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Does spatial agglomeration increase national growth? some evidence from Europe

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Abstract

Economic geographers and regional economists have long been concerned with the problems provoked by uneven regional development and the ways by which policy intervention may be able to reduce such inequalities. However, in recent years the traditional argument for seeking to secure a reduction in the spatial concentration of economic activity in particular regions has been questioned and in some cases it has been suggested that policies that try to reduce regional economic inequalities may even reduce national efficiency. This article examines the evidence for a link between growth in productivity and the degree of spatial agglomeration across the nations of Europe. In doing so it considers how spatial agglomeration should be measured and how the relationship between agglomeration and the growth of productivity can be modelled.

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1. Introduction

Economic geographers and regional economists have long been concerned with uneven regional development, with why it is that the processes of economic growth do not lead to similar levels of prosperity, employment and welfare across space, and thence with the issue of how far and in what ways policy intervention can help to reduce such inequalities. And with regard to this latter aim, there are some critical issues at stake. Just how far is it possible to reduce regional inequality? How does the reduction of regional inequality influence the workings and performance of the national economy? Our answers to these questions obviously depend on the theories we use and the rationale we invoke for policy intervention.

In practice, of course, many countries have long operated some form of regional policy designed to redress spatial disparities in economic prosperity and welfare. In the UK, for example, regional policies have existed since the 1920s and 1930s, when in the depths of economic depression and intense structural change, radical policy 'experiments' were introduced in an attempt to alleviate and reverse the collapse of many of the country's industrial areas. To take another example, since the European Union came into being, the pursuit of regional policy there has been regarded as an essential tool to help secure economic and social integration among the Member States, a key goal of the Union. While the specific forms taken by regional policies in different countries have evolved over time, partly in response to changes in economic circumstances, and partly to accommodate shifting fads and fashions in academic and political thinking about the nature of 'the regional problem', traditionally the case for regional policies has been made on the basis of two arguments: economic efficiency and social equity.

According to the first of these, persistent regional disparities in economic activity–for example in employment rates and productivity–are nationally inefficient, since the underutilization and underperformance of labour and capital in less prosperous regions mean that national wealth is lower than it could otherwise be if those resources were fully and more productively employed. Policies that raise the utilization and productivity of labour and capital in such regions should raise the economic performance of those regions, and therefore the nation as a whole. At the same time, according to this view, reducing regional disparities also aids national economic management. A highly spatially imbalanced economy can distort both fiscal and monetary policies. For example, macro-economic measures to promote national growth can lead to full-employment bottlenecks and inflationary pressures in the more prosperous and fully employed regions even while significant underutilization of labour and capital still exists in less prosperous regions. In regions of persistent high activity, the rate of inflation at which growth is maximized is likely to be higher than the optimum rate in low-activity regions. And the existence of large differences in regional propensities to inflation can impart potential instability to the national system For example, the central imposition of system wide credit controls or higher rates of interest aimed at stemming price inflation emanating from regions of high activity and high propensity to inflation is likely to be injurious to industry and jobs in regions of low activity and inflation propensity (for example by raising costs, restricting investment and making firms there less competitive in open markets).[1] On the face of it, strong efficiency arguments can be made for policies aimed at reducing regional disparities.

At the same time, a strong case can be made for regional policy on welfare grounds, irrespective of economic efficiency imperatives as such. The underlying motivation here is the belief that individuals should not be seriously and systematically socially disadvantaged with respect to job opportunities, housing conditions, access to public services and the like, simply by virtue of living in one region rather than another. The spatial concentration of socio-economic disadvantage can become self-reinforcing, leading to entrenched problems of poverty, social deprivation and social exclusion, poor health and so on. National welfare and related programmes may not be enough on their own to alleviate these problems, and suitably designed regional policies may be required to improve the place-specific economic conditions and opportunities in such

1 This is precisely what happened in the UK in the 1990s, as high-wage, high-cost economic growth concentrated in London and the surrounding South East region, causing inflationary pressures there. The Bank of England responded by raising the national rate of interest, even though economic activity was much less buoyant in the northern regions of the country. According to the then Governor of the Bank of England, unemployment in the north of the UK was 'a price worth paying' for keeping national inflation low. Not surprisingly, northern businesses questioned why they should be penalized (by high interest rates) for the economic excesses of London and the South East. Interestingly, Magnifico (1973) alluded to this problem of regional differences in the propensity to inflation in his discussion of the conditions for and consequences of European Monetary Union nearly 40 years ago.

areas. A case for regional policies can thus also be made on social welfare, social cohesion and citizenship grounds.

The relative political weight given to these two perspectives in regional policy discourse and practice has sometimes varied. But the two sets of justifications have typically been seen as complementary. Securing higher rates of employment and higher productivity in economically lagging regions not only brings national efficiency gains, but can increase the general standard of living and social welfare in such regions, and thereby achieve greater spatial equality of opportunities and outcomes. This in turn reduces expenditure on unemployment and other social welfare problems, and this means, all other things being equal, that general taxes can be lower. Improving the skills and training of workers in less prosperous regions through spatially targeted measures can help improve their employability, their incomes, their consumer spending power, and thus local demand. In short, regional policies can be justified both on efficiency and equality grounds.

However, recently, arguments have emerged in some quarters that seem to call the rationale for regional policy into question. The contention is that regional imbalance, or the spatial agglomeration or concentration of economic activity and employment in particular regions, may be nationally efficient and actually benefit national growth. The implication is that policies that seek to reduce regional economic inequalities may therefore be nationally inefficient. In other words, a policy choice may exist between the pursuit of national growth and the reduction of regional economic disparities: policy-makers may face a 'trade-off' between maximizing national growth or minimizing regional inequalities, and seeking the latter may jeopardize the former.

This type of thinking appears to be attracting attention and interest among policy-makers (Martin, 2008). For example, ideas along these lines are current within the European Commission and the OECD. Broadly similar arguments also figure prominently in the conceptual framework used to inform the World Bank's *World Development Report, 2009* on and development policy (World Bank, 2009). It can also be detected within certain national regional policy circles. In the UK, for example, this new take on regional policy thinking has been circulating within the Treasury and the Department of Transport. And a not dissimilar outlook seems to be at work in the Netherlands, where recent developments in spatial policy favour strengthening the existing Ranstad agglomeration as against promoting greater regional equality. There are definite signs, therefore, that this trade-off idea has begun to infiltrate official regional policy theory thinking and practice. It has certainly led to a questioning of customary assumptions and approaches.

Where do the ideas informing this new twist in regional policy discourse come from? Arguments concerning the benefits of spatial agglomeration and urbanization for stimulating growth, innovation and productivity can be found in various disciplines, from economic geography, to urban economics to the 'new' economic geography (see, for example, Henderson, 2003, 2005; Baldwin and Martin, 2004; Glaeser, 2008; Florida, 2009). That agglomeration can promote national growth is one of the key implications of 'new' economic geography (NEG) models (Baldwin et al., 2003). Does the empirical evidence support the claims of theory? Our aim in this article is to investigate this question. We begin by setting out how NEG theory links national growth to spatial agglomeration and regional inequality. Our main argument is that even if we accept the NEG account, there are some key issues confronting the empirical testing of the relationship between national growth and spatial agglomeration. *First*, there is the problem of how we measure spatial agglomeration. This is not a trivial matter, both because different indicators are possible, and because data restrictions limit the choice of measure that can be used for the sort of EU-wide analyses we carry out here. *Second*, there is the question of inserting our chosen measure of spatial agglomeration into an appropriate model of national growth. The difficulty here is that the NEG model is not itself a model of national growth but a model of the spatial agglomeration of firms, and how such agglomeration is supposed to raise their productivity. Thus we have to specify a national growth model that can be estimated from the data available. This relates to a *third* problem, namely the limited length of the time series data that can be used for consistent EU-wide empirical work. We divide our study period, 1980–2007, into growth phases and use panel methods in order to minimize data constraints, but such a strategy is not itself unproblematic. We begin by setting out the theory behind the idea of a national growth-regional equity trade-off, particularly as it is articulated by the NEG perspective.

2. Spatial agglomeration and the regional inequality-national growth trade-off: the theory

2.1. The NEG theory of the trade-off

Within economic geography, there has been relatively little interest in 'national efficiency versus spatial equity' type issues (one notable exception is Dall'erba and Hewings, 2003). But in economics there has long been debate around the idea of an 'efficiency-equity' trade-off (Kuznets, 1955; Williamson, 1965; Okun, 1975). It is perhaps not surprising, therefore, that this issue should surface in recent work in the 'new economic geography' (NEG). One of the criticisms of the first generation of NEG models was that they contained little discussion or analysis of the role or impact of policy (Martin, 1999; Neary, 2001). The main focus was on developing a formal abstract model of spatial agglomeration (Fujita et al., 1999). However, following the contributions by P. Martin (1999); Puga (1999); Baldwin et al. (2003); Brakman et al. (2009) and others, the policy implications of NEG models have been attracting growing interest, and as part of this development the idea of a trade-off between national growth and regional economic equality has figured explicitly. According to NEG models, the spatial structure of the economy is the outcome of two sets of opposing forces. On the one hand, NEG models predict that under conditions of imperfect competition, increasing returns to scale, and factor mobility, there are strong (centripetal) forces making for the spatial concentration (agglomeration) of economic activity. On the other, various centrifugal processes, namely high transport costs, restricted factor mobility, market crowding and local congestion effects are assumed to encourage the geographical dispersal of firms and workers. When transport costs and inter-regional transaction costs are high, distant provision of goods (and even some services) is too costly so that they need to be provided locally, and firms will disperse spatially to be near immobile markets. When transport and inter-regional transaction costs are low, immobile markets can be provided (served) effectively (cheaply) at a distance, so allowing firms to agglomerate spatially to gain from the various economies of scale and externalities that such agglomeration confers. In these models, agglomeration forces

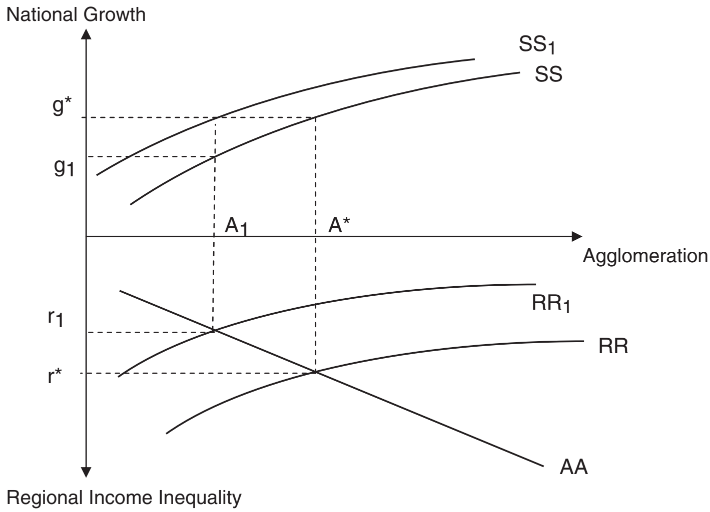

Figure 1. Agglomeration, growth and regional inequality. (After P. Martin, 1999; Baldwin et al., 2003; Lackenbauer and Meyer, 2006).

tend to dominate over spatial dispersal forces. When agglomeration increases, regional inequality increases, which in turn fuels further agglomeration since firms will want to locate where demand and income are highest, and where the scope for inter-firm linkages is high; and workers will be attracted by the increased job opportunities there (the so-called 'home market effect'). There is thus a positive causal relationship between agglomeration and regional inequality (curve AA in Figure 1).

Further, spatial agglomeration is assumed to raise national economic growth. Following endogenous growth arguments, when localized positive spillovers exist, the spatial concentration of economic activities has a beneficial effect on innovation (by lowering its cost). Increased innovation raises average productivity in the agglomeration, and hence the growth of real output there. Thus the model posits a positive relationship between the degree of spatial agglomeration (regional concentration of activity) in the national economy and the national rate of economic growth–sometimes referred to as the 'local spillovers effect' (curve SS in Figure 1). At the same time, however, the theory posits that high rate of innovation leads to more market entries by new firms, which compete with incumbent firms thereby lowering profit rates (the so-called 'competition effect)'. As monopolistic firms are more numerous in the rich agglomeration region than in poorer region, the decline of their profits leads to a reduction of regional income disparities. Also the attraction of firms into the rich, agglomeration region gives rise, after some point, to various congestion effects and related negative externalities which reduce regional income inequalities (curve RR in Figure 1).

As in all NEG models, the focus is on the derivation of an equilibrium outcome. In this case it is given by the intersection of the agglomeration-regional inequality relationship (AA) and the agglomeration-competition and congestion relationship (RR). This gives an equilibrium degree of agglomeration (A^*), regional inequality (r^*)

and national growth (g^*). The next step follows on automatically. If policy-makers seek to reduce regional inequality via interventions that actively relocate and disperse economic activity away from the spatial agglomeration(s), or through redistributive monetary and fiscal measures, the RR curve is shifted inwards to RR_1, and as a consequence spatial agglomeration is reduced to A_1, and regional inequality falls to r_1. This is due to the transfer of purchasing power to the poorer regions, which increases market demand there and attracts firms into those regions. However, according to the model, the decrease in spatial agglomeration is less conducive to spillovers and innovation, so that overall national growth falls to g_1. Hence a 'trade-off' is predicted to exist between regional equality and national growth.

Because of the way NEG models are formulated, they also imply a similar trade-off may exist *within* regions: spatial agglomeration of activity within a region raises that region's growth rate. Indeed, the whole argument rests on the assumption that agglomerated regions–those in which a nation's economic activity is particularly concentrated–will grow faster than other regions. A key implication is that policies to stem spatial agglomeration, or that seek to reduce it, in an effort to close inter-regional (or intra-regional) economic disparities, may be economically inefficient from a national growth point of view. For example, discussing the implications of this model in a European context, P. Martin (2005) argues that 'spatial agglomeration of economic activities may [. . .] have positive efficiency effects and may be a welcome consequence of trade integration' (pp. 99–100), implying a trade-off between efficiency and equity. He goes on to suggest that 'there is no real need for European regional policy to deal with intra-national regional inequalities' (p. 107). And, likewise, as a recent UK Treasury paper puts it:

> a positive relationship exists between regional disparities and national growth, forming a policy trade-off between economic efficiency and a regionally equitable spread of economic activity . . . *Theory and empirical evidence suggests that allowing regional concentration of economic activity will increase growth.* As long as economies of scale, knowledge spillovers and a local pool of skilled labour result in productivity gains that outweigh congestion costs, the economy will benefit from agglomeration, in efficiency and growth terms at least (Lees, 2007, p. 24; Emphasis added).

The main exception according to these models relates to policies that raise the innovation rate in poorer regions (Baldwin et al., 2003; Lackenbauer and Meyer, 2006). The main effect of such a policy is to shift the SS curve upwards to SS_1 in Figure 1. According to Baldwin et al. (2003) 'making knowledge spillovers more global is both pro-growth and pro-dispersion', since the lagging regions benefit more from spillovers and innovation, which increases their growth without reducing that of the richer regions, so that national growth is also raised (to g^* in Figure 1). The effect is to reduce the overall degree of spatial agglomeration and regional inequality while increasing national growth, thereby avoiding the equality-efficiency trade-off. Several possible policy approaches are typically mentioned in this context, including policies that improve technology transfers and spillovers from the rich region to the poorer regions (through improved telecommunication and IT infrastructures, for example). As Baldwin et al. (2003, 433) put it, '[o]ne could think of this type of policy as one that facilitates trade in ideas rather than trade in goods'. Lackenbauer and Meyer (2006) also contend that any policy able to reduce the cost of innovation (such as an R&D

subsidy) may have the same result of raising national growth and reducing regional inequality simultaneously.

2.2. Ambiguous empirical support

The empirical evidence seems to provide some support for a national growth-regional equality trade-off, but it is by no means unequivocal. P. Martin (2005), for example, produces some evidence in favour of agglomeration effects by plotting disparities in GDP per capita at EU Member State level against the level of GDP per capita, and again with both indicators in growth rate form. In both cases Martin finds evidence of a positive association, leading to claims that a trade-off seems apparent which policy makers should take account of when making growth/inequality decisions. The study by Crozet and Koening (2007) for EU regions over 1980–2000 found some evidence for the growth promoting effects of agglomeration, with regions with a more uneven internal spatial distribution of production appearing to grow faster. In contrast, Bosker's (2007) study of 208 regions across the EU for the period 1977–2002 found that agglomerated regions–i.e. those with dense concentrations of economic activity–grew more slowly than other regions, indicating a negative agglomeration effect. The implications of these studies for the national growth-regional equality relationship are thus ambiguous. In their study of the national growth-regional inequality (spatial agglomeration) relationship across a large number of OECD and other countries, Brülhart and Sbergami (2009) find that agglomeration boosts national GDP growth, but only up to a certain level of development (approximately a per capita GDP of $10,000): at levels of development above this critical level, the trade-off between national growth and regional equality seems to lose its relevance. And other studies also question the benefits of agglomeration because of the congestion costs, commuting costs, and other negative externalities that may arise (see, for example, Glaeser and Kahn, 2004; Accetturo, 2010). The implication here is that for advanced economies, like most of those across Europe, spatial agglomeration may not boost national growth.

What emerges from the literature on the equity versus efficiency trade-off issue is that the relationship between inequality and growth is complex, the predictions of theoretical models of that relationship are highly dependent on the type of model and assumptions used, the level, stage and cyclical position of economic development, and the empirics vary and are often difficult to interpret. All this should perhaps encourage caution when trade-off type notions appear in discussions of spatial agglomeration, regional inequality and national growth (Martin, 2008). Certainly there would seem room for further empirical work, which is the focus of the rest of this article. Given that the impact of agglomeration on national growth is assumed to work primarily through effects that eventually manifest themselves in enhanced productivity, in what follows we concentrate our attention on the growth of this variable.

3. Measuring spatial agglomeration

3.1. The problem of defining a measure

A second issue in assessing the empirical grounds for the impact of spatial agglomeration on national growth concerns the measurement of agglomeration itself.

As Rosentahal and Strange (2001, 2004) comment, ideally agglomerations should be defined on the basis of the location of individual firms and the externalities and economies that proximity is supposed to provide. They remark:

> It is fair to say that relatively little of the empirical work on the scope of agglomeration economies has addressed the issue of establishment uniqueness and continuity. Instead, with regard to geography, most studies have grouped industries and plants into politically defined regions such as Metropolitan Statistical Areas (MSAs) . . . Activity in neighbouring regions is then typically assumed, usually implicitly, to have no effect on the region in question, and all activity within the specified region is treated as being situated at exactly the same spot (Rosenthal and Strange, 2004).

In previous work Rosenthal and Strange (2001), Duranton and Overman (2002) and Henderson (2003) all find that geographic localization effects decay quite steeply with distance, typically within <50 km. In yet other work, Rosenthal and Strange (2003), using the Ellison and Glaeser (1997) index of agglomeration calculated at the zip code, county and state levels of geography, find US evidence that the geographic scale of agglomeration varies according to the type of agglomeration force being investigated. Thus the identification of agglomeration defined in terms of knowledge spillovers might be expected to yield a different spatial scale and degree of agglomeration than other alleged agglomeration processes or externalities.

Another problem relates to the spatial units employed in attempts to measure empirically the extent of agglomeration. As Guillain and Le Gallo (2006) point out, most approaches to measure and map economic agglomeration ‘share a common weakness: they are a-spatial in the sense that geographic units are considered spatially independent of each other. The spatial units are treated identically, even if they are neighbours or distant, so that spatial agglomeration can be mis-estimated’ (p. 4). They advocate an approach that incorporates concepts of economic potential and contiguity into the measurement of spatial agglomeration. Although there has been much research in recent years that has sought to provide measures of economic potential across Europe (see for example the survey by Combes and Overman, 2004), and potential accessibility maps for the European Union are provided in research undertaken for ESPON (2004), how to convert local and regional economic potentials into an overall index of agglomeration remains an unresolved issue.

In fact, the spatial units for which economic data are collected in most countries are often more a reflection of administrative convenience rather than any judgement on the economic boundaries that are relevant to the operation of localization effects. To produce better measures of agglomeration some studies have sought to use establishment based data to construct meaningful spatial units by adding companies together across ‘continuous space’ (Duranton and Overman, 2002). However, the data requirements of such an approach are very demanding (Head and Mayer, 2004). As Guillain and Gallo point out, ‘despite the significant interest in the benefits that arise from economic agglomeration the identification of the spatial limits of agglomeration remains problematic’ (p. 3). As they emphasis, ‘the use of the term ‘agglomeration’ in a general sense can be justified since the forces at work in the agglomeration process depend on the spatial scale considered–so that the type of agglomeration to which the authors refer has to be specified depending on the type of analysis’ (p. 3). However, as they go on to argue, there is still 'no agreement in the empirical literature as to the geographical limits of the forces at work' (op cit, p. 3).

Notwithstanding these and other problems, researchers have adopted a number of different approaches to measuring spatial agglomeration. But, as Bickenbach and Bode (2008, p. 360) have argued: 'choosing between the different measures actually implies choosing between different definitions of concentration or specialization rather than just choosing between different ways of measuring a single, uniform theoretical construct of concentration or specialization'. They suggest that this problem is compounded by the widely differing sectoral and spatial scales adopted in empirical studies. The scale selected influences the values of the statistical measures and how they can be understood. They argue that measures of agglomeration should be defined according to three characteristics, namely; the *weighting system* which defines the units adopted in the analysis; the *reference or benchmark,* which in the case of spatial agglomeration is defined to reflect a spatial system with no agglomeration and thus even proportional distribution of the measured variable across space; and what they call the *projection function,* which specifies the range of values possible under the measure (i.e. the meaning assigned to positive/negative values and the distance from the benchmark).

3.2. Comparing alternative measures

With these considerations in mind, we calculated and compared a number of different measures of agglomeration as candidates for inclusion in our modelling of the relationship between spatial agglomeration and national growth across Europe. Two of these were the familiar coefficient of variation and the Theil index. A third measure was the Herfindahl index (H), another well-known measure of concentration. This index sums the square of the share of production (however measured) in each region in the country. If there are n regions the value of the index ranges from $1/n$ (no concentration with all regions having the same volume of production) through to 1 (all production is contained in only one region). However, it is likely that regions in a nation will differ in geographical area and Ellison and Glaeser (1997) have redefined the Herfindahl index to allow for this. The EG Index thus provided our third measure.

However, as has been pointed out (OECD, 2003) a significant limitation of the EG index is that it is sensitive to the level of aggregation of the regional data and since this varies between countries this complicates its use in international comparisons. The EG index has been adjusted further in seeking to reduce the severity of this problem by deriving an index of geographic concentration (GC) which has its maximum value when all production is concentrated in the smallest region in terms of area (Spiezia, 2002). The GC was our fourth measure. The GC measure has then been refined to produce an adjusted geographic index (AGC), which is felt to offer a better index for international comparison of geographic concentration where the size of regions differs systematically between countries (see Box 1 for its derivation). This index takes a range of zero (no concentration) to one (maximum concentration). The AGC represented our fifth measure.

These five measures were complemented by three further measures that sought to incorporate a measure of economic potential, in line with the argument put forward by

Box 1. The adjusted geographic concentration index (AGC). *Source*: OECD (2003)

The Herfindahl index (H) is defined as:

$$H = \sum_{i=1}^{N} y_i^2,$$

where y_i is the employment share of region i and N stands for the number of regions. The index lies between $1/N$ (all regions have the same employment share, i.e. there is no concentration) and 1 (all employment is concentrated in one region, i.e. maximum concentration). In general, however, regions have different areas so that a correct measure of geographic concentration has to compare the employment share of each region with its share in the national territory. An index that takes into account regional differences is the one proposed by Ellison and Glaeser (1997):

$$\mathrm{EG} = \sum_{i=1}^{N} (y_i - a)^2,$$

where a_i is the area of region i as a percentage of the country area. If the employment share of each region equals its relative area, then there is no concentration and EG equals zero. Therefore, the bigger the value of EG, the higher geographic concentration.

A major drawback of the EG index is that it is not suitable for international comparisons because it is very sensitive to the level of aggregation of regional data. This feature is due to the fact that the differences between the employment share and relative area of each region are squared. To correct for this bias due to aggregation, the EG index can be reformulated into the following index of geographic concentration (GC) (Spiezia, 2002):

$$\mathrm{GC} = \sum_{i=1}^{N} \left| y_i - a_i \right|,$$

where | | indicates the absolute value. Going back to our two examples, it is clear that in both cases the aggregation bias would be smaller for the GC index than for the EG index. International comparability of the GC index can be increased further by noticing that the index reaches its maximum when all employment is concentrated in the region with the smallest area. The maximum value of the GC index is the equal to:

$$\mathrm{GC}^{\mathrm{MAX}} = \sum_{i \neq \min} a_i + 1 - a_{\min} = 1 + 1 - 2a_{\min} = 2(1 - a_{\min}),$$

where $a_{\min}$ is the relative area of the smallest region.

The GC index, therefore, is not internationally comparable if the size of regions differs systematically between countries. This would be the case, for instance, if one compared a country in which regions are classified at the territorial level 2 with a country where regional data are available at the territorial level 3.

A natural correction for this second aggregation bias is provided by the adjusted geographic concentration index (AGC), defined as

$$\mathrm{AGC} = \mathrm{GC}/\mathrm{GC}^{\mathrm{MAX}}.$$

Guillain and Le Gallo (2006) concerning the need to take the spatial relationship between regions into account. Economic potential is a measure of the potential market size and can be calculated in a number of ways at national level, as outlined in Box 2 below.

Box 2. Measures of economic potential

Method 1: Averaging over NUTS2 regions (ECPOT 1)

The economic potential for a given region, *i*, is calculated by dividing the overall GDP in a typical region, *j*, by a function of the distance between regions *i* and *j* and then summing across all *n* regions to obtain the overall (external) economic potential of region *i*. The internal economic potential of region *i* is added to the external economic potential to obtain the total economic potential of region *i*. This requires a measure of distance from region *i* to 'itself', in the same way that external economic potential requires the distance between regions *i* and *j*. The problem of calculating the internal distance for region *i* (to obtain the internal potential) was solved by the method of Stewart (1947), which has been adopted by many researchers (Keeble et al., 1981). This takes the internal economic potential at the centre of a uniform circular disc to be equal to the GVA of the disc divided by half the radius. The internal distance is therefore a fraction of the radius of a circle of the same area as the NUTS-2 region.

$$\mathrm{EP}_{1i} = \sum_{j=1}^{n} \frac{\mathrm{GDP}_j}{d_{ij}}.$$

To derive a national measure of economic potential then becomes a relatively straightforward task, i.e. simply sum the regional economic potential within a country and divide by its number of regions. Such a measure provides an adequate measure of national economic potential, but does not focus very well on the influence of major agglomerations within each Member State. For this reason two additional measures were calculated.

Method 2: Using capital cities (ECPOT 2)

This calculates economic potential using the capital city (defined at NUTS2 level or above) of each country as the focal point for measuring activity (GDP), again deflated by the distance from all other capital cities. However, such a measure clearly introduces a discontinuity for Germany, which changed its capital city in 1991.

Method 3: Using the largest agglomerations (ECPOT 3)

As an alternative to the capital city region measure, the largest agglomeration in each country, identified on the basis of employment density in 1980 (the start of the sample) was selected as the national location from which activity (GDP) was used distance measures were calculated. Clearly such a measure is likely to be highly correlated with the capital city measure, as in many countries the regional selection will be the same, but there are some differences as discussed below.

We used area weights[2] (proportion of the relevant total national land area) to calculate all of the agglomeration and potential measures referred to above, to allow for variation in the size of the spatial units used in the analysis, and in each case the measures were calculated using total regional employment and at three geographical scales, namely NUTS 1–3. Given the time span under consideration, the analysis is confined to the EU-15 Member States.

The results using the various agglomeration measures are shown in Table 1. In relation to the coefficient of variation and the Theil, some countries have seen little variation through time. When the exercise is repeated at the NUTS 3 level it produces little alteration to the basic pattern observed using NUTS 2 regions. Table 1 also shows the Ellison and Glaeser (EG) index for the EU-15 countries at different NUTS levels. The general picture is one of not much change over time whatever the spatial scale adopted. Greece and Finland tend to show more variation with a tendency to increasing concentration over the study period. Table 1 shows the geographic concentration index (GC) for the Member States at different NUTS levels. Again, the greater its value, the greater the extent of geographic concentration in the member state. It shows a fairly stable pattern of results over time. Greece and Finland again show a tendency to increased concentration. Finally, Table 1 also presents the adjusted geographic concentration index (AGC), which, following the argument presented in Box 1, would seem to be the preferred measure. The results are broadly consistent with the previous measures.

The evidence suggests that whatever measure is adopted, the degree of concentration, and thus for our present purposes agglomeration, remains fairly stable over time for all NUTS spatial levels, although the size of the index usually increases the smaller the geographical scale (NUTS). This is to be expected. The Coefficient of Variation and Theil indices tend to show more variation over time than the EG, GC and AGC indices. The results from the AGC would seem to be the more reliable given the limitations of the others. This index tends to emphasis relative stability with most Member States experiencing little change, only Greece, Finland and to a lesser extent Spain exhibiting a trend towards slightly increased levels of regional agglomeration. This broad stability over time suggests that agglomeration is unlikely to explain cyclical growth pattern particularly well, but could be better-suited to explaining long-run effects, i.e. why a particular national long-term average growth rate is higher/lower than it would otherwise have been.

Table 2 shows the sets of regions selected by using the second and third economic potential methods (ECPOT2 and ECPOT 3). The three differences between the two measures are for the Netherlands (Zuid-Holland rather than Nord-Holland), Germany (Hamburg rather than Koln pre-1981 Berlin 1991-) and Italy (Lombardia rather than Lazio). Using 1980 data as the base, the rankings for the largest agglomeration and

2 Area weights are just one set of weights that can be used. An alternative is population or employment weights. For an example of the use of population weights see Petrakos et al. (2005). In the present study we chose area weights for three reasons. First, population is closely related to employment and so weighting employment density by population risks a kind of double-counting, whereas area is not related to employment at all. Second, the area weights do not change over time, whereas population weights will. In this way, the use of area weights keeps the focus of the measure on how employment density changes which is one of the key concerns of the research presented in this paper. Third, the AGC measure is defined using area weights and we have chosen to be consistent with this for the other agglomeration statistics.

Table 1. Agglomeration across EU-15 countries

Member state	Start year (1980)			End year (2007)		
	NUTS1	NUTS2	NUTS3	NUTS1	NUTS2	NUTS3
Coefficient of variation						
Belgium	0.43	0.57	1.38	0.54	0.51	1.21
Denmark	NA	0.45	0.59	NA	0.43	0.58
Germany	0.81	0.56	1.02	0.82	0.57	1.13
Greece	0.37	0.99	2.16	0.42	1.24	2.80
Spain	0.48	0.92	1.20	0.56	1.02	1.44
France	0.39	0.94	1.02	0.38	0.96	0.91
Ireland	NA	0.46	0.53	NA	0.51	0.61
Italy	0.35	0.91	1.14	0.34	0.92	1.27
Luxembg	NA	NA	NA	NA	NA	NA
Netherlands	0.59	0.71	0.84	0.55	0.68	0.86
Austria	0.27	0.61	1.35	0.29	0.60	1.36
Portugal	0.00	0.60	1.21	0.00	0.62	1.26
Finland	0.99	0.81	0.93	0.99	0.91	1.27
Sweden	0.29	0.47	1.12	0.34	0.54	1.20
UK	0.45	0.62	0.97	0.42	0.57	0.93
Theil statistic						
Belgium	0.09	0.18	0.56	0.14	0.14	0.49
Denmark	NA	0.10	0.16	NA	0.09	0.17
Germany	0.32	0.14	0.31	0.34	0.15	0.35
Greece	0.08	0.36	0.85	0.10	0.50	1.13
Spain	0.12	0.40	0.43	0.15	0.46	0.56
France	0.07	0.29	0.32	0.07	0.32	0.31
Ireland	NA	0.11	0.12	NA	0.14	0.15
Italy	0.07	0.38	0.38	0.06	0.38	0.43
Luxembourg	NA	NA	NA	NA	NA	NA
Netherlands	0.16	0.24	0.29	0.15	0.23	0.31
Austria	0.04	0.19	0.46	0.05	0.18	0.49
Portugal	NA	0.21	0.43	NA	0.23	0.48
Finland	0.66	0.36	0.30	0.65	0.41	0.46
Sweden	0.05	0.12	0.42	0.07	0.15	0.47
UK	0.10	0.17	0.33	0.09	0.15	0.32
EG statistic						
Belgium	0.11	0.06	0.05	0.12	0.06	0.04
Denmark	0.00	0.11	–	0.00	0.09	–
Germany	–	–	–	0.03	0.02	0.00
Greece	0.11	0.09	0.08	0.18	0.14	0.14
Spain	0.12	0.06	0.04	0.16	0.08	0.05
France	0.05	0.05	0.01	0.05	0.05	0.01
Ireland	0.00	0.08	0.11	0.00	0.10	0.12
Italy	0.02	0.02	0.01	0.02	0.02	0.02
Luxembourg	0.00	0.00	0.00	0.00	0.00	0.00
Netherlands	0.09	0.04	0.03	0.07	0.03	0.03
Austria	0.03	0.07	0.07	0.03	0.07	0.07
Portugal	0.00	0.14	0.08	0.00	0.14	0.09
Finland	0.00	0.24	0.14	0.00	0.28	0.19
Sweden	0.40	0.20	0.14	0.44	0.22	0.15
UK	0.09	0.05	0.02	0.09	0.05	0.02

(continued)

Table 1. Continued

Member state	Start year (1980)			End year (2007)		
	NUTS1	NUTS2	NUTS3	NUTS1	NUTS2	NUTS3
GC statistic						
Belgium	0.53	0.56	0.78	0.57	0.58	0.72
Denmark	0	0.58	–	0	0.54	–
Germany	–	–	–	0.51	0.58	0.83
Greece	0.55	0.61	0.78	0.70	0.76	0.91
Spain	0.67	0.77	0.82	0.73	0.83	0.91
France	0.39	0.50	0.63	0.39	0.53	0.67
Ireland	0.00	0.41	0.58	0.00	0.46	0.64
Italy	0.25	0.46	0.64	0.27	0.46	0.63
Luxembourg	0.0	0.0	0.0	0.0	0.0	0.0
Netherlands	0.49	0.52	0.76	0.45	0.50	0.71
Austria	0.30	0.54	0.80	0.29	0.54	0.85
Portugal	0.03	0.71	0.98	0.03	0.69	1.03
Finland	0.00	0.84	0.92	0.00	0.90	1.00
Sweden	1.03	1.03	1.03	1.08	1.08	1.08
UK	0.67	0.85	1.08	0.64	0.81	1.00
AGC statistic						
Belgium	0.27	0.28	0.39	0.29	0.29	0.36
Denmark	–	0.31	–	–	0.29	–
Germany	–	–	–	0.26	0.29	0.41
Greece	0.29	0.31	0.39	0.36	0.38	0.46
Spain	0.34	0.39	0.41	0.37	0.42	0.45
France	0.20	0.25	0.31	0.20	0.27	0.33
Ireland	–	0.39	0.30	–	0.43	0.32
Italy	0.15	0.23	0.32	0.16	0.23	0.32
Luxembourg	–	–	0.50	–	–	0.50
Netherlands	0.31	0.27	0.38	0.28	0.26	0.36
Austria	0.21	0.27	0.40	0.20	0.27	0.43
Portugal	0.02	0.36	0.49	0.02	0.35	0.52
Finland	0.00	0.42	0.46	0.00	0.45	0.50
Sweden	0.57	0.52	0.52	0.60	0.55	0.54
UK	0.34	0.42	0.54	0.32	0.41	0.50

capital city measures turn out to be identical. However, some differences emerge against the average regional measure (ECPOT 1), as shown in Table 3 (the table ranks from highest economic potential to lowest). Clearly there are some similarities, as one might expect, with the more peripheral economies of Europe with low values in what remains a distance-based measure for all three indicators. The most noticeable effect is for Austria, which drops down to mid-ranking when measured on the agglomeration and capital city basis.

Our investigation of possible suitable agglomeration measures suggested that it was best to proceed with the CV, Theil and AGC based indices and the three different economic potential indices. With these six indices in place we assessed the correlation that existed for each of the 14 Member States and for the specific periods (1980, 1984, 1991, 1994 and 2002) that we wished to use in the formal modelling work presented in the next section. Table 4 presents the results. As would be expected, there is a fair degree

Table 2. Regional selection for measures of economic potential

Country	Capital city region code/description (ECPOT 2)	Largest agglomeration region code/ description (ECPOT3)
Belgium	Région de Bruxelles-Capitale/Brussels Hoofdstedelijk Gewest	Région de Bruxelles-Capitale/Brussels Hoofdstedelijk Gewest
Denmark	Hovedstaden	Hovedstaden
Germany	Köln pre-1991 Berlin 1991 onwards	Hamburg
Greece	Attiki	Attiki
Spain	Comunidad de Madrid	Comunidad de Madrid
France	Île de France	Île de France
Ireland	Southern and Eastern	Southern and Eastern
Italy	Lazio	Lombardia
Netherlands	Noord-Holland	Zuid-Holland
Austria	Wien	Wien
Portugal	Lisboa	Lisboa
Finland	Etelä-Suomi	Etelä-Suomi
Sweden	Stockholm	Stockholm
UK	Inner London	Inner London

Table 3. Country ranking for measures of economic potential

Average region (ECPOT 1)	Capital city (ECPOT 2)	Largest agglomeration (ECPOT 3)
Belgium	NL	NL
UK	BE	BE
Austria	UK	UK
Denmark	DE	DE
The Netherlands	DK	DK
Denmark	IT	IT
France	FR	FR
Italy	AT	AT
Spain	GR	GR
Sweden	PT	PT
Greece	ES	ES
Portugal	IE	IE
Ireland	SE	SE
Finland	FI	FI

of correlation among the various agglomeration measures, particularly between the CV and Theil statistics, and among these statistics at the same spatial level. This indicates that, for the same spatial level, there is possibly little to choose between the Theil and CV measures, and that the main choice to be made is the appropriate level of spatial detail entering into the calculation. Concerning the AGC statistic, there is actually a negative correlation with both the Theil and CV at the NUTS1 and NUTS2 levels, and only a weak positive association at the NUTS3 level. Due to its superior properties when investigating international comparisons of regional concentration, it was decided to use the AGC statistic at the expense of the CV and Theil alternatives. The correlation

Table 4. Correlation matrix of agglomeration measures

Correlation Probability	CV_N1	CV_N2	CV_N3	THIEL_N1	THIEL_N2	THIEL_N3	AGC_N1	AGC_N2	AGC_N3	ECPOT1	ECPOT2	ECPOT3
CV_N1	1.000											
	–											
CV_N2	0.165	1.000										
	0.213	–										
CV_N3	−0.172	0.512	1.000									
	0.195	0.00	–									
THIEL_N1	0.903	0.143	−0.152	1.000								
	0.000	0.283	0.253	–								
THIEL_N2	0.221	0.949	0.465	0.261	1.000							
	0.094	0.000	0.000	0.047	–							
THIEL_N3	−0.209	0.454	0.987	−0.192	0.415	1.000						
	0.114	0.000	0.000	0.148	0.001	–						
AGC_N1	−0.103	−0.209	0.096	−0.382	−0.304	0.152	1.000					
	0.437	0.114	0.472	0.003	0.020	0.253	–					
AGC_N2	0.120	−0.174	0.049	0.240	−0.088	0.101	0.419	1.000				
	0.367	0.189	0.713	0.069	0.510	0.448	0.001	–				
AGC_N3	−0.073	−0.403	0.017	0.143	−0.304	0.061	0.144	0.840	1.000			
	0.583	0.001	0.898	0.282	0.020	0.646	0.277	0.000	–			
ECPOT1	0.065	−0.472	−0.106	−0.138	−0.533	−0.048	0.179	−0.238	−0.099	1.000		
	0.624	0.000	0.424	0.298	0.000	0.716	0.177	0.071	0.458	–		
ECPOT2	0.173	−0.371	−0.360	−0.072	−0.418	−0.304	0.122	−0.449	−0.367	0.764	1.000	
	0.192	0.004	0.005	0.586	0.001	0.019	0.361	0.000	0.004	0.000	–	
ECPOT3	0.202	−0.399	−0.350	−0.036	−0.454	−0.288	0.155	−0.363	−0.282	0.765	0.979	1.000
	0.127	0.001	0.007	0.784	0.000	0.028	0.242	0.005	0.031	0.000	0.000	–

Covariance analysis: ordinary; Sample: 15; Included observations: 58.

between the three economic potential measures shows some interesting results. Unsurprisingly, a high correlation of 0.963 exists between the capital city (ECPOT 2) and largest agglomeration (ECPOT 3) measures, while a similar degree of association (between 0.7 and 0.8) exists between the average economy measure and the other two. Based on these findings, and the issue of dealing with the discontinuity for Germany with the capital city-based measure, it was decided to pursue the average regional and the largest agglomeration measures of economic potential (ECPOT 1 and ECPOT 3) in the modelling exercise described in the next section.

4. Evidence on the relationship between national productivity growth and spatial agglomeration

4.1. Specifying a model

As a prelude to empirically assessing the impact of agglomeration on national growth across the EU, we examine whether regions with a high density of economic activity (i.e. where a high proportion of national economic activity is concentrated) have been associated with, other things being equal, higher growth rates of productivity, than regions which contain less activity (i.e. with low densities). Figure 2 shows the relationship between regional employment density and regional productivity growth, for various NUTS levels for the EU-15 Member states. We confine our attention to the

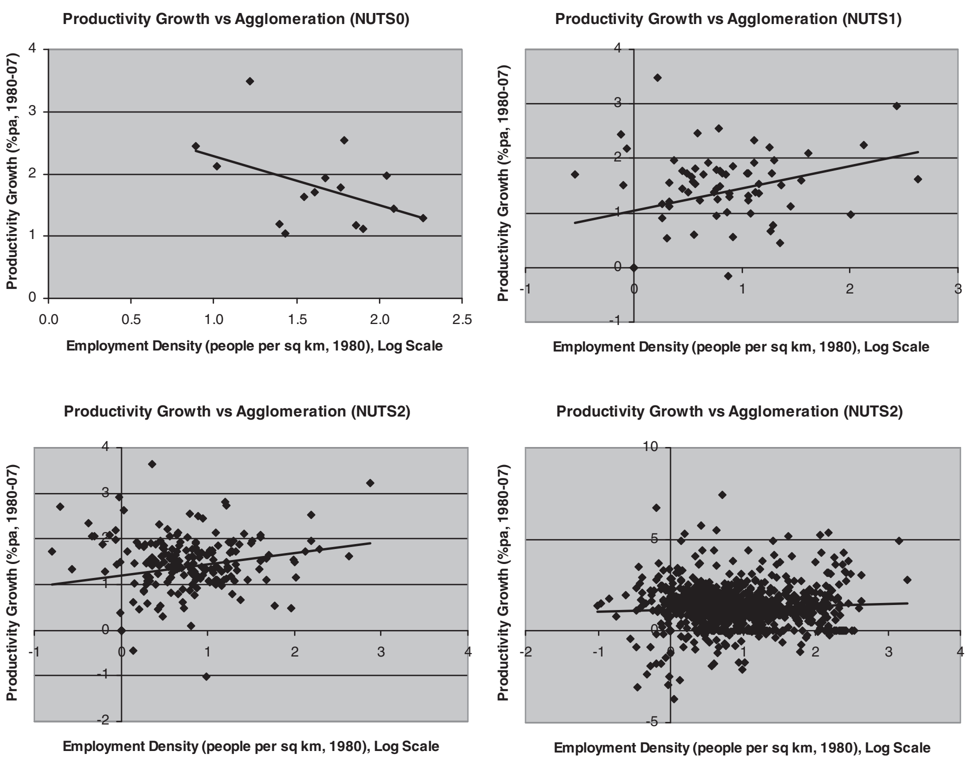

Figure 2. Regional employment density and productivity growth.

EU-15, first because the most consistent data for the period 1980–2007 relate to this group, and because since the early 1990s the New Member States have been on a somewhat different development path relative to what they had experienced before that. There appears to be no consistent positive relationship of the sort assumed or implied by the NEG model linking national growth and spatial agglomeration (such models imply that regions with high employment densities should exhibit faster growth rates). For Member States (NUTS0) the relationship is negative, for NUTS1 and NUTS2 regions it is positive, but for NUTS3 regions it is virtually flat. Similarly, plotting the relationship between national growth and the degree of spatial agglomeration of economic activity–using our AGC measure–also yields ambiguous results (Figure 3): the relationship is negative when spatial agglomeration is measured at the NUT1 regional level, moderately positive when spatial agglomeration is measured at the NUTS2 scale, but only very weakly so when measured at the NUTS3 level. Clearly, there are mixed messages coming from such simple bivariate analyses, and sizeable heterogeneity around the linear association and so a proper analysis must develop a model to investigate the conditional relationship, i.e. when other growth-influencing factors are taken into account. It is to this that we now turn.

There are of course several different perspectives on what are the determinants of national (and indeed, regional) growth, and various attempts to evaluate the relative importance those determinants, including the use of Bayesian model averaging

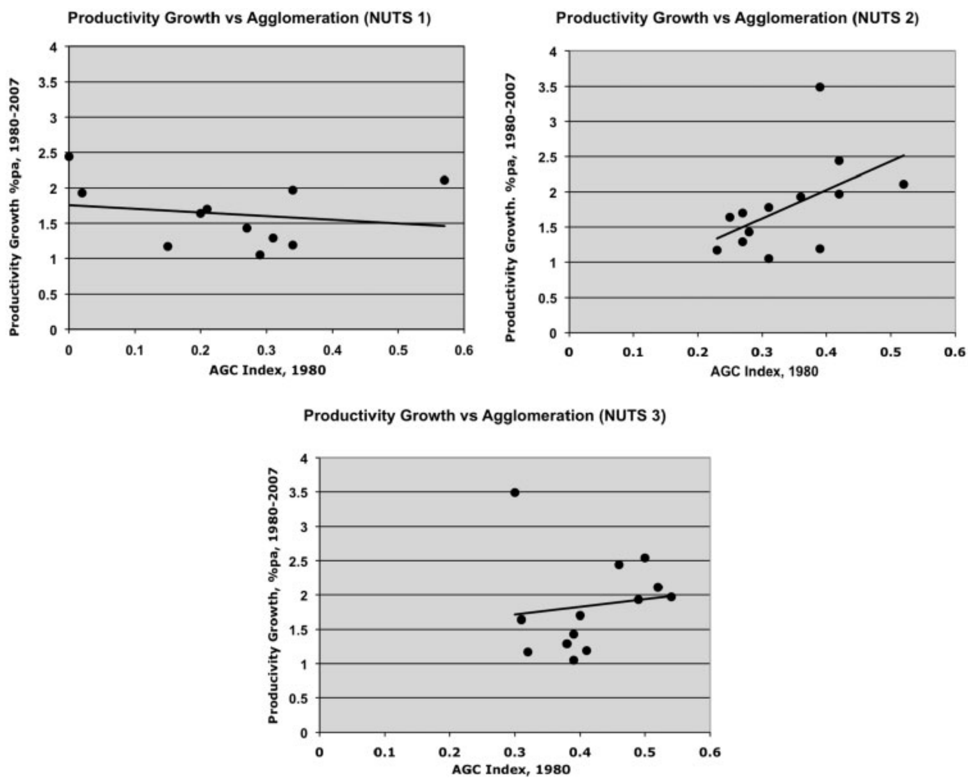

Figure 3. Agglomeration and productivity growth.

(Sala-i-Martin et al., 2004; www.euregionalgrowth.eu/). The basic model specification for our work has the form:

$$g_{ip} = \alpha y_{i0} + \beta A_{i0} + \gamma X_{ip} + \mu_i$$

where g is the growth rate of the dependent variable capturing economic performance, defined for country (i) and period (p); y is the levels-equivalent of the dependent variable at the starting year of the period; A is an agglomeration measure, or group of measures, which may interact with other control variables; X comprises a set of initial conditioning/control variables which are also expected to influence the growth process; and μ is an error term with standard properties. In a recent study that explored the relationship between spatial agglomeration and national growth for a cross section of OECD nations, Bruhart and Sbergami (2009) suggested a number of possible candidates for the explanatory X variables. These are shown in Table 5 along with their definition and expected sign and reason for inclusion.

Given that we only have 14 Member States, and 27 observations through time on national productivity growth (1981–2007), as mentioned above these short data series afford very few degrees of freedom from an econometric point of view.[3] We therefore divided the study period into sub periods of cyclical 'up-swing' and 'down-swing' in productivity growth at the aggregate EU level (see Figure 4 below). This gave five observations per member state, or a maximum of 70 observations on national productivity growth across our 14 Member states in all.[4] Dividing the study period in this way also allows for any differing agglomeration impacts through time. The AGC indices were calculated for different spatial scales (NUTS1, 2 and 3) using the methodology as outlined in Section 4. The area-weighted measures still suffer from an inability to distinguish different specific geographies of agglomeration, although the different spatial aggregations do go some way to resolving the issue. Other than these factors, the basic specification has deliberately sought to include other relevant causal variables, and the estimation methodology used dynamic panel procedures.

It has become customary in growth models estimated across countries and across regions to include the initial levels of GDP per capita or GVA per capita, to allow for 'catch-up' (convergence) effects on the part of those countries or regions with low starting levels of productivity.

4.2. Empirical findings for Europe

A fixed-effect panel OLS regression without any agglomeration effects was initially estimated to provide a benchmark against which to judge the effects of including the agglomeration measures, with the results shown in Table 6.[5] The negative sign on the initial productivity level implies some slow convergence, which is probably all that can be expected among the more developed western European Member States. The main

3 Luxembourg is excluded as it is not possible to calculate an agglomeration measure due to no regional disaggregation being available.

4 As seen in Table 1, for some spatial levels it was not possible to calculate the AGC statistic, which further reduced the sample size.

5 A more econometrically-sophisticated panel GMM approach was attempted, but estimation was not possible due to insufficient observations.

Table 5. Explanatory variables for national growth regression

Explanatory variable	Variable name (in regressions)	Definition	Reason for inclusion	Expected sign
Standard regressors				
Initial GVA per employee	PROD_START	Initial starting level of wealth/development	Initial conditions not captured by other explanatory variables	Negative implying conditional convergence, positive implying divergence
R&D intensity	RD_INT	Research and development spending as a percent of GDP	Capturing the effect of innovation on productivity growth	Positive
Investment share	INV_SHARE	Ratio of investment (private sector) to GDP	Proxy for initial capital stock effect on output growth	Positive
Higher education	HIGH_ED	Percentage of higher education attained in total population	Quality of initial human capital stock	Positive
Openness	OPENNESS	Exports plus imports as a share of GDP	Importance of trade, proxying for benefits trade can bring in terms of lower costs and greater variety	Positive
Government share	GOV_SHARE	Government consumption as a share of GDP	Capturing public sector crowding out effects of productivity	Negative
Additional synthetic variables				
Dummy variable reflecting the productivity shock to Finland (Russia collapse) and Germany (re-unification) in the early 1990s	DEFIDUM	For Germany: 1984–1991 = 1 Otherwise = 0 For Finland: 1991–1994 = 1 Otherwise = 0	Structural change occurring is so significant/specific as to warrant a specific treatment	Positive
Agglomeration measures and interactive terms				
Economic potential	ECPOT1	Sum of GDP in surrounding areas weighted by square of distance from that area–national values obtained by aggregating across various spatial levels and dividing by the number of regions in a given country	The aggregate effect of regional agglomeration forces within a country could/should transmit to a better growth performance	Positive, according to NEG theory
	ECPOT3	Similar to ECPOT1 but uses largest regional agglomeration in 1980 as focal point for each country	The presence of a large regional agglomeration within a country could/should transmit to a better growth performance	Positive, according to NEG theory
Agglomeration–AGC	AGC_Nx, where x = 1–3 depending on the NUTS level being used	AGC index for intra-country spatial distribution of sectoral employment	Intra-regional dispersion of activity	Positive, according to NEG theory

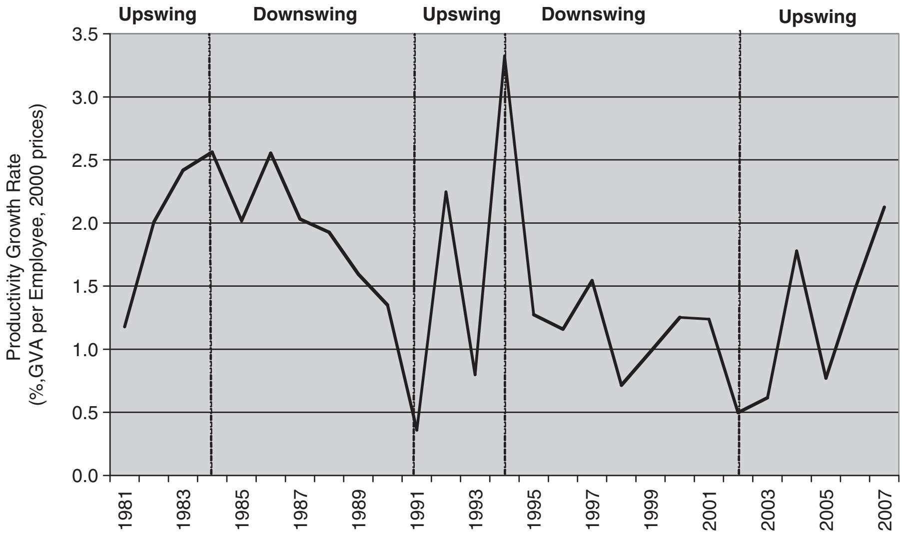

Figure 4. Productivity growth cycles in the EU-15, 1981–2007.

problem variable in this regression is the education measure, which is difficult to obtain on a consistent international basis–hence it is probably not surprising that the coefficient is wrongly signed (albeit insignificant).

To the initial specification outlined in Table 6, agglomeration effects (AGC and economic potential) were then added as described in Table 5. Additional investigation was undertaken of how the results change by altering the spatial scale (NUTS1-3) of the AGC index, while all other variables remain the same in each regression. Table 7 reports the various options of spatial scale explored and the resulting findings in terms of the size, sign and significance of the agglomeration factors (as all that is changing between the regressions is the spatial scale of the AGC statistic: we have not reported any supporting statistics). As with the no agglomeration results shown in Table 6, the starting level of productivity and the R&D intensity are the predominantly significant (and correctly signed) regressors, with mixed findings for most of the others. The results vary both across the different measures of agglomeration and the different spatial scales. The Economic Potential variables are both significant and correctly-signed in all regressions. Meanwhile, the AGC statistic is significant but wrongly-signed in the NUTS1 and NUTS2-level regressions, and only appears correctly-signed at one spatial level (NUTS3), at which point it becomes insignificant.

It is useful to compare our findings with those obtained by Brülhart and Sbergami (op cit) in their study of growth across OECD nations. They noted the difficulty in obtaining robust results from what are frequently relatively short datasets. In particular, with respect to the EU, they state:

> Given that we now have a much smaller sample, consisting of 16 countries, it is not surprising that we find relatively fewer statistically significant coefficients (than the world regression).... The estimates on which statistical significance is found, however, mostly conform to expectations (op cit, p. 57).

Table 6. Panel regression results–no agglomeration measure

Variable	Coefficient	Standard error	*t*-Statistic	Probability
C	2.558	4.936	0.518	0.607
LOG(PROD_START)	−3.004	1.292	−2.324	0.024
HIGH_ED	−0.023	0.016	−1.388	0.171
RD_INT	1.539	0.584	2.636	0.011
INV_SHARE	0.089	0.115	0.767	0.447
GOV_SHARE	0.203	0.176	1.154	0.254
OPENNESS	0.011	0.032	0.353	0.726
DEFIDUM	8.497	0.613	13.858	0.000
Effects specification				
Cross-section fixed (dummy variables)				
Weighted statistics				
R-squared	0.701	Mean dependent variable		2.657
Adjusted *R*-squared	0.578	SD dependent variable		2.632
SE of regression	1.679	Sum squared resid		138.200
F-statistic	5.731	Durbin–Watson stat		2.033
Prob (*F*-statistic)	0.000			
Unweighted statistics				
R-squared	0.634	Mean dependent var		2.364
Sum squared resid	159.671	Durbin-Watson stat		2.080

Dependent variable: PROD_GROWTH; Method: panel EGLS (cross-section weights); Sample: 15; Periods included: 5; Cross-sections included: 14; Total panel (balanced) observations: 70; Linear estimation after one-step weighting matrix; White cross-section standard errors and covariance (d.f. corrected).

Table 7. Summary of panel regression results–with agglomeration

Explanatory variable	NUTS1		NUTS2		NUTS3	
	Coeff	T-ratio	Coeff	T-ratio	Coeff	T-ratio
LOG(PROD_START)	−7.621	−5.091**	−7.950	−4.756**	−8.792	−4.315**
HIGH_ED	−0.029	−1.680	−0.030	−1.600	−0.030	−3.283**
RD_INT	3.640	3.761**	3.075	3.461**	3.712	4.076**
INV_SHARE	−0.018	−0.165	−0.078	−0.712	0.015	0.111
GOV_SHARE	0.236	1.363	0.317	1.956*	0.290	2.226**
OPENNESS	0.007	0.142	0.041	1.183	0.018	0.673
FIDUM	9.412	12.406**	9.308	10.295**	9.122	10.764**
ECPOT1	0.011	3.036**	0.013	3.102**	0.012	2.877**
ECPOT3	0.027	3.850**	0.013	2.729**	0.031	5.607**
AGC STATISTIC	−38.101	−2.569**	−43.703	−1.916*	0.158	0.014

* and ** indicate significance at the 90 and 95% levels of confidence, respectively.

Their findings are that the Theil agglomeration index they use is positive in three out of the four specifications. Despite the positive findings on the influence of agglomeration some of the effects from other variables in their regression were somewhat counter-intuitive, including a negative effect from openness in three out of four specifications, investment share, education and population density all negative in one out of four specifications, and the starting level of GDP per capita positive in two out of four of their specifications. Brülhart and Sbergami summarize these findings by stating:

> These results run counter to the prediction whereby internal agglomeration becomes more important the less open a country is to international trade, thus confirming the conclusion that no clear-cut relationship can be discerned between openness and the growth effects of agglomeration (op cit, p. 58).

Our results, though based on a more thorough attempt to derive a meaningful agglomeration than the Theil index, and using a subdivision of the study period based on growth phases, rather than the arbitrary simple 5-year divisions used by Brülhart and Sbergami, also provide mixed evidence that spatial agglomeration boosts national growth. In part, this could reflect data restrictions that constrain the available observations. By restricting ourselves to looking at national (rather than regional) growth, and by keeping the focus on Western Europe (EU-15), we have limited the number of cross-sections of data available to us.

4.3. Robustness checking–annual growth model

In an attempt to improve on the previously-identified degrees of freedom issue and how this might affect any conclusions drawn from the regression results reported in Tables 6 and 7, we examined alternative specifications that might allow us to use annual data and thus increase the number of observations by an order of magnitude.

As a first attempt, we explored the possibility of estimating a convergence-type regression on annual data, using dummy variables to condition the effects of productivity cycles that emerge once period averages are abandoned. This approach had the advantage that we could identify the heterogeneity that exists among the European Member States, but it is not without difficulties. First, the identification of the cycle remains subjective, and secondly the treatment of the explanatory variables becomes contentious, as effectively each annual year's growth of productivity is explained by the lagged-level of productivity, R&D intensity, etc. Such an approach makes it difficult to identify long-run effects and, unsurprisingly, there is little evidence of this methodology in the economic literature.

Having ruled out the convergence-type regression, we instead focussed on a more straightforward growth model. Such models are easily derived from a production function approach,[6] and are most recently associated with total factor productivity (TFP) analysis, although we retained the focus on labour productivity in our model so as to maintain a more direct comparison to the previous results.

The results of the annual growth regression without agglomeration effects, equivalent to Table 6, are shown in Table 8. The increase in observations from using annual data is clear–indeed, we were able to add another year to the sample, something that has little

6 From the starting point of a production function where output depends on labour, capital and technological progress, it can easily be shown how labour productivity depends upon technical progress and capital per employee. Growth of labour productivity then depends on growth of capital per employee and the growth of factors that might affect technological progress.

Table 8. Growth regression results–no agglomeration measure

Variable	Coefficient	Standard error	*t*-Statistic	Probability
C	1.508	0.195	7.723	0.000
DLOG(CS_EMP) × 100	0.327	0.069	4.719	0.000
D(RD_INT)	−0.592	0.979	−0.605	0.546
D(HIGH_ED)	−0.054	0.065	−0.842	0.400
D(OPENNESS)	0.068	0.033	2.072	0.039
D(GOV_SHARE)	−0.659	0.219	−3.015	0.003
Effects specification				
Cross-section fixed (dummy variables)				
R-squared	0.205	Mean dependent variable		2.123
Adjusted *R*-squared	0.167	SD dependent variable		1.778
SE of regression	1.623	Akaike info criterion		3.853
Sum squared resid	982.240	Schwarz criterion		4.046
Log likelihood	−736.264	Hannan–Quinn criterion		3.930
F-statistic	5.357	Durbin–Watson stat		1.614
Prob (*F*-statistic)	0.000			

Dependent variable: DLOG(PROD_LEVEL) × 100; Method: panel least squares; Sample (adjusted): 1981–2008; Periods included: 28; Cross-sections included: 14; Total panel (balanced) observations: 392; White cross-section standard errors and covariance (d.f. corrected).

Table 9. Summary of annual regression results–with agglomeration

Explanatory variable	NUTS1		NUTS2		NUTS3	
	Coeff	T-ratio	Coeff	T-ratio	Coeff	T-ratio
DLOG(CS_EMP) × 100	0.698	8.526**	0.394	3.851**	0.398	5.762**
D(RD_INT)	0.173	0.210	−0.413	5.817**	−0.450	−0.542
D(HIGH_ED)	−0.065	−0.460	−0.097	−0.514	−0.079	−1.253
D(OPENNESS)	0.075	1.966**	0.043	−1.569	0.051	1.860*
D(GOV_SHARE_	−0.634	−3.119**	−0.642	1.688*	−0.633	−3.915**
DLOG(ECPOT1) × 100	0.249	2.935**	0.053	−4.032**	0.019	0.283
DLOG(ECPOT3) × 100	0.048	0.717	0.136	0.817	0.150	2.446**
D(AGC STATISTIC)	−48.598	−2.922**	−61.487	2.566**	−18.024	−1.150

* and ** indicate significance at the 90 and 95% levels of confidence, respectively.

effect in a model using average growth periods, but which adds another 14 observations in our case. The variables are as described previously, the only exception being that we now use capital stocks per employee (CS_EMP) in place of the share of private investment (INV_SHARE) as the former has a more direct relationship to the new specification we are using. In general, the findings are promising in terms of the number of significant and correctly-signed coefficients with sensible magnitudes–only R&D intensity and the higher education variables are insignificant.

To this specification we then added the agglomeration factors as before, but expressed in terms of year-on-year changes to balance with the other variables in the equation. The results from these regressions are shown in Table 9 below, again as a direct counterpart to Table 7.[7] We find these results promising, in the sense that they are generally a reaffirmation of the previous findings:

- the variables that were previously significant and correctly signed are fairly robust to the addition of the agglomeration variables;
- the agglomeration factors generally have the same signs as before, and similar magnitudes (there seems to be some interaction between the two measures of economic potential that did not exist in the period growth model, but at least one of them is significant at all spatial levels);
- in particular, the AGC statistic is negative and significant at the NUTS1 and NUTS2 levels, but insignificant at NUTS3, exactly as before.

So the general conclusion from this additional analysis is that the increase in observations afforded by the shift to an annual growth model reinforces the previous findings on the mixed effects of agglomeration at different spatial scales–neither a shift to annual growth from period growth, nor a shift from convergence to simple growth model, radically alters our findings.

5. Concluding comments

Economic geographers and regional economists have long been concerned with the problems provoked by uneven regional development and the ways by which policy intervention may be able to reduce such inequalities. However, as we discussed in the 'Introduction' section, in recent years the traditional argument for seeking to secure a reduction in the spatial concentration of economic activity has been questioned and in some cases it has been suggested that policies that try to reduce regional economic inequalities may even reduce national efficiency. As we have highlighted these sorts of arguments are not new and reflect an old, almost eternal, ongoing debate that seems to come round every decade or so (Williamson, 1965). Recently the impetus for the re-emergence of the line of argument has been the ascendancy of the 'new economic geography (NEG) model.

This article has focused on exploring the empirical evidence for the alleged positive impact of spatial agglomeration on national growth–and its corollary, that a trade-off exists between national growth and the pursuit of greater regional equality in economic outcomes. More specifically, as our empirical case study we have examined the relationship between national productivity growth and the spatial agglomeration of economic activity across the EU-15 countries for the period 1981–2007. Our findings on a tradeoff between the rate of growth experienced and the degree of agglomeration are rather mixed. The precise results obtained depend on the measure of agglomeration adopted and the spatial scale at which the analysis is conducted. The problems we have faced in undertaking this research are fairly well-known. The spatial units for which economic data reflect administrative convenience rather than being configured to capture localization effects. While much progress is being made by using establishment

7 There is a slight difference in the statistics recorded in Table 8 (Akaike, Schwarz and H-Q Criteria) and Table 6 due to the annual observations versus panel structure of the respective datasets which allow the software used for the estimation (EViews) to supply the additional diagnostic indicators.

based data we have been constrained to use data based on traditional administrative boundaries.

There is also a clear desire to incorporate better measures of economic potential and contiguity and although we have made some progress in this direction what we have been able to do in this respect is inevitably limited. Besides the problem of producing good measures of agglomeration there is the lack of a definite and generally agreed and accepted model of national growth to which agglomeration measures can be added. This is also the result of data problems (including short-time series). We have tried to investigate these factors with different measures of agglomeration, by dividing our study period into growth phases, and by modifying the specification into an annual growth model to solve the degrees of freedom problem.

The provision of more robust supporting evidence and better modeling techniques will all help future research, but we should perhaps conclude this paper by recognizing that the basic model we have sought to test is a highly simplified model of the factors determining the location of economic activity and a very crude model with which to explain national variations in economic growth. The underlying assumptions of NEG models are highly simplistic, and raise questions about the credibility of these models as representations of the economic landscape and its dynamics (Garretsen and Martin, 2010; Martin, 2010). Such models ignore the various negative externalities associated with spatial agglomeration (or at least treat them in a very simple way): this is arguably a key weakness of the theoretical models that claim to link spatial agglomeration and national growth. Further, NEG models also ignore the inflationary effect of agglomerations on the rest of the economy and the way in which such agglomeration activity can draw key human and capital resource from other regions such that the capacity for growth in those regions is reduced (e.g. migration of educated labour which can reduce the capacity of a peripheral region to absorb technology spillovers from the core agglomeration).

Rather than derive predictions of the impact of spatial agglomeration on national growth using a highly simplified abstract model it would perhaps be better to try to measure empirically what the effect of spatial agglomeration/regional inequality are on growth, and then build a model that captures the mechanisms involved, reflecting the spirit of the original Krugman (1991) method of deriving NEG models (in which he drew on the observed historical agglomeration of economic activity in the US manufacturing belt). It is perhaps also worth noting how in his most recent work (Krugman, 2009, 2010) he has suggested that perhaps in the advanced economies agglomeration may no longer a primary source of growth enhancing increasing returns that it once was. Recent studies by economic geographers tend to support this view, in that there is evidence that agglomeration economies may go through a 'life cycle' in terms of the benefits they provide for spatial concentrated industries (Potter and Watts, 2010). In the meantime policy makers should be cautious in basing any policy on assumptions of a trade-off between national growth and regional inequality.

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