germany, ERSA conference papers, European Regional Science Association

Brülhart, M. and Mathys, N. A. (2008): Sectoral agglomeration economies in a panel of European regions. *Regional Science and Urban Economics*, 38: 348-362

Brülhart, M. and Sbergami, F. (2009): Agglomeration and Growth: Cross-Country Evidence. *Journal of Urban Economics*, 65: 48-63

Cabrer-Borrás, B. and Serrano-Domingo, G. (2007) Innovation and R&D spillover effects in Spanish regions: A spatial approach. *Research Policy*, 36: 1357–1371

Chesire, P. and Magrini, S. (2009) Urban growth drivers in a Europe of sticky people and implicit boundaries. *Journal of Economic Geography*, 9 (1): 85-115

Ciccone, A. and Hall, R. (1996) Productivity and the Density of Economic Activity. *American Economic Review*, 86 (1): 54-70

Ciccone, A. (2002): Agglomeration effects in Europe. *European Economic Review*, 46 (2): 213-227

Ciccone, A. and Cingano, F. (2003) Skills and Clusters, in J. Bröcker; D. Dohse and R. Soltwedel (eds) *Innovation clusters and interregional competition*. Berlin: Springer.

Cingano, F. and Schivardi, F. (2004) Identifying the Sources of Local Productivity Growth. *Journal of the European Economic Association*, 2 (4): 720-742

Combes, P-P., Duranton, G., Gobillon, L. (2008) Spatial Wage Disparities: Sorting Matters! *Journal of Urban Economics*, 63: 723-742

Duranton, G. (2007) From cities to productivity and growth in developing countries. University of Toronto Working Paper 306

Fingleton, B. (2003) Increasing returns: evidence from local wage rates in Great Britain. *Oxford Economic Papers*, 55: 716–739

Fingleton, B., Le Gallo, J. (2008) Estimating spatial models with endogenous variables, a spatial lag and spatially dependent disturbances: Finite sample properties. *Papers in Regional Science*, 87: 319-339

Fujita, M. (1988) A monopolistic competition model of spatial agglomeration: Differentiated product approach. *Regional Science and Urban Economics*, 18 (1): 87-124

Fujita, M., Krugman, P., A. J. Venables (1999) *The Spatial Economy*. Cambridge, MA: The MIT Press.

Glaeser, E., Kolko, J., Saiz, A. (2001) Consumer City. *Journal of Economic Geography*, 1: 27-50

Glaeser, E., Kallal, H. D., Scheinkman, J. A., Shleifer, A. (1992) Growth in cities. *Journal of Political Economy*, 100: 1126-1152

Graham, D. J. (2007) Agglomeration, productivity and transport investment. *Journal of Transport Economics and Policy*, 41: 317–343

Hanson. G. H. (2005) Market potential, increasing returns and geographic concentration. *Journal of International Economics*, 67: 1-24

H. M. Treasury (2001) *Productivity in the UK: 3-The regional dimension*

Kelejian, H. H. and Prucha, I. R. (1998) A generalized spatial two-stage least squares procedure for estimating a spatial autoregressive model with autoregressive disturbances. *Journal of Real Estate Finance and Economics*, 17: 99–121

Kelejian, H. H. and Prucha, I. R. (1999) A Generalized Moments Estimator for the Autoregressive Parameter in a Spatial Model. *International Economic Review*, 40: 509-533

Kelejian, H. H. and Prucha, I. R. (2007) HAC estimation in a spatial framework. *Journal of Econometrics*, 140: 131-154

Kennedy, P. (1992) *A guide to econometrics*, 3rd Edition, Oxford: Blackwell.

Krugman, P. (1991) Increasing Returns and Economic Geography. *Journal of Political Economy*, 99 (3): 483-499

Moreno, R., Paci, R., Usai, S. (2005) Geographical and sectoral clusters of innovation in Europe. *Annals of Regional Science*, 39: 715–739

Moretti, E. (2004) Human capital externalities in cities. In: V. Henderson and J. Thisse (eds) *Handbook of Urban and Regional Economics*, vol. 4.

Patacchini, E. and Rice, P. (2007) Geography and Economic Performance: Exploratory Spatial Data Analysis for Great Britain. *Regional Studies*, 41.4: 489–508

Rice, P., Venables, A.J., Patacchini, E. (2006) Spatial determinants of productivity: Analysis for the regions of Great Britain. *Regional Science and Urban Economics*, 36: 727–752

Rosenthal, S. S. and Strange, W. C. (2004) Evidence on the nature and sources of agglomeration economies. In: V. Henderson and J. Thisse (eds) *Handbook of Urban and Regional Economics*, vol. 4.

Serfling, R. J. (1980) *Approximation theorems of mathematical statistics* New York: Wiley, cop.

Shea, J. (1997) Instrument relevance in multivariate linear models. A simple measure. *NBER* Technical Working Paper 193

Wosnitza, B. and Walker, M. (2008) Regional economic indicators with a focus on differences in sub-regional economic performances. *Economic & Labour Market Review*, 2 (5)

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