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Urban Growth Drivers and Spatial Inequalities: Europe - a case with geographically sticky people

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Abstract
We try to combine theory with empirical analysis to investigate the drivers of spatial growth processes, welfare and disparities in a context in which people are markedly immobile. Drawing on two of our recent papers (Cheshire and Magrini, 2006 and 2008), we review the evidence on the drivers of differential urban growth in the EU both in terms of population and output growth. The main conclusion from our findings is that one cannot reasonably maintain the assumption of full spatial equilibrium in a European context. This has a number of wider implications. It suggests that i. differences in real incomes in Europe - and more generally where populations are relatively immobile - are likely to persist and indicate real differences in welfare; ii. there is no evidence of a unified European urban system but rather of a set of national systems; iii. there are significant but theoretically consistent, differences in the drivers of population compared to economic growth.

Keywords
Growth, urban system, spatial equilibrium

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1. Introduction

In this chapter we try to combine theory with empirical analysis to investigate the drivers of spatial growth processes, welfare and disparities in a context in which people are markedly immobile. Much work has been done on regional growth processes in the USA (for example, Rey and Montouri, 1999; Glaeser *et al*, 1995), but the assumption has been either explicitly or implicitly, that a reasonable underlying assumption is of full spatial equilibrium. This is explicitly the case with (Glaeser *et al*, 1995) who argue that given full spatial equilibrium, since people are unable to improve their welfare by moving from one place to another, flows of people indicate changes in the distribution of spatial welfare - as people move to places offering superior opportunities or lifestyles - more directly than do changes in income levels or rates of growth of income.

Research in Europe, however, shows that people tend to be quite immobile. Net migration between geographically similarly sized regions in the USA is 15 times greater than in Europe (Cheshire and Magrini, 2006) despite differences in real incomes and employment opportunities being very substantially greater and geographic distances being smaller. Even mobility within countries is restricted compared to the US but national boundaries - as we illustrate here - offer particular barriers to spatial adjustment. Thus it is unreasonable to assume full inter regional or inter urban equilibrium in a European context and differences in per capita incomes are persistent and are likely to signal real spatial welfare differences. Furthermore, it implies that the drivers of what population movement there is, may differ from the drivers of spatial differences in productivity or output growth.

In this chapter, drawing on two of our recent papers (Cheshire and Magrini, 2006 and 2008), we review the evidence on the drivers of differential urban growth in the EU both in terms of population and output growth. The conclusion is that while environmental 'goods', in the form of climate differences have significant influences on urban population growth, there is no apparent process of the European population 'moving to the sun'. Climate differences are only significant as they vary from national values: not as they systematically vary from European values. Moreover while there do appear to be some Europe-wide economic drivers of population movement, their influence is restricted compared to the case of economic growth differences; and spatial econometric evidence also reveals substantial national boundary barriers to both population and economic adjustment. Together these findings suggest one cannot reasonably maintain the assumption of full spatial equilibrium in a European context.

Apart from increasing our understanding of the drivers of spatial growth and adjustment processes this has a number of wider implications. It suggests differences in real incomes in Europe - and more generally where populations are relatively immobile - are likely to persist and indicate real differences in welfare. Although it does not tell us how significant they are compared to other sources of welfare differences between individuals, it does imply that people of similar personal characteristics may have different life chances because they are born in one region rather than another. It suggests, contrary to some recent assertions (for example Kresl, 2007) that there is no evidence of a unified European urban system but rather of a set of national systems, with weak responses to variations in local economic opportunities when national boundaries intervene. It also shows there are significant but theoretically consistent, differences in the drivers of population compared to economic growth, Agglomeration economies, concentrations of R&D activity and of highly skilled human capital and systems of urban governance play a significant role in driving spatial economic growth differences but none when it comes to population growth. And, in contrast, while there is strong evidence of environmental factors driving population growth they do not seem to influence economic growth differences. We might finally speculate that findings for Western Europe may have more application to conditions in Asia, with its long history of settlement and its patchwork of languages and cultures (as well as the deliberate restrictions on population mobility imposed in China) than do those from the USA.

Our units of analysis are core-based urban regions - or Functional Urban Regions (FURs) - similar in concept to the Standard Metropolitan Statistical Areas (SMSAs) familiar from the USA literature. These FURs were originally defined in Hall and Hay (1980) but their boundaries were slightly updated and revised in Cheshire and Hay (1989) where full details are available. Since then, the data set relating to these FURs has been continuously updated although their boundaries remain fixed as at 1971. The urban cores are identified on the basis of concentrations of jobs. Using the smallest spatial units in each country for which the basic data were available, all contiguous units with job densities exceeding 12.35 per hectare were amalgamated to identify the FUR core-city. The FUR hinterland was then identified by amalgamating all the contiguous units from which more people commuted to jobs in the given core than commuted elsewhere with a minimum cut-off of 10 percent. This definitional method was used for the great majority of countries but in some critical data were unavailable, so alternative methods had to be used. The most extreme departure was in Italy where previously defined retail areas were substituted for the FUR boundaries. Because of the difficulties of estimating comparable data for the FURs, we analyse patterns of growth only in the largest 121. These are all FURs in the former EU of 12[1] - excluding Berlin - with a total population of more than one third of a million and a core city of more than 200,000 at some date since 1951.

There are substantial advantages of using functionally as opposed to the commonly used administratively defined regions as the units of analysis. Even across a comparatively unified country such as the USA, states,

[1] That is in the countries of Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Portugal, Spain and the United Kingdom.

counties and cities vary considerably in how they relate to patterns of behaviour or economic conditions. In Europe the official regions (the NUTS[2]) are far more disparate since they combine within one system very different national systems. Even within one country - Germany - the regions vary from historical hangovers from the Middle Ages - such as Bremen (population 0.7 million) or Hamburg (1.7 million) - to regions such as Bavaria, with a population of 12.3 million and the size of several smaller European countries run together. In terms of administrative competence Germany has 16 of the functionally very disparate Länder (NUTS Level 1 regions), each with substantial powers and constituting the elements of its Federal system; and below that the Kreise (NUTS Level 3) - 439 of them in 2003. Britain has 12 NUTS 1 regions corresponding in mean size to the Länder but only one of them - Scotland - has any real administrative or fiscal independence. In Britain there are only 133 of the smaller units supposedly equivalent to the Kreise. Bavaria, despite including major cities such as Munich, had a population density of only 174 people per square km compared to 4,539 in the NUTS Level 1 region of London or 2,279 in Hamburg (CEC, 2004).

More significant than their heterogeneity in size and administrative powers is the fact the official NUTS regions are economically heterogeneous, in some cases containing very different local economies within the same statistical unit (for example, Glasgow and Edinburgh in Scotland or Lille and Valenciennes in Nord-Pas-de-Calais) and in others dividing a single city-region between as many as three separate units. The functional reality of Hamburg, for example, is divided between three different Länder, Hamburg, Schleswig-Holstein and Niedersachsen. There are thus many NUTS regions with large scale and systematic cross border commuting and some contain mainly dormitory suburban areas of large cities. Others (for example, Brussels, London, Bremen or Hamburg) are effectively urban cores or only small parts of urban cores. This means that residential segregation influences the value of variables such as unemployment, health or skills if measured on the basis of the boundaries of NUTS; and measures of Gross Domestic Product, Value Added or productivity can be grotesquely distorted since output is measured at workplaces and people are counted where they live.

Even measured growth in GDP pc can be seriously distorted since over time residential (de)centralisation may occur at different rates to job (de)centralisation. The reported growth in GDP pc for the NUTS region of Bremen during the 1980s, for example, was 40 percent higher than for the Bremen functionally defined region. These problems are concentrated in the

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2 Nomenclature des Unités Territoriales Statistiques (N.U.T.S.) regions. This is a nesting set of regions based on national territorial divisions. The largest are Level 1 regions; the smallest for which a reasonable range of data is available are Level 3. Historically these corresponded to Counties in the UK, Départements in France; Provincies in Italy or Kreise in Germany.

larger cities, because these tend to spill over their administrative boundaries, and in the richer regions. This last facet of the distortions to official regional statistics results not only because richer regions tend to include larger cities but because a significant proportion of larger cities extend functionally beyond their administrative boundaries, so their recorded GDP pc is overstated.

These are obvious points, causing serious reservations in relation to the many published analyses of regional growth rates in Europe using the official Eurostat data for NUTS regions. They mean official measures of so-called 'regional disparities' - showing, for example, that in 2001 the 'region' of Inner London was 2.5 times as 'rich' in per capita GDP as the mean for the EU of 15 and 3.2 times as 'rich' as the UK's poorest region, are complete nonsense. It is for these reasons that we rely on our own data for FURs. There is one additional advantage of this choice in the present context which is that FURs are as economically independent divisions of national territories as it is possible to construct. They represent concentrations of jobs and all those people who depend on those jobs - the economic spheres of influence of major cities. So the benefits of additional employment or output are as confined to those who live within them as is possible for any sub national regions. We have data for the 121 largest FURs in the old EU of 12 member states, excluding Berlin and the cities of the former Eastern Germany. We are comparing the drivers of population growth, analysed as quasi-net migration between 1980 and 2000, with those of growth in GDP per capita measured at PPS between 1979 and 1994.

Two idiosyncrasies of our models should be noted. In our analysis of growth in GDP pc we do not include the initial level of GDP pc. So this is not a contribution to the regional growth regression literature stemming from the work of Barro and Sala-i-Martin (Barro, 1991; Barro and Sala-i-Martin, 1991; 1992 or 1995). Not only do we find this literature theoretically suspect (see the discussion in Cheshire and Malecki, 2004, for reasons) but we find it empirically suspect, too. In our better specified models, including the initial level of GDP pc clearly introduces multicollinearity and leads to very unstable parameter estimates for the variable - even signs flip. In essence, it is possible to generate either apparent β-convergence or β-divergence in equally respectable looking models but in all the better specified ones the effect of initial GDP pc on subsequent growth performance is statistically entirely insignificant.

The second idiosyncrasy is our approach to, and interpretation of, issues of spatial dependence. We interpret a finding of spatial dependence as not surprising since systematic patterns in growth should be expected; but as an indication of omitted variable(s) and so failing to account for those patterns. In our models instead of reporting results with spatial lags (which 'cure' any problems of spatial dependence we encounter) we find additional variables directly reflecting spatial processes. In testing for spatial dependence and formulating our variables to reflect spatial economic processes we also find that results critically depend on how the spatial weights matrix is formulated. Following standard procedures to specify the spatial weights matrix, using contiguity, geographic or even time-distance test statistics reveal no apparent problems of spatial dependence with the theoretically more satisfying models. Problems of spatial dependence are only indicated when an additional time-distance penalty for national borders is introduced. This is consistent with other findings - for example that climatic differences only influence population mobility if expressed relative to a country's mean – indicating the continuing barrier national borders present in Europe to processes of spatial adjustment.

We start by summarising the results on the drivers of population growth reported in detail in Cheshire and Magrini (2006) and then summarise the results of a more recent analysis of the drivers of growth in FUR GDP pc (Cheshire and Magrini, 2008). Because we find strong indications of population immobility and sluggish migration response across national borders, we expect the drivers of productivity/GDP growth to be significantly independent and also that over any period we can actually observe we will not be observing a full spatial equilibrium. So differences in economic growth rates across space in Europe are likely to represent real differences in welfare. In analysing the drivers we pay particular attention to the role of highly skilled human capital, concentrations of R&D and the potential role of differences in systems of local government in a ('non-Tiebout') world of sticky people and territorial spillovers with local public goods.

2. Data and Results

2.1 Common features

Appendix Tables 1a & b define the main variables used. Both sets of analysis apply the same basic approach. We first build a 'base' model and test it for standard specification problems and for spatial dependence. In the latter tests we pay particular attention to the specification of the spatial weights matrix - choosing weights which maximised the indicated sensitivity to problems of spatial dependence while conforming to obvious economic logic. For both sets of models we use OLS except for the estimation of models with a spatial lag when we use maximum likelihood. We take care to minimise problems of endogeneity although we accept that our efforts do not necessarily entirely eliminate all such problems. Our position is that ultimately there must be some judgement and what matters is that any remaining endogeneity problems do not seriously influence the results.

There are two families of models: those with 1) the FUR rate of change of population from 1980 to 2000 as the dependent variable and 2) the FUR rate of growth of GDP pc at PPS measured from the mean of 1978-80 to the mean of 1992-94. The main control variables in the two families of models are similar. We have consistently found that specific measures of reliance on old, resource-based industries - the coal industry, port activity and agriculture - perform better than more generalised measures such as employment in industry or unemployment at the start of the period (although each of these is included in one model and is marginally useful). Since reliance on the coal industry is measured with a geological indicator, it seems safe to assume it is exogenous. Port activity is measured very early - 1969 - before the main transformation of the industry to modern methods and before any likely integration effects of creating the European Union would be apparent. Concentration on agriculture is not in the FUR itself but in the larger region containing the FUR - again well before the start of the period covered by the dependent variable. These control variables do reflect economic factors and work in very similar ways whether FUR population or GDP pc growth is the dependent variable.

A feature of using the major FURs as our spatial units of analysis is that a large proportion of the territory of each country is outside their area. The total population of the EU of 12, excluding Berlin, in 2001 was some 340.5 million. Almost exactly half - 169.2 million - lived in its major Functional Urban Regions as defined here. This property of the FURs allows us to define two additional control variables: the rate of natural growth of population in the area of each country outside its major FURs and the rate of growth of GDP pc in the same area. In each case we calculate these over the same period as our dependent variable. By including the rate of non-FUR natural population growth as an independent variable in the population models, we effectively model quasi-net migration.

In cross-sectional analyses of regional growth the conventional control for all country specific factors (notably the incidence of the national economic cycles but also institutional and policy differences between countries) has been national dummies. This would be problematic with our data set since in Denmark, Greece, Ireland and Portugal there are only one or two major FURs so we would have to arbitrarily choose which countries to pool to construct national dummies. More interestingly, since we wish to infer causation, our underlying assumption must be that our observational units - the major FURs of Western Europe - are in statistical terms a homogeneous population. A more elegant solution to control for national factors not explicitly included as independent variables is, therefore, to include ‘non-FUR growth’ as a continuous control variable.

2.2 Population Growth 1980 to 2000

Table 1 shows the ‘Base’ model for FUR population growth. Apart from those discussed above there are two other variables reflecting expectations about systematic spatial patterns of growth. The first of these is taken directly from Clark *et al*, 1969 (with values extended to cover Spain and Portugal, using Keeble *et al*, 1988). The process of European integration, in combination with falling transport costs, was expected to lead to systematic changes in regional economic potential, favouring ‘core’ regions. Clark *et al* estimated for each region of the original six member countries plus Denmark, Ireland, Norway and the UK, the impact on ‘economic potential’ (measured as the accessibility costs to total GDP at every point, allowing for the costs of trade and transport and how those would change with the abolition of tariffs, EU enlargement and transport improvements to include containerisation and roll-on roll-off ferries). We have added our own estimates for the major FURs of Greece. Clark *et al*'s expectation was that changes in economic potential so measured would indicate the regional patterns of systematic gains and losses from the creation and enlargement of the EU. Although the original theoretical underpinnings were somewhat *ad hoc*, such a prediction seems entirely compatible with New Economic Geography models.

Table 1 about here

There are likely to be other systematic spatial patterns between FUR population growth rates because of interaction between contiguous FURs. People in Europe may be very immobile but in the specific conditions of dense urbanisation there are alternative forms of spatial labour market adjustment. In the EU, there are swathes of densely urbanised territory where FURs are not just tightly clustered but their boundaries and commuting hinterlands touch and at the 'commuter shed' still there is substantial cross-border commuting. In such conditions, if the economic attractions of one FUR increase relative to its neighbours, it will attract in additional commuters. Since changes in commuting patterns are cheap - particularly if there are good transport links - such adjustments between adjacent FURs should be expected to respond to small changes in the spatial distribution of opportunities.

If changes in commuting patterns act in this way as spatial adjustment mechanisms between neighbouring FURs, then we should expect a 'growth shadow effect'. A FUR growing economically faster will initially suck in additional workers from neighbouring FURs. Over time a proportion of these long distance commuters attracted to work in the faster growing FUR may move residence and become short distance inter-FUR 'migrants' leading to population growth in the subsequent period in the economically more dynamic FUR. Moreover, since long distance commuters have higher human capital and perhaps favourable unmeasured productivity characteristics then there would also be a composition effect. The productivity of the labour force of the FUR attracting additional commuters would grow relative to that of its neighbour(s). Finally, there might also be dynamic agglomeration effects favouring productivity growth in the faster growing FUR. That commuting flows adjusted in this way in Europe was shown in Cheshire *et al*, 2004.

We represent this localised interaction through the medium of labour market adjustment with the Interaction variable. This is measured as the sum of the differences in the growth rates of employment in each FUR and in all other FURs within 100 minutes travelling time weighted by the inverse of time-distance over the period 1979-1991. It thus proxies for net commuters attracted to employment in each FUR over the first half of the period. The estimated parameter for the variable is significant and positive, supporting the interpretation that commuters attracted in one period reinforce the dynamism of the more successful FUR relative to its neighbours and generate differential population growth in it over the period as a whole. Although not reported here, it is also worth mentioning that compared to models not including the variable, indicated problems of spatial dependence are much reduced.

Table 2 about here

All variables are significant and have the expected signs. Table 2 now shows what happens if we include geographic and climatic variables in the base model. Two conclusions emerge clearly: the first is that FURs further south grew faster but that this effect was only a 'within countries' one. If the position of a FUR was measured relative to a fixed point in the EU of 12 (taken arbitrarily as the centroid of the FUR of Brussels) then its geographic position was statistically entirely non-significant. But there was still a strong effect of being further south within each country. Being further west within a country had a minor but non-significant effect on population growth: being further west within the EU as a whole had no significant impact on growth. Numerous studies in the US (for example, Graves, 1976, 1979, 1980 and 1983; Rappaport, 2004) have shown that migration is - other things equal - sensitive to better weather. Likewise in the 'Quality of Life' literature (for example, Blomquist *et al*, 1988; Gyourko and Tracey, 1991) climate is an important driver of quality of life. Data does not allow us to estimate full 'Quality of Life' models in Europe. However we can include measures of weather and the results of including a selection of these are shown in the fourth to seventh columns of Table 2. We can see that these are statistically highly significant and, if anything, perform rather better than the geographic position of a FUR. The functional form that is most appropriate seems to be quadratic, although the relationship is quite close to linear. These results confirm that it is only the climate of a FUR relative to the mean for its country that is significant. Again expressing climatic differences relative to the mean for the EU proves entirely non-significant. Table 3 shows the results for some better performing models and shows that the best result are achieved if measures of both dryness and warmth relative to national means are included.

Table 3 about here

Diagnostic test results are reported in Cheshire and Magrini, 2006. These suggest that there are no problems of either heteroskedasticity or non-normality of errors. The value of the multicollinearity condition number is relatively high in most of the models in which climate variables are included in quadratic form but since the parameter estimates are stable and the functional form (effectively suggesting that it is asymptotic to an upper value) seems sensible, this does not seem to be a cause for concern.

As is well known the major problem in testing for problems of spatial dependence is the choice of measures of 'distance'. There is no 'theoretically correct' measure one should select *a priori*. The spatial econometrics literature has examples of many measures: contiguity; linear geographic distance; time-distance; or the inverse of time distance. Our view is that any indications of spatial dependence should in principle be reflections of underlying spatial processes. This suggests two points: one should select the distance weights in a way that makes sense in terms of spatial economics and spatial economic adjustment processes; and a reasonable criterion for choosing the weights is that - subject to them making sense in economic terms - they maximise sensitivity to spatial dependence.

The results are not reported in detail here but we measured distance between FURs as the transit time by road, including any ferry crossings and using the standard commercial software for road freight. We tested for both the inverse of time distance and the inverse of time distance squared. Given that we had already found that national frontiers constituted strong barriers to spatial mobility (from the results on climate and geographical variables) we also experimented with an added time distance for all FURs separated by a national border. We found that the greatest sensitivity in the tests for spatial dependence was achieved if the time cost of a national border was set at 120 minutes.

Table 4 about here

Spatial dependence seems likely to be only a minor problem, however. It only shows up as significant at all when distance is represented in the most sensitive form - as the inverse of time distance squared including the 120 minute national border effect: indeed if no time-distance penalty for national borders was included then, in the better models, no problems of spatial dependence were indicated. And even then, in Model 16, indicated spatial dependence was only on the margins of significance at 10%. Nevertheless it seemed safer to re-estimate including a spatial lag of the dependent variable and selected (and representative) results are reported in Table 4. The spatially lagged value of population growth is significant. However all signs remain appropriate and - except for the spatial effects of EU integration in the 'base' model - all variables are significant at 10% at least. A few variables, however, cease to be significant at 5% although the diagnostics remain reassuring. Perhaps most reassuring of all, and again consistent with the conclusion that problems of spatial dependence are for practical purposes very minor, the coefficient estimates for equivalent models hardly change numerically in the spatially lagged estimates (Table 4) compared to the robust standard errors, OLS estimates reported in Tables 1, 2 and 3.

2.3 Growth in GDP pc 1978 to 1994

The analysis of FUR per capita GDP growth draws on Cheshire and Magrini (2008). We use similar controls to those used in the models of population growth but learn from that process, dividing our variables more strictly between those designed to reflect specific drivers - such as inheritance of old, resource-based industries - and those designed to reflect systematic spatial patterns and adjustment processes. We are particularly interested in investigating the role of concentrations of highly skilled human capital and the localised impact of concentrations of R&D but also in seeing whether the evidence is consistent with dynamic agglomeration economies and what the impact - independently of agglomeration - of density may be. Finally we are also interested in testing hypotheses about the impact of governmental arrangements on economic growth.

All these variables were available to be included in our models of population growth, although our main interest there was on the impact of climate and the extent to which there appeared to be a single unified European urban system. But all the variables relating to human capital concentrations, R&D and urban government were included in the population models for completeness and the main point of the present chapter is perhaps that they proved to be completely non-significant. In a complementary way, for completeness we included climate variables in the economic growth models but none was significant (although having a wetter climate relative to the national mean came quite close to being significantly and positively related to economic growth). The evidence is strong that many of the most significant drivers of economic growth are entirely different from those of population growth and vice versa. Moreover, something useful can be learned from these differences. There are also similarities: both processes reveal how important national boundaries still are in Europe and what significant barriers they represent for spatial adjustment; and there are some controls common to both processes.

Table 5 about here

The rate of growth of GDP pc outside the major FURs (Non-FUR Growth) proves significant and, as the models become more fully specified, the value of the estimated co-efficient tends to get closer to 1 (compare results in Tables 5 and 6). The results of estimating the ‘Base’ model are shown in Table 5. As can be seen all variables are significant and have the expected signs although adding a spatial lag of the dependent variable reduces the significance of the concentration in agriculture in the wider region in 1975. There are indications of dynamic agglomeration economies - larger FURs grew faster other factors controlled for - but once this was done FURs which were denser grew more slowly. The reasoning underlying the inclusion of these variables is that factors generating agglomeration economies are distinct from density itself. Agglomeration economies arise as a result of the number and net value of productive interactions between economic agents and these are larger in larger cities. Larger cities also tend to have denser population and in studies of agglomeration economies, density of employment or population has often been used as the 'explanatory' variable. This is not inappropriate in unregulated conditions but in the conditions ruling in a number of EU countries in which there are very strong urban containment policies, density and size will vary to an extent independently of each other. Once size has been allowed for, higher density should be associated with higher space costs (see Cheshire and Hilber, 2008) and more congestion and so is expected to be associated with less favourable conditions for economic activity. The results reported in Tables 5 and 6 are entirely consistent with this reasoning.

We do not report the test statistics here but those for standard problems of heteroskedasticity, non-normality of errors, multicollinearity and functional form were all acceptable (see Cheshire and Magrini, 2008). So, too, were tests for spatial dependence unless an additional time-distance penalty for national borders was included. Further experimentation showed that indicated spatial dependence problems were maximised if this national border penalty was set at 600 minutes. The indicated textbook solution was to include the spatially lagged dependent variable as an additional independent variable. Results of doing so are shown in the second set of columns in Table 4. The spatially lagged dependent variable is significant but makes little difference to the other estimated parameters except for reducing the significance of past specialisation in agriculture in the wider region.

Our preferred approach to problems of spatial dependence is, as was noted above, to treat a significant result as indicating a problem of omitted variables: in the present case the omission of variables driving systematic spatial patterns of FUR growth. Table 6 shows the results of including such variables, plus additional variables designed to test specific hypotheses.

The idea that concentrations of highly skilled human capital should be associated with faster rates of real GDP pc growth (itself very closely related to productivity growth) is not novel. It is represented here as the ratio of university students to total employees at the very start of the period (to help reduce any possible problems of endogeneity). Equally, there is a large literature on the tendency for patents to be applied closer to their points of origin (see for example Audretsch, 1998 or, for a recent application to a European context, Barrios *et al*, 2008). So we should expect FURs with greater concentrations of R&D activity at the start of the period to have grown faster. This is measured as R&D facilities of the largest firms per 1000 inhabitants - again at the start of the period.

The third variable designed to test hypotheses about the drivers of economic growth is rather more novel. Tiebout (1956) is one of the most cited papers in local public finance. It shows that, given certain conditions, if there are many competing local jurisdictions then the provision of local public goods will match the structure of demand as people vote with their feet to find the best combination of tax rates and public goods available to them. The 'certain conditions' assumed to prevail are that people are perfectly mobile and that there are no spillovers of public goods from one jurisdiction to another. It is easy, however, to think of local public goods which might involve jurisdictional spillovers: for example, crime reduction or pollution control. Moreover, as we have been discussing, people in Europe are far from perfectly mobile.

Suppose therefore we consider an 'anti-Tiebout' world - the provision of a local public good which may involve jurisdictional spillovers, in a world where mobility is expensive. Then the implications are that a more efficient provision may result if jurisdictional boundaries coincide with the set of households/agents affected by the local public good(s). One of the notable recent developments in Europe is the spread of local economic development efforts which is, in effect, local growth promotion. Now if we suspend our disbelief and allow for the possibility that such policies[3] may have some positive impact, then they would consist of the provision of a pure local public good: extra local growth would have zero opportunity costs in consumption and would be non-excludable. If, because of additional local growth, my rents go up that is no cost to other owners of real estate: if a local growth promotion agency is successful, it will not be possible to exclude residents from outside the jurisdiction benefiting from the better job opportunities or higher wages.

Since intentionally FURs are defined to be economically self-contained, their boundaries should minimise spillovers of local growth. Those who benefit from the jobs created within them live within their boundaries (although there may be external owners of assets). So the more closely a local jurisdiction's boundaries correspond to the extent of a FUR, the smaller - other things equal - will be the spillover losses from successful growth promotion efforts. The other factor determining the incentive to local actors to establish a growth promotion agency will be the transactions costs incurred. Since such agencies typically consist of public-private partnerships (a 'club') initiated and facilitated by local government, again the larger is the central local jurisdiction, the lower will be the transactions costs and so the greater the net payoff from establishing a growth promotion agency. Arguments such as these prompted Cheshire and Gordon (1996, page 389) to hypothesis that growth promotion policies would be more

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[3] We abstract from what form such policies may take. Clearly much of the effort of local growth promotion agencies goes into trying to attract mobile investment. This is not necessarily a policy with much payoff. More effective policies may include simple efficiency in public administration, transparent regulation, flexible land use policies with quick and cheap decisions and effective co-ordination of public infrastructure provision with private investment. None of these policies will necessarily be measured in higher local expenditures - so total spending - even if data were available - by either local government or local development agencies is unlikely to effectively capture the efficiency of local growth promotions efforts. Moreover since the functions of local government compared to national and, where it exists, regional, vary so much across Europe, it is impractical to use measures of local spending as indicators of local growth promotion efforts.

likely to appear and be more energetically pursued where ‘there are a smaller number of public agencies representing the functional economic region, with the boundaries of the highest tier authority approximating to those of the region…’.

A variable can be defined to capture this idea. That is simply a measure of how closely each FUR’s boundaries match those of the central jurisdiction defined as the ratio of jurisdiction to FUR population at the start of the period. The hypothesis is that the more closely these match, the greater will be the payoff to forming an effective growth promotion club or agency, other things being equal. It could be that the advantage increases as the size of the governmental unit gets bigger than the FUR itself (as happens in some European countries in which there is an effective regional tier of government - Madrid might be an example) because the resources and clout of the governmental unit will be bigger. But if the governmental unit is too large, the interests of the main FUR within it may get diluted by those of outlying smaller cities and rural areas. This implies - if growth promotion agencies are able to have any impact on local economic growth - that we should expect a positive relationship between the variable we call the ‘policy incentive’ and GDP pc growth with perhaps a quadratic relationship, since having a regional tier of government too greatly exceeding the size of your economic region or FUR, may dilute the positive impact on growth.

Table 6 about here

Model 3 in Table 6 includes all these variables and we can see they are all significant. Their inclusion improves the fit of the model without significantly changing the estimated parameter values of the existing variables and only the functional form of the policy incentive variable is unclear, since the quadratic term, although it has the expected sign, is not significant. Testing for spatial dependence (see Cheshire and Magrini, 2008 for details), however reveals apparent problems if the 600 minute time-distance penalty is included for national borders. This suggests that variables reflecting systematic spatial patterns are omitted.

Models 4 and 5 show the impact of including variables designed to capture such spatial influences. The first is the Integration Gain variable already discussed, intended to capture the spatial effect of European integration. Partly as a response to the perceived advantage accruing to ‘core’ regions from European integration, Europe - starting from the mid-1970s - has developed stronger policies aimed at redistributing economic activity to ‘peripheral’ regions than any other political grouping. Such policies in 1972 accounted for 4 percent of spending by the European Commission but increased their share of the budget to 15 percent by 1980 and to some 30 percent by 1994. Although their impact has been questioned (see, Midelfart and Overman, 2002; Rodriguez-Pose and Fratesi, 2004) it still seems worth including a variable for ‘peripherality’. To avoid subjectivity this is arbitrarily defined as being all FURs more than 600 minutes time-distance from Brussels.

It is also plausible that in the more densely urbanised parts of Europe conditions in FURs will influence each other - that there will be interaction between neighbours. Three variables are included to try to capture this, drawing on the literature on spatial labour markets and the distance decay effect of innovations. Since there is evidence, particularly from the spatial applications of patents, that new innovations are subject to a distance decay effect and we have already seen that concentrations of R&D favour FUR growth, so if there are concentrations of R&D in a FUR one would expect that to favour growth in FURs close by - subject to a distance decay effect. This is reflected in the design of the R&D Facilities Density variable. Equally if a concentration of highly skilled labour favours a FUR's growth then having a higher concentration in neighbouring FURs would be expected to reduce its growth since the faster growth they generate in the surrounding FURs will tend to attract highly skilled commuters away from the slower growing FUR. This is reflected in the University Student Density variable. Finally, some studies suggest an initial higher level of unemployment is prejudicial to subsequent growth. Glaeser *et al*, 1995, for example, report that in their study.

Models 4 and 5, therefore, include both the initial level of unemployment in FUR_i and an Unemployment Density variable calculated as the distance weighted level of unemployment in all neighbouring $FURs_{j-n}$ up to 120 minutes between centroids. The time distance cut-off applied to calculating the R&D Facilities and University Students Density variables is rather higher: 150 minutes. These differential cut-offs both provide better statistical performance but are also consistent with underlying reasoning. The unemployed, who are biased towards the least skilled, are likely to have a geographically more confined influence than the most highly skilled or innovation. In all cases the 600 minute time-distance penalty for national borders is applied in calculating the value of these spatial interaction variables for each FUR. Again this not only performs better statistically but is consistent with other findings.

The results are reported in Table 6. We can see that all variables have the expected sign and are significant at at least the 10 percent level - even the quadratic term for the policy incentive variable. Tests for joint significance provide further evidence of the fact that the underlying functional form of the policy incentive variable is quadratic (with the maximum favourable impact of the relationship between FUR and administrative boundaries coming when the administrative jurisdiction containing the FUR is about 1.5 times its size). More encouraging (reported in detail in Cheshire and Magrini, 2008) is the fact that all signs of spatial dependence are eliminated. As before no conventional econometric problems are indicated.

In the context of understanding the main drivers of the rate of FUR GDP pc growth these results suggest that there is evidence of dynamic agglomeration economies but - other things equal - higher population density is bad for growth. They also suggest that while the process of European integration does indeed favour 'core' regions, policies to reduce 'spatial disparities' (the official aim of European regional policies) may at least in part have offset for that. They are certainly consistent with concentrations of highly skilled human capital and R&D favouring local growth. Perhaps more surprisingly they suggest not only that local growth promotion policies may have some positive impact but the incentives regional actors face in developing such policies are themselves influential. It helps if local jurisdictional boundaries coincide more closely with those of self-contained economic regions - FURs - because in the presence of spillovers and transactions costs in forming effective growth promotions clubs. such a coincidence of boundaries means there are greater expected gains to actors. Finally we find strong evidence of the barrier national boundaries still provide to processes of spatial adjustment in Europe when investigating issues of spatial dependence.

4. Contrasting the Drivers of Population and Economic Growth

Given the reluctance of Europeans to move in the face of changing patterns of opportunity it is not appropriate to assume that Europe is characterised by full spatial equilibrium. This has implications both for the persistence of spatial disparities in welfare and for the processes driving spatial differences in population compared to economic growth. Offsetting for differences in the natural rate of growth of population, we do find some economic drivers of population growth - such as an inheritance of an old, resource-based local economy or the systematic impacts of European integration. But these Europe-wide drivers are quite weak and only the impact of European integration can really be classed as 'Europe-wide'. The slower population growth of FURs with past specialisations in coal or port activity may only impact on growth in FURs within the same country without such disadvantages. When we analyse the impact of climate on population growth we find compelling evidence of a purely national impact. It is not differences in climate relative to some European mean that is significant: it is only relative to national conditions that climate drives FUR population growth. Moreover in analysing the sources of spatial dependence we find strong evidence that while growth in a FUR influences that in its neighbour(s), if a national border separates two FURs, that influence is much diminished.

We also find a powerful national border barrier to spatial interaction between neighbouring FURs when we examine the drivers of economic growth. But in other ways the drivers of economic growth are significantly different. Dynamic agglomeration economies and concentrations of R&D and highly skilled labour are significant in driving GDP pc growth but not for population growth. Moreover the 'policy incentive' variable designed to reflect the incentives faced by local actors to promote local growth is highly significant in accounting for difference in economic growth rates between FURs but not at all significant in accounting for differences in population growth. Spatial interactions between neighbouring FURs seem more complex when it comes to economic growth differentials and these plausibly relate to local labour market adjustment processes and the spatial diffusion of innovation. It has been asserted that climate and environmental factors have become more important in influencing firm location because they are supposed to influence the locational choices of highly skilled labour (the so-called 'new location factors'[4]). Our findings provide no support at all for this view. Climatic differences - the most obvious environmental factor - are not statistically significant in models of GDP pc growth and the closest they come is perverse with respect to the power of the alleged 'new location factors': if the number of wet days relative to the national mean is included the sign is positive and it is on the verge of significance. For economic growth, if anything, wetter seems to be better.

Overall both the differences and the points in common broadly reflect theoretical explanations. In a world of sticky people we would expect sluggish adjustment to spatial differences in opportunity and we would also expect national boundaries to represent additional obstacles to spatial adjustment. Both expectations are supported by this analysis. Although it has perhaps had less attention than it deserves, we might also expect there to be systematic adjustment process between FURs in densely populated and urbanised wider regions. The literature on labour market search and on induced commuting tells us that these processes tend to even out spatial opportunities as they occur in sets of labour markets linked by significant (potential) commuting flows. Although FUR boundaries are designed to delimit self-contained labour markets, where their boundaries are contiguous, then people living in the suburban hinterlands can alter their commuting patterns over time to take advantage of opportunities in neighbouring FURs. As a result of vacancy chains, opportunities will tend to be equalised over the set of linked local labour markets (Morrison, 2005). The condition appears simply to be that cross-boundary commuting flows exceed some threshold (see Gordon and Lamont, 1982). Thus without conventional geographic mobility, spatial equilibrium may be produced through local labour market interactions when geography and transport systems facilitate adjustment in commuting patterns. If we include variables designed to reflect this process (and other spatial interactions), spatial dependence problems are eliminated but we find strong evidence that adjustment is greatly impeded across European borders. This is true for both population growth and economic growth and reinforces the conclusion that spatial differences in Europe are persistent: not just because people are geographically immobile but because, if national borders intervene, they tend not even to take advantage of opportunities they could reach without re-locating.

[4] See for example http://geographyfieldwork.com/HighTechLocationFactors.htm

Table 1: Population Growth – Base Model

Dependent Variable: FUR Population Growth Rate 1980 to 2000

Model	**1**	**2**	**3**	**4**	**5**	**6 'Base'**
R-squared	0.2460	0.3101	0.3830	0.4818	0.5014	0.5180
constant	0.0068865	0.0066006	0.0084915	0.0055553	0.0053513	0.005074
t	4.15	4.02	4.77	3.76	3.51	3.31
Agriculture	0.0003431	0.0002432	*0.0001806*	0.0003818	0.0003966	0.0004102
t	3.59	2.57	1.93	4.04	4.07	4.21
Agriculture^2	-0.000009	-0.0000065	-0.000005	-0.0000092	-0.0000092	-0.0000094
t	-3.50	-2.47	-2.04	-3.62	-3.52	-3.61
Industry	-0.0001456	-0.0001123	-0.000134	-0.0001564	-0.0001716	-0.0001693
t	-3.93	-2.78	-3.25	-3.81	-4.11	-4.07
Coalfield: core		-0.0026591	-0.0029095	-0.0028371	-0.0024507	-0.0021143
t		-2.75	-3.31	-3.27	-2.90	-2.43
Coalfield: hinterland		-0.0020922	-0.0023182	-0.0022892	-0.0027245	-0.0020548
t		-3.60	-2.88	-3.14	-3.65	-2.48
Port size			-0.0010267	-0.0008617	-0.0008216	-0.0007278
t			-3.08	-2.90	-2.98	-2.56
Port size^2			0.0000569	0.0000478	0.0000412	0.0000366
t			3.36	3.21	2.91	2.51
Nat Non-FUR Growth				0.4731661	0.4559771	0.4417852
t				4.38	4.15	3.95
Integration Gain^2					0.0011008	0.0011278
t					2.30	2.48
Empl. Interaction						0.0440806
t						2.11

Note: Parameter estimates shown in *italics* are significant only at 10%: all other parameter estimates are significant at 5% or better

Table 2: Popolation Growth - Base Model plus Geographic and Climate Variables
Dependent Variable: FUR Population Growth Rate 1980 to 2000

	Base model + geographical variables				Base model + climate variables			
Model	**7**	**8**	**9**	Model	**10**	**11**	**12**	**13**
R-squared	0.6012	0.5951	0.5258	R-squared	0.5940	0.6090		
West	*-0.000002*			Wet day frequency ratio	-0.00789	-0.02615		
t	*-1.44*			t	-4.70	-3.98		
South	0.000005	0.000005		Wet day frequency ratio^2		0.009387		
t	4.02	4.69		t		2.91		
EU West			*0.0000008*	Mean temperature ratio			0.5863	
t			*0.99*				-0.048056	
EU South			*0.0000004*	Mean temperature ratio^2			0.5863	
t			*0.66*	t			-0.048056	
EU West			*0.0000008*	Max temperature ratio				0.5946
t			*0.99*	t				-0.076058
EU South			*0.0000004*	Max temperature ratio^2				-2.29
t			*0.66*	t				0.041133

Note: Parameter estimates shown in *italics* are not significant at 10%

Table 3: Best Models

Dependent Variable: FUR Population Growth Rate 1980 to 2000

Model	**14**	**15**	**16**
R-squared	0.6325	0.6326	0.6405
Constant plus:			
Agriculture	0.0003127	0.0004266	0.0004079
t	3.02	4.32	4.42
$Agriculture^2$	-0.0000056	-0.0000083	-0.0000075
t	-2.09	-3.31	-3.06
Industry	-0.0000962	-0.0001457	-0.0001213
t	-2.55	-3.71	-3.55
Coalfield: core	-0.0015896	-0.001655	-0.001812
t	-2.21	-2.10	-2.42
Coalfield: hinterland	-0.0020415	-0.001682	-0.0018028
t	-2.47	-2.12	-2.37
Port size	-0.0005831	-0.0006274	-0.0006521
t	-2.30	-2.59	-2.64
Port $size^2$	0.0000291	0.0000294	0.0000315
t	2.31	2.39	2.55
National Non-FUR Growth	0.3029144	0.5536141	0.4710524
t	2.41	4.91	4.38
Integration $Gain^2$	0.0015988	0.0020954	0.0020679
t	3.41	4.54	4.50
Empl. Interaction	0.0539774	0.0532723	0.0519908
t	2.69	2.70	2.73
South within EU	0.0000032		
t	2.80		
Frost frequency ratio		-0.0039281	
t		-2.50	
Frost frequency $ratio^2$		0.0020628	
t		3.36	
Max temperature ratio			-0.0752656
t			-2.33
Max temperature $ratio^2$			0.0379645
t			2.51
Wet day frequency	-0.0214449	-0.0247	-0.0202854
t	-3.77	-3.76	-3.58
Wet day frequency ^{2}	0.0082249	0.008621	0.0069708
t	2.78	2.81	2.37

Note: All parameter estimates significant at 5% or better

Table 4: Inclusion of Spatially Lagged Population Growth 1980 to 2000

Dependent Variable: FUR Population Growth Rate 1980 to 2000

Model	**17 (Base+)**	**18 (14+)**	**19 (16+)**
R-squared	0.5416	0.6418	0.6468
Loglikelihood	554.986	568.97	569.604
Spatially lagged population growth	0.37939	0.25415	0.21369
prob	0.0004	0.0196	0.0540
Agriculture	0.00033	0.00037	0.00036
prob	0.0003	0.0000	0.0000
Agriculture^2	-0.00001	-0.00001	-6.6E-06
prob	0.0018	0.0027	0.0056
Industry	-0.00013	-0.00013	-0.00011
prob	0.0001	0.0003	0.0013
Coalfield: core	-0.00169	-0.00141	-0.0016
prob	0.0214	0.0357	0.0154
Coalfield: hinterland	-0.00177*	-0.00150*	-0.00165*
prob	0.0774*	0.0984*	0.0668*
Port Size	-0.00069	-0.00061	-0.00064
prob	0.0032	0.0050	0.0024
Port Size^2	0.00003	0.00003	3.04E-05
prob	0.0236	0.0427	0.0233
Integration Gain^2	*0.00077*	0.00175	0.00178
prob	*0.1146*	0.0002	0.0002
Empl. Interaction	0.04829	0.05532	0.05378
prob	0.0194	0.0029	0.0037
National Non-FUR Growth	0.37956	0.50526	0.43847
prob	0.0000	0.0000	0.0000
Wet day frequency ratio		-0.02122	-0.01743
prob		0.0130	0.0391
Wet day frequency ratio^2		0.00715*	*0.00563*
prob		0.0937*	*0.1853*
Frost frequency ratio		-0.00350	
prob		0.0401	
Frost frequency ratio^2		0.00193	
prob		0.0097	
Max Temperature			-0.07122
prob			0.0060
Max Temperature^2			0.03555
prob			0.0042

Notes: * means that estimated parameters significant at 10%. All other estimates significant at 5% or better except those in italics which are not significant at 10%.

Table 5: Base Model (OLS) and Base Model + Spatial lag (ML)
Dependent Variable: annual rate of growth of GDP p.c. (mean 1978/80-mean 1992/94)

Model	1		2	
R^2	0.5903		0.6053	
Adjusted R^2	0.5570			
LIK	485.56		488.74	
Constant	-0.0205		-0.0240	
t-test - prob	-2.05	0.04	-2.55	0.01
Spatial Lag of GDP p.c. growth			0.2648	
t-test - prob			2.61	0.01
National Non-FUR Growth	0.8600		0.7119	
t-test - prob	8.06	0.00	6.24	0.00
Coalfield: core	-0.0054		-0.0050	
t-test - prob	-4.25	0.00	-4.13	0.00
Coalfield: hinterland	-0.0057		-0.0054	
t-test - prob	-3.29	0.00	-3.37	0.00
Port Size	-0.1364		-0.1416	
t-test - prob	-3.18	0.00	-3.56	0.00
Port $Size^2$	0.6166		0.6550	
t-test - prob	2.28	0.02	2.61	0.01
Agriculture	0.0409		0.0254	
t-test - prob	2.55	0.01	1.67	0.10
$Agriculture^2$	-0.1125		-0.0737	
t-test - prob	-2.51	0.01	-1.75	0.08
Population Size	0.0021		0.0019	
t-test - prob	3.16	0.00	3.11	0.00
Population Density	-0.0015		-0.0015	
t-test - prob	-2.00	0.05	-2.19	0.03

Table 6: Models excluding and including 'Spatial Variables'
Dependent Variable: annual rate of growth of GDP p.c. (mean 1978/80-mean 1992/94)

Model	**3**		**4**		**5**	
R-squared	0.6765		0.7413		0.7555	
Adjusted R-squared	0.6372		0.6986		0.7095	
LIK	499.86		513.38		516.80	
Constant	-0.0320		-0.0233		-0.0261	
t-test - prob	-3.14	0.00	-3.52	0.01	-2.84	0.01
National Non-FUR Growth	0.9442		0.8975		0.9050	
t-test - prob	9.22	0.00	9.07	0.00	9.31	0.00
Coalfield: core	-0.0062		-0.0051		-0.0051	
t-test - prob	-5.18	0.00	-3.99	0.00	-4.00	0.00
Coalfield: hinterland	-0.0042		-0.0034		-0.0032	
t-test - prob	-2.61	0.01	-2.23	0.03	-2.06	0.04
Port Size	-0.1474		-0.1003		-0.0932	
t-test - prob	-3.69	0.00	-2.62	0.01	-2.46	0.02
Port Size squared	0.7634		0.4871		0.4669	
t-test - prob	3.04	0.00	2.02	0.05	1.97	0.05
Agriculture	0.0508		0.0384		0.0478	
t-test - prob	3.22	0.00	2.48	0.01	3.02	0.00
Agriculture squared	-0.1345		-0.1126		-0.1231	
t-test - prob	-3.21	0.00	-2.82	0.01	-3.12	0.00
Unemployment			-0.0332		-0.0312	
t-test - prob			-2.45	0.02	-2.29	0.02
Population Size	0.0021		0.0016		0.0016	
t-test - prob	3.53	0.00	2.90	0.00	2.87	0.01
Population Density	-0.0015		-0.0015		-0.0013	
t-test - prob	-2.25	0.03	-2.36	0.02	-2.07	0.04
Integration Gain			0.0073		0.0082	
t-test - prob			3.20	0.00	3.61	0.00
University Students	0.0309		0.0367		0.0303	
t-test - prob	2.67	0.01	3.62	0.00	2.87	0.01
R&D Facilities	0.8079		0.8947		0.8512	
t-test - prob	2.84	0.01	3.26	0.00	3.10	0.00
Policy Incentive	0.0075		0.0026		0.0086 [a]	
t-test - prob	2.24	0.03	2.45	0.02	2.49	0.01
Policy Incentive squared	-0.0021				-0.0027 [a]	
t-test - prob	-1.32	0.19			-1.72	0.09
R&D Facilities Density			0.0531		0.0703	
t-test - prob			2.19	0.03	2.70	0.01
Peripherality Dummy			0.0059		0.0054	
t-test - prob			4.51	0.00	4.10	0.00
University Student Density			-0.0025		-0.0030	
t-test - prob			-2.46	0.02	-2.93	0.00
Unemployment Density					-0.0036	
t-test - prob					-1.92	0.06

Note: [a] Test of joint significance: $\chi^2(2) = 10.4333$ (0.01).

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Appendix Tables

Table 1a: Variable Definitions - Rate of FUR Population Growth 1980 to 2000 Dependent Variable

Industry	Share of labour force in industry in surrounding NUTS 2 in 1975
Coalfield: core	Dummy=1 if the core of the FUR is located within a coalfield
Coalfield: hinterland	Dummy=1 if the hinterland of the FUR is located within a coalfield
Port*	Volume of port trade in 1969 in tons
Agriculture*	Share of labour force in agriculture in surrounding NUTS 2 in 1975
Integration Gain*	Change in economic potential for FUR resulting from pre-Treaty of Rome EEC to post enlargement EU with reduced transport costs (estimated from Clark *et al* 1969 and Keeble *et al* 1988)
Interaction '79-91	The sum of the differences in the growth rates of employment each FUR and in all other FURs within 100 minutes travelling time weighted by distance over the period 1979-1991.
West	Distance west of centre of FUR from national capital city (Amsterdam taken as capital of Netherlands; Bonn of Germany)
South	Distance south of centre of FUR from national capital city (Amsterdam taken as capital of Netherlands; Bonn of Germany)
EU West	Distance west of centre of FUR from Brussels
EU South	Distance south of centre of FUR from Brussels
National Non-FUR Growth	Annualised rate of growth of population in territory of country outside major FURs between 1980 and 2000
Wet day frequency ratio*	Ratio of wet day frequency between FUR and national average (1970s and 1980s)
Frost frequency ratio*	Ratio of ground frost frequency between FUR and national average (1970s and 1980s)
Maximum temperature ratio*	maximum temperature percentage difference between FUR and national average (1970s and 1980s)
Cloud cover ratio: country*	Ratio of cloud cover days between FUR and national averages (1970s and 1980s)
Minimum temperature ratio: country*	Ratio of minimum temperatures between FUR and national average (1970s and 1980s)
Mean temperature ratio: country*	Ratio of mean temperature between FUR and national average (1970s and 1980s)
Max temperature ratio: country*	Ratio of maximum temperature between FUR and national average (1970s and 1980s)

Note: * denote variables tried with a quadratic specification for reasons explained in the text: never entered as squared value alone.
All climate variables were also expressed as the ratio of the FUR value to the EU mean.

Table 1b: Variable Definitions – Rate of Growth of GDP pc at PPS 1978/80 to 1992/94 Dependent Variable

Variable Name	Description
Population Size	Population size in 1979 (natural logarithm)
Population Density	Density of population in FUR in 1979 (1000 inhabitants/Km^2)
Coalfield Dummy: core	Dummy = 1 if the core of the FUR is located within a coalfield
Coalfield Dummy: hinterland	Dummy = 1 if the hinterland of the FUR is located in a coalfield
Port size *	Volume of port trade in 1969 (100 tons)
Agriculture *	Share of labour force in agriculture in surrounding NUTS 2 in 1975
Unemployment *	Unemployment rate (average rate between 1977 and 1981 – from Eurostat NUTS3 data)
National Non-FUR Growth	Growth of GDP p.c. in the territory of each country outside the FURs (annualised rate between 1978/80 and 1992/94)
Policy Incentive *	Ratio of the population of the largest governmental unit associated with the FUR to that of the FUR in 1981 (see below for details)
Integration Gain	Change in economic potential for FUR resulting from pre-Treaty of Rome EEC to post enlargement EU with reduced transport costs (estimated from Clark *et al* 1969 and Keeble *et al* 1988)
Peripherality Dummy	Dummy = 1 if the FUR is more than 10 hours away from Brussels
University Students *	Ratio of university students (1977-78) to total employment (1979)
R&D Facilities *	R&D laboratories of Fortune 500 companies per 1000 inhabitants in 1980
Unemployment Density	Sum of differences between the unemployment rate (average between 1977 and 1981) of a FUR and the rates in neighbouring FURs (within 2 hours), discounted by distance (with 10 hours time penalty for national borders)
University Student Density	Sum of university students per employees in neighbouring FURs (within 2.5 hours), discounted by distance (with 10 hours time penalty for national borders)
R&D Facilities Density	Sum of R&D laboratories per 1000 inhabitants in neighbouring FURs (within 2.5 hours), discounted by distance (with 10 hours time penalty for national borders)

Note: * denote variables tried with a quadratic specification for reasons explained in the text. Never entered as squared value alone.