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Paul C. Cheshire* and Stefano Magrini**

Abstract

Analysts of regional growth differences in the US tend to assume full spatial equilibrium (Glaeser et al, 1995). Flows of people thus indicate changes in the distribution of spatial welfare more effectively than differences in incomes. Research in Europe, however, shows that people tend to be immobile. Even mobility within countries is restricted compared to the US but national boundaries offer particular barriers to spatial adjustment. Thus it is less reasonable to assume full spatial equilibrium in a European context and differences in per capita incomes may persist and 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. This paper analyses the drivers of differential urban growth in the EU both in terms of population and output growth. The results show significant differences in the drivers as well as common ones. They also reveal the extent to which national borders still impede spatial adjustment in Europe. This has important implications for policy and may apply more generally to countries – for example China - less homogeneous than the USA.

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Table of Contents

Urban Growth Drivers and Spatial Inequalities: Europe - a Case with Geographically Sticky People

1. Introduction

Much work has been done on regional growth processes in the U.S. (e.g., Rey and Montouri, 1999; Glaeser *et al*, 1995). However, this work has been based on an explicit or implicit underlying assumption of full spatial equilibrium. This is explicitly the case with Glaeser *et al* (1995). They argue that since, if there is full spatial equilibrium, 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.

In contrast, research in Europe shows that people tend to be quite immobile. Net migration between similarly sized geographic regions in the U.S. is 15 times greater than in Europe (Cheshire and Magrini, 2006). This is despite the fact that differences in real incomes and employment opportunities are substantially greater and geographic distances smaller in Europe than in the U.S. Even mobility *within* countries is limited compared to the U.S. But as we will illustrate here, national boundaries offer particular barriers to spatial adjustment. Thus it seems unreasonable to assume full inter-regional or inter-urban equilibrium in a European context; differences in per capita incomes are persistent and likely to signal real spatial welfare differences. Furthermore, the reluctance of people to move countries or apparently even move inter-regionally in Europe suggests that the drivers of whatever population movement there is in Europe may differ from the drivers of spatial differences in productivity or output growth.

This paper combines 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 2009), we review the evidence on the drivers of differential urban growth in the European Union (EU), both in terms of population and Gross Domestic Product (GDP) per capita growth. We conclude that while environmental 'goods', in the form of climate differences, are significant influences on urban population growth, there is no general process of the European population 'moving to the sun'. Climate differences are significant only 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, we find that their influence is less than in the case of economic growth differences. Analysis of spatial dependence and its determinants also reveals substantial national boundary barriers to both population and economic adjustment. Together, these findings suggest that one cannot reasonably maintain the assumption of full spatial equilibrium in a European context.

In Section 2 we give some technical detail and explanation about our units of analysis – Functional Urban Regions (FURs). These are a 'core-based' type of urban region similar to the Standard Metropolitan Statistical Areas which provide the units for much applied urban economics in the U.S. Readers may want to skip this section at a first reading although the use of data for FURs is central to our approach. In Section 3 we summarize the results concerning the drivers of population growth, reported in detail in Cheshire and Magrini (2006), and then summarize the results of a more recent analysis of the drivers of growth in FUR GDP per capita (Cheshire and Magrini, 2009).We find strong indications of population immobility and sluggish migration response across national borders and also find that economic adjustment between neighboring city-regions is strongly impeded by national borders. In analyzing the drivers of economic growth, 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. Although when analyzing the determinants of urban population and economic growth there are some drivers in common and these apparently reflect the immobility of Europeans, we also find important differences. The final section offers an interpretation of why there are such differences and what they suggest both for spatial adjustment, spatial equilibrium and policy.

2. Meaningful Data for Useful Regions

Our regions

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 U.S. literature. These FURs were originally defined in Hall and Hay (1980), but some of their boundaries were slightly updated and revised in Cheshire and Hay (1989). 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 combined to identify the FUR core-city. The FUR hinterland was then identified by combining 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 cases critical data were unavailable, so alternative methods had to be used. The most extreme case was Italy, where previously defined retail areas were substituted for the FUR boundaries. Because of the difficulties of estimating comparable data for the FURs, we analyze patterns of growth only for the largest 121 FURs. All of these FURs are in the former EU-12[1] –

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

excluding Berlin – and all had 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.

Why FURs not NUTS?

There are significant advantages of using functionally, as opposed to administratively, defined regions as the units of analysis. Even across a country as constitutionally unified and developmentally homogeneous as the U.S., states, counties and cities vary considerably in how they relate to patterns of behavior 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 largest NUTS Level 1 regions vary from 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 combined. 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; below that are 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 that the official NUTS regions are economically heterogeneous. In some cases

[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 Level 3 NUTS regions corresponded to Counties in the UK, Départements in France; Provincies in Italy or Kreise in Germany.

they contain 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 a single city-region is divided among as many as three separate units. The functional reality of Hamburg, for example, is divided among 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 bedroom communities near 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. Moreover, measures of Gross Domestic Product (GDP), Value Added or productivity per capita can be grotesquely distorted since output is measured at workplaces and people are counted where they live.

Even measured growth in GDP per capita can be seriously distorted since over time residential (de)centralization may occur at different rates to job (de)centralization. The reported growth in GDP per capita for the NUTS region of Bremen during the 1980s, for example, was 40 percent higher than for the Bremen functionally defined region. This was because of strong residential relative to job decentralization during that decade. These problems of statistical distortion are concentrated in the larger cities, because these tend to spill over their administrative boundaries; they are also concentrated in 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 (or GVA) per capita is overstated.

Implications for Conventional Analyses of Spatial Disparities

These are obvious points, causing us to have serious reservations about the many published analyses of regional growth rates in Europe that use official Eurostat data for NUTS regions. This means that official measures of so-called 'regional disparities'

– which show, 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-15 and 3.2 times as 'rich' as the UK's poorest region - are in essence completely invalid.

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. FURs are the most economically independent divisions of national territories that can be constructed. They represent concentrations of jobs and all those people who depend on those jobs – the economic spheres of influence of major cities. As a result, the benefits of additional employment or output are confined as much as possible to those who live within a given FUR.

Our Approach to 'Growth Regressions' and Spatial Dependence

Two idiosyncrasies of our approach should be noted. First, in our analysis of growth in GDP per capita we do not include the initial level of GDP per capita. So this analysis does not contribute to the regional growth regression literature stemming from the work of Barro and Sala-i-Martin (Barro, 1990; Barro and Sala-i-Martin, 1991; 1992 or 1995). We find this literature to be both theoretically (see the discussion in Cheshire and Malecki, 2004) and empirically suspect. Empirically when we include the initial level of GDP per capita in our models, it 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. However, in all of our better specified models, the effect, if included, of initial GDP per capita on subsequent growth performance is statistically insignificant.

The second idiosyncrasy of our approach is in our interpretation of any finding of spatial dependence. That the growth performance of cities or regions close to each other should interact is not in itself surprising, so we should expect to find systematic spatial patterns in growth. These might be caused by common factors (e.g. some shared structural or institutional features) but we should also expect to find localized interactions to be more pervasive and responsive than those between cities or regions that are widely separated or – given the findings on population mobility – separated by national borders. If, therefore, we can find variables that reflect spatial adjustment mechanisms between neighboring regions we should be able to 'explain' remaining spatial patterns in the data. In other words a finding of spatial dependence is really an indicator of an omitted variables problem and if the model(s) can be more fully and appropriately specified then any indicated problems of spatial dependence should be resolved. In testing for spatial dependence and formulating our variables to reflect spatial adjustment 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, we experiment with contiguity, geographic and time-distance and find test statistics which reveal no apparent problems of spatial dependence in 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 our other findings, which show, for example, that climatic differences only influence population mobility if expressed relative to a country's mean. These findings indicate that national borders in Europe present a continuing barrier to processes of spatial adjustment - even for localized economic adjustment.

3. Results

Common Features of Models of Population and Economic Growth

Appendix Tables 1a & b define the main variables used. Models for both population and GDP per capita growth 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 maximize the indicated sensitivity to problems of spatial dependence while conforming to obvious economic logic. For both sets of models we use OLS. The exception is the estimation of models with a spatial lag where we use maximum likelihood. We try to minimize problems of endogeneity. Although we recognize that our efforts do not necessarily entirely eliminate all such problems, we believe that any remaining endogeneity problems do not significantly influence the results.

There are two families of models in our analysis: 1) those that use the FUR rate of change of population from 1980 to 2000 as the dependent variable and 2) those that use the FUR rate of growth of GDP per capita at purchasing power standard (PPS) measured from the mean of 1978-80 to the mean of 1992-94 as the dependent variable. 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 (e.g., the coal industry, port activity, agriculture) perform better than more generalized 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 reflect economic factors and work in very similar ways, whether FUR population or GDP per capita growth is the dependent variable.

One result 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. In 2001, the total population of the EU-12, excluding Berlin, was about 340.5 million. At that time, almost exactly half – 169.2 million – lived in its major FURs 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 that is outside its major

FURs and the rate of growth of GDP per capita in the same area. In each case, we calculate these control variables 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. However, this would be problematic with our data set since Denmark, Greece, Ireland and Portugal each have only one or two major FURs. This means 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.

4. Results for Population Growth (1980 to 2000)

Table 1 shows the 'Base' model for FUR population growth. All variables are significant and have the expected signs. There are two variables, in addition to those discussed above, that reflect 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, favoring 'core' regions. Clark *et al* estimated for each region of the original six member countries, plus Denmark, Ireland, Norway and the UK, the impact of European integration on 'economic potential.'[3] 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.

3 This is 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 elimination of tariffs, EU enlargement, and transport improvements to include containerisation and roll-on roll-off ferries.

Table 1
Dependent Variable: FUR Population Growth Rate 1980 to 2000 - The Base Model

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
Agric Emp.'75	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
$(\text{Agric Emp.'75})^2$	-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
Ind. Emp.'75	-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: hint'land		-0.0020922	-0.0023182	-0.0022892	-0.0027245	-0.0020548
T		-3.60	-2.88	-3.14	-3.65	-2.48
Port size '69			-0.0010267	-0.0008617	-0.0008216	-0.0007278
T			-3.08	-2.90	-2.98	-2.56
$(\text{Port size '69})^2$			0.0000569	0.0000478	0.0000412	0.0000366
T			3.36	3.21	2.91	2.51
Nat Non-FUR Pop Growth '80-'00				0.4731661	0.4559771	0.4417852
T				4.38	4.15	3.95
$(\text{Integration Gain})^2$					0.0011008	0.0011278
T					2.30	2.48
Interaction '79-'91						0.0440806
T						2.11

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

Variables are defined in Appendix Tables 1a and 1b. Sources for all variables are shown in Cheshire and Magrini, 2006 and 2009. Parameter values in the above table are the authors' estimates.

Localized adjustments

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 urbanization there are alternative forms of spatial labor market adjustment. In the EU, there are swathes of densely urbanized territory where FURs are not just tightly clustered; their boundaries and commuting hinterlands touch and, at the 'commuter shed', there is still substantial cross-border commuting. In such conditions, if the economic attractions of one FUR increase relative to its neighbors, that FUR will attract 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 as spatial adjustment mechanisms between neighboring FURs, then we would expect there to be a 'growth shadow effect'. That is, a FUR growing economically faster than neighboring FURs will initially attract additional workers from those FURs. Over time, a proportion of these long distance commuters attracted to work in the faster growing FUR may move there and become short distance inter-FUR 'migrants,' which would lead to population growth in the subsequent period in the economically more dynamic FUR. Moreover, since long distance commuters have higher human capital and perhaps favorable unmeasured productivity characteristics, there would also be a composition effect. This means the productivity of the labor force of the FUR that has attracted additional commuters would grow relative to that of its neighbor(s). Finally, there might also be dynamic agglomeration effects favoring productivity growth in the faster growing FUR. It was shown in Cheshire *et al*, 2004, that commuting flows between FURs do in fact adjust to differential employment opportunities in the way indicated above and that the response of net commuting to differential growth in employment opportunities is subject to a quite sharp distance decay effect.

We represent this localized interaction through the medium of labor market adjustment using the "Interaction" variable. This is measured as the sum of the differences in the employment growth rates in each FUR and in all other FURs within 100 minutes traveling 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 to a FUR in one period reinforce the dynamism of the more successful FUR relative to its neighbors and generate differential population growth over the period as a whole. Although not reported here, it is also worth mentioning that compared to models that do not include this "Interaction" variable, problems of spatial dependence are much reduced.

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

	Base + geographical variables				Base model + climate variables			
					Linear	Quadratic		
	West or South within country	South within country	West or South within EU		Wet day frequency ratio: country	Wet day frequency ratio: country	Mean Temperature ratio: country	Maximum Temperature ratio: country
Model	7	8	9		10	11	12	13
R^2	0.6012	0.5951	0.5258		0.5940	0.6090	0.5863	0.5946
West	*-0.000002*			$\hat{\beta}_1 x$	-0.00789	-0.02615	-0.048056	-0.076058
T	*-1.44*			t	-4.70	-3.98	-2.37	-2.29
South	0.000005	0.000005		$\hat{\beta}_2 x^2$		0.009387	0.026076	0.041133
T	4.02	4.69		t		2.91	2.74	2.58
EUwest			*0.0000008*					
T			*0.99*					
EUsouth			*0.0000004*					
T			*0.66*					

Parameter estimates shown in *italics* are not significant at 10%
Variables are defined in Appendix Tables 1a and 1b. Sources for all variables are shown in Cheshire and Magrini, 2006 and 2009. Parameter values in the above table are the authors' estimates.

Better weather attracts

Table 2 shows what happens if we include geographic and climatic variables in the base model. Two conclusions clearly emerge. The first is that FURs further south grew faster, but this effect was only within countries. When the position of a FUR is measured relative to a fixed point in the EU- 12 (taken arbitrarily as the centroid of the FUR of Brussels) then its geographic position is statistically insignificant. However, there was still a strong effect of being further south within each country. Being further west within a country had a minor but insignificant effect on population growth: being further west within the EU as a whole had no significant impact on population growth. Numerous studies in the US (e.g., Graves, 1976, 1979, 1980 & 1983; Rappaport, 2004) have shown that - other things equal - migration is sensitive to better weather. Likewise in the 'Quality of Life' literature (e.g., Blomquist *et al*, 1988; Gyourko and Tracey, 1991) climate is an important driver of quality of life. The data do not allow us to estimate full 'Quality of Life' models in Europe. However, the results of including measures of weather are shown in the last four columns of Table 2. We can see that these weather variables 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 as a whole proves entirely insignificant. Table 3 shows the results for some better performing models and shows that the best results are achieved if measures of both dryness and warmth relative to national means are included.

Table 3
Dependent Variable: FUR Population Growth Rate 1980 to 2000 - Best Models

Model	14	15	16
R-squared	0.6325	0.6326	0.6405
Constant plus:			
Agric Emp.'75	0.0003127	0.0004266	0.0004079
t	3.02	4.32	4.42
(Agric Emp.'75)^2	-0.0000056	-0.0000083	-0.0000075
t	-2.09	-3.31	-3.06
Industrial Emp.'75	-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: hint'land	-0.0020415	-0.001682	-0.0018028
t	-2.47	-2.12	-2.37
Port size '69	-0.0005831	-0.0006274	-0.0006521
t	-2.30	-2.59	-2.64
(Port size '69)^2	0.0000291	0.0000294	0.0000315
t	2.31	2.39	2.55
Nat Non-FUR Pop Growth '80-'00	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
Interaction '79-'91	0.0539774	0.0532723	0.0519908
t	2.69	2.70	2.73
South within EU	0.0000032		
t	2.80		
Frost frequency ratio : country		-0.0039281	
t		-2.50	
(Frost frequency ratio : country)^2		0.0020628	
t		3.36	
Maximum temperature ratio : country			-0.0752656
t			-2.33
(Maximum temperature ratio : country)^2			0.0379645
t			2.51
Wet day frequency ratio : country	-0.0214449	-0.0247	-0.0202854
t	-3.77	-3.76	-3.58
(Wet day frequency ratio : country)^2	0.0082249	0.008621	0.0069708
t	2.78	2.81	2.37

All parameter estimates significant at 5% or better
Variables are defined in Appendix Tables 1a and 1b. Sources for all variables are shown in Cheshire and Magrini, 2006 and 2009. Parameter values in the above table are the authors' estimates.

Spatial dependence

The results of diagnostic tests on these models are reported in Cheshire and Magrini, 2006. These results 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. However, 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 practical issue in testing for problems of spatial dependence is the choice of measures of 'distance'. There is no 'theoretically correct' measure that one should select *a priori*. The spatial econometrics literature provides examples of many measures: contiguity; linear geographic distance; time-distance; or the inverse of time distance. Our view is that any indicators 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, assuming they make sense in economic terms, they maximize sensitivity to spatial dependence.

With these points in mind, 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
Inclusion of Spatially Lagged Population Growth 1980 to 2000

	Model 17	Model 18	Model 19
R-squared	0.5416	0.6418	0.6468
Loglikelihood	554.986	568.97	569.604
Spatially lagged pop growth 1980-'00	0.37939	0.25415	0.21369
prob	0.0004	0.0196	0.0540
Agric Emp.'75	0.00033	0.00037	0.00036
prob	0.0003	0.0000	0.0000
(Agric Emp.'75)^2	-0.00001	-0.00001	-6.6E-06
prob	0.0018	0.0027	0.0056
Industrial Emp.'75	-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: hint'land	-0.00177*	-0.00150*	-0.00165*
prob	0.0774*	0.0984*	0.0668*
Port size '69	-0.00069	-0.00061	-0.00064
prob	0.0032	0.0050	0.0024
(Port size '69)^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
Interaction '79-'91	0.04829	0.05532	0.05378
prob	0.0194	0.0029	0.0037
Nat Non-FUR Pop Growth '80-'00	0.37956	0.50526	0.43847
prob	0.0000	0.0000	0.0000
Wet day frequency ratio : country		-0.02122	-0.01743
prob		0.0130	0.0391
(Wet day frequency ratio : country)^2		0.00715*	*0.00563*
prob		0.0937*	*0.1853*
Frost frequency ratio : country		-0.00350	
prob		0.0401	
(Frost frequency ratio : country)^2		0.00193	
prob		0.0097	
Max. Temperature : country			-0.07122
prob			0.0060
(Max. Temperature : country)^2			0.03555
prob			0.0042

* Estimated parameters significant at 10%. All other estimates significant at 5% or better except those in italics which are not significant at 10%.
Variables are defined in Appendix Tables 1a and 1b. Sources for all variables are shown in Cheshire and Magrini, 2006 and 2009. Parameter values in the above table are the authors' estimates.

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 and including the 120 minute national border effect. Indeed, if no time-distance penalty for national borders is included, then, in the better models, no problems of spatial dependence were indicated. Even then, in Model 16 (in Table 3), 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. Selected (and representative) results of this re-estimation are reported in Table 4. The spatially lagged value of population growth is significant. All signs remain appropriate and – except for the spatial effects of EU integration in the 'base' model - all variables are significant at least at 10%. 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 are numerically very similar in the spatially lagged estimates (Table 4) and the robust standard error OLS estimates reported in Tables 1, 2 and 3.

5. Analysis and Results for GDP Growth per Capita (1978 to 1994)

Many of the drivers of economic growth differ

The analysis of FUR per capita GDP growth draws on Cheshire and Magrini (2009). Although we use similar controls to those in the models of population growth, we learn from that process by 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 localized impact of concentrations of R&D. However, we are also interested in seeing whether the evidence is consistent with dynamic agglomeration economies and what the impact of density may be, independent of agglomeration. Finally, we are interested in testing hypotheses about the impact of governmental arrangements on urban economic growth.

In our models analyzing population growth, our main interest was on the impact of climate and the extent to which there appeared to be a single unified European urban system. For completeness, however, all the variables relating to human capital concentrations, R&D, and urban government were included in the population models. None proved to be significant. In a complementary way, for completeness, we included climate variables in the economic growth models, but, again, 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. However, there are also some similarities: both processes reveal the continued importance of national boundaries in Europe and that they are significant barriers to spatial adjustment other than across wider densely urbanized regions. There are also some controls that are common to both processes.

Table 5
Dependent Variable Annualized Rate of Growth of GDP p.c. Mean 1978/80 to mean 1992/4 - Base Model OLS: Base Model + Spatial lag – Max. Lik.

	Model 1		Model 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 dep. variable			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 squared	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 squared	-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

Variables are defined in Appendix Tables 1a and 1b. Sources for all variables are shown in Cheshire and Magrini, 2006 and 2009. Parameter values in the above table are the authors' estimates.

Controlling for 'national' factors

The rate of growth of GDP per capita 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. This can be seen by comparing the results in Tables 5 and 6. The results of estimating the 'Base' model are shown in Table 5. 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.

Growth: agglomeration good; density bad

There are indications of dynamic agglomeration economies – larger FURs grew faster when other factors were controlled for. However, once FUR size was controlled for, those FURs that were denser grew more slowly. The rationale for including both FUR size and initial population density is that the 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. Population density also rises with city size and in studies of agglomeration economies, density of employment or population has often been used as the 'explanatory' variable. While this approach is not inappropriate in unregulated conditions, in a number of EU countries where there are very strong urban containment policies, population density and population size will to some extent vary independently of each other. Once size has been controlled for, higher density should be associated with both higher space costs (see Cheshire and Hilber, 2008) and more congestion, and is thus expected to be associated with less favorable conditions for economic activity. The results reported in Tables 5 and 6 are entirely consistent with this reasoning.

Spatial dependence – introducing a spatial lag

Although we do not report the test statistics in Tables 5 and 6, those for the standard problems of heteroskedasticity, non-normality of errors, multicollinearity and functional form were all within acceptable ranges (see Cheshire and Magrini, 2009). So, too, were tests for spatial dependence, except for the case where an additional time-distance penalty for national borders was included. Further experimentation showed that spatial dependence problems were maximized 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. The results of doing so are shown for model 2 reported in the final column of Table 5. The spatially lagged dependent variable is significant but has little effect on the other estimated parameters except for reducing the significance of past specialization in agriculture in the wider region.

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

Human capital, R&D and local growth promotion with spatial spillovers

The idea that concentrations of highly skilled human capital should be associated with faster rates of real GDP per capita growth (itself very closely related to productivity growth) is not new. 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 which would certainly be a danger if, for example, the variable was defined as university graduates in the labor force at the end of the period). There is a large literature on the tendency for patents to be applied closer to their points of origin (see e.g., Audretsch, 1998, or, for a recent application to a European context, Barrios *et al.*, 2008). So we would 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, under 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, such as crime reduction or pollution control, which are likely to involve jurisdictional spillovers. Moreover, as already noted here, people in Europe are far from perfectly mobile.

Therefore we consider an 'anti-Tiebout' world in which the provision of a local public good may involve jurisdictional spillovers and where mobility is expensive. In this case, the implications are that a more efficient provision of local public goods may result if jurisdictional boundaries coincide with the set of households/agents affected by the local public good(s). One of the notable recent trends in Europe is the spread of local growth promotion efforts by authorities or agencies representing cities and regions. Now, if we suspend our disbelief and allow for the possibility that such policies[4] may have some positive impact, then local growth promotion policies would consist of the provision of a pure local public good. Extra local growth would have zero opportunity costs in consumption and be non-excludable. If, my rents go up because of additional local growth, that imposes no cost on other owners of real estate. Moreover, if a local growth promotion agency is successful, it will not be possible to exclude residents from outside the jurisdiction from benefiting from the better job opportunities or higher wages.

Since FURs are intentionally defined to be economically self-contained, their boundaries should minimize spillovers of local growth. Those who benefit from any jobs or incomes created within a FUR live within its 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

[4] We are not here concerned with the particular 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 will not too effectively capture the efficiency of local growth promotions efforts. Moreover since the functions of local government compared to national and, where it exists, regional government, vary so much across Europe, it is impractical to use local spending as an indicator of local growth promotion efforts.

incentive to establish local growth promotion agencies will be the transaction costs incurred. Such agencies typically consist of public-private partnerships initiated and facilitated by local government. The fewer the total number of jurisdictions and the larger is the central local jurisdiction, the lower will be the transaction costs, and so the greater will be the net payoff from establishing a growth promotion agency. Arguments such as these prompted Cheshire and Gordon (1996, page 389) to hypothesize that growth promotion policies would be more 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 that captures this idea 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 agency, other things being equal. It could be that the advantage increases as the governmental unit becomes 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 greater. 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. Assuming that growth promotion agencies are able to have any impact on local economic growth, this implies a positive (perhaps quadratic) relationship between the variable we call the 'policy incentive' and GDP per capita growth, since a regional tier of government that too greatly exceeds the size of the economic region or FUR may dilute the positive impact on growth.

Table 6
Dependent Variable Annualized Rate of Growth of GDP p.c. Mean 1978/80 to mean 1992/4 – Models excluding and including 'Spatial Variables'

	Model 3		**Model 4**		**Model 5**	
R^2	0.6765		0.7413		0.7555	
Adjusted R^2	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).
Variables are defined in Appendix Tables 1a and 1b. Sources for all variables are shown in Cheshire and Magrini, 2006 and 2009. Parameter values in the above table are the authors' estimates.

Model 3 in Table 6 includes all these variables. Including these variables, which are all significant, improves the fit of the model without significantly changing the estimated parameter values of the existing variables. 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, 2009 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.

Systematic spatial influences on growth

Models 4 and 5 in Table 6 show the impact of including variables designed to capture such spatial influences. The first two relate to Europe-wide influences on spatial patterns of urban growth. The first is the “Integration Gain” variable, which is intended to capture the spatial effect of European integration. Partly as a response to the perceived advantage accruing to ‘core’ regions from European integration, starting in the mid-1970s, Europe developed stronger policies aimed at redistributing economic activity to ‘peripheral’ regions. In 1972, such policies accounted for 4 percent of spending by the European Commission but increased to 15 percent by 1980 and about 30 percent by 1994. Although its impact has been questioned (see, Midelfart and Overman, 2002; Rodriguez-Pose and Fratesi, 2004), a variable for ‘peripherality’ still seems worth including. To avoid any apparent subjectivity in selecting ‘peripheral’ regions, this variable is arbitrarily defined as being all FURs more than 600 minutes time-distance from Brussels.

It is also plausible that in the more densely urbanized parts of Europe conditions in FURs will influence each other. That is, there will be interaction between neighboring cities. Drawing on the literature on spatial labor markets and the distance decay effect of innovations, we include three variables to try to capture these interactions. 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

favor FUR growth. Thus, if there are concentrations of R&D in a FUR, one would expect it to favor growth in FURs close by, subject to a distance decay effect. This is reflected in the design of the "R&D Facilities Density" variable. Similarly, if a concentration of highly skilled labor favors a FUR's growth, then a higher concentration in neighboring FURs would be expected to reduce the FUR's growth since the faster growth generated 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 (e.g., Glaeser *et al*, 1995) suggest that a higher initial level of unemployment inhibits subsequent growth. Therefore, models 4 and 5 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 neighboring $FURs_{j\text{-}n}$ with up to 120 minutes between centroids. The time distance cut-off applied to the R&D Facilities and University Students Density variables is higher – 150 minutes. These differential cut-offs 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 either the most highly skilled workers or innovation. For each FUR, the 600 minute time-distance penalty for national borders is applied to calculate the value of these spatial interaction variables implying that the processes of adjustment between the economies of neighboring FURs are severely impeded if a national border separates them. This is consistent with the logic underlying our choice for the spatial weights matrix but it also fits the data better. That is according to the test statistics a finding of spatial dependence becomes even more improbable if the 600 minute time distance penalty is included in the calculation of these localized spatial adjustment variables. This version of the model not only performs better statistically but is consistent with our other findings (see Table 6).

As shown in Table 6, all variables have the expected sign and are significant at at least the 10 percent level. Tests for joint significance provide further evidence that the underlying functional form of the policy incentive variable is quadratic, with the maximum favorable impact of the relationship between FURs and their administrative boundaries appearing when the administrative jurisdiction containing the FUR is about

1.5 times its size. Even more encouraging is the fact that all signs of spatial dependence are eliminated (see Cheshire and Magrini, 2009, for details). As before, no conventional econometric problems are indicated.

In the context of understanding the main drivers of the rate of FUR GDP per capita growth, these results suggest the existence of dynamic agglomeration economies, but that other things equal, higher population density is bad for growth. The results also suggest that while the process of European integration does indeed favor 'core' regions, policies to reduce 'spatial disparities' (the official aim of European regional policies) may have at least partially offset this tendency. The results are certainly consistent with the hypothesis that concentrations of highly skilled human capital and R&D favor local growth. Perhaps more surprisingly, they suggest that local growth promotion policies may have some positive impact because we find significant evidence that the incentives regional actors face in developing such policies are themselves influential in explaining urban growth performance. It helps if local jurisdictional boundaries coincide more closely with those of self-contained economic regions – FURs – because when there are spillovers and transactions costs associated with forming effective growth promotion agencies, such a coincidence of boundaries increases the expected gains to actors. Finally, we find strong evidence that national boundaries are still a barrier to the processes of spatial adjustment in Europe.

6. Comparing and Contrasting the Drivers of Population and Economic Growth

Given the reluctance of Europeans to migrate in response to changing patterns of opportunity or follow the sun beyond their national boundaries, it does not seem appropriate to assume that Europe is characterized 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 and economic growth. Controlling for differences in the natural rate of population growth, we 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'. When we analyze 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 analyzing the sources of spatial dependence, we find strong evidence that while population growth in one FUR influences its neighbor(s), if a national border separates two FURs, that influence is much diminished.

When we examine the drivers of economic growth, we also find a powerful national border barrier to spatial interaction between neighboring FURs. But in other ways, the drivers of economic growth are significantly different from the drivers of population growth. Dynamic agglomeration economies and concentrations of R&D and highly skilled labor are significant in driving GDP per capita growth but not in driving 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 differences in economic growth rates between FURs but not at all significant in accounting for differences in population growth.

It has been asserted that climate and environmental factors have become more important in influencing firm location because of their supposed influence on the locational choices of highly skilled labor (the so-called 'new location factors'[5]). However, our findings provide no support for this view. Climatic differences – the most obvious environmental factor – are not statistically significant in models of GDP per capita growth; the closest they come, indeed, runs counter to the supposed role of the alleged 'new location factors'. When we include the number of wet days relative to the national mean in the model, the variable has a positive sign and is on the verge of being significant, suggesting that for economic growth, wetter is better.

Overall, both the differences and similarities between the drivers of population growth

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

and economic growth broadly reflect theory. In a world of "sticky" people, we would expect sluggish adjustment to spatial differences in opportunity. We would also expect national boundaries to represent additional obstacles to spatial adjustment. Both expectations are supported by this analysis. We might also expect there to be a systematic adjustment process between FURs in densely populated regions and FURs in wider urbanized regions. The literature on labor market search and on induced commuting tells us that these processes tend to even out spatial opportunities as they occur in sets of labor markets linked by significant (potential) commuting flows. Although FUR boundaries are designed to delimit self-contained labor markets, where the boundaries are contiguous, people living in the suburban hinterlands can alter their commuting patterns over time to take advantage of opportunities in neighboring FURs. As a result of vacancy chains - that is the fact that if a person leaves a job in one location to fill a vacancy somewhere else they create a vacant job to be filled by someone living elsewhere - opportunities will tend to be equalized over the set of linked local labor markets (Morrison, 2005). The condition for this opportunity equalization between neighboring areas appears to be simply 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 labor 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 also find strong evidence that adjustment is greatly impeded across European borders. This is true for both population growth and economic growth, reinforcing the conclusion that spatial differences in Europe are persistent, not just because people are geographically immobile but because, if national borders intervene, people tend not to take advantage of even those opportunities they could reach without re-locating.

Apart from increasing our understanding of the drivers of spatial growth and adjustment processes, the evidence presented in this paper has a number of wider implications. It suggests that differences in real incomes in Europe – and more generally where populations are relatively immobile – are likely troublesomely to persist and that they are likely to indicate real differences in welfare, certainly if prices do not fully adjust. Although the evidence does not indicate how significant inter-regional income differences are relative to other sources of welfare difference between individuals, it does imply that people of similar personal characteristics may have different life chances simply because they are born in one region rather than another. Contrary to some recent assertions (e.g., Kresl, 2007), our findings also suggest 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. We also find that there are significant, but theoretically consistent, differences in the drivers of population compared to economic growth. Agglomeration economies, concentrations of research and development (R&D) activity and highly skilled human capital, and systems of urban governance play a significant role in driving spatial economic growth differences, but no role 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. Finally, we might speculate that the findings for Western Europe may be more applicable than those for the U.S. to conditions in Asia, with its long history of settlement, its patchwork of languages and cultures, and, particularly to China, where, in addition, there are deliberate restrictions on population mobility.

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Appendix

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

Industrial Emp.'75	Percentage of labor force in industry in surrounding level 2 region in 1975: source Eurostat
Coalfield: core	A dummy=1 if the core of the FUR is located within a coalfield
Coalfield: hinterland	A dummy=1 if the hinterland of the FUR is located within a coalfield
Port size '69*	Volume of port trade in 1969 in tons
Agric Emp.'75*	Percentage of labor force in agriculture in surrounding Level 2 region 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 traveling 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)
EUwest	Distance west of centre of FUR from Brussels
EUsouth	Distance south of centre of FUR from Brussels
Nat Non-FUR Pop Growth '80-'00	Annualized rate of growth of population in territory of country outside major FURs between 1980 and 2000
Wet day frequency ratio : country*	Ratio of wet day frequency between FUR and national average (1970s and 1980s)
Frost frequency ratio : country*	Ratio of ground frost frequency between FUR and national average (1970s and 1980s)
Maximum temperature ratio : country*	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.
Sources for all variables are shown in Cheshire and Magrini, 2006 and 2009.

Table 1b
Variable Definitions – Rate of Growth of GDP per capita at PPS 1978/80 to 1992/94 = Dependent Variable

No	Variable Name	Description
	Constant	
1	Population Size	Population size in 1979 (natural logarithm)
2	Population Density	Density of population in FUR in 1979 (1000 inhabitants/Km^2)
3	Coalfield Dummy: core	Dummy = 1 if the core of the FUR is located within a coalfield
4	Coalfield Dummy: hinterland	Dummy = 1 if the hinterland of the FUR is located in a coalfield
5	Port size *	Volume of port trade in 1969 (100 tons)
6	Agriculture *	Share of labor force in agriculture in surrounding NUTS 2 in 1975
7	Unemployment *	Unemployment rate (average rate between 1977 and 1981 – from Eurostat NUTS3 data)
8	National Non-FUR Growth	Growth of GDP p.c. in the territory of each country outside the FURs (annualized rate between 1978/80 and 1992/94)
9	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)
10	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)
11	Peripherality Dummy	Dummy = 1 if the FUR is more than 10 hours away from Brussels
12	University Students *	Ratio of university students (1977-78) to total employment (1979)
13	R&D Facilities *	R&D laboratories of Fortune 500 companies per 1000 inhabitants in 1980
14	Unemployment Density	Sum of differences between the unemployment rate (average between 1977 and 1981) of a FUR and the rates in neighboring FURs (within 2 hours), discounted by distance (with 10 hours time penalty for national borders)
15	University Student Density	Sum of university students per employees in neighboring FURs (within 2.5 hours), discounted by distance (with 10 hours time penalty for national borders)
16	R&D Facilities Density	Sum of R&D laboratories per 1000 inhabitants in neighboring 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.
Sources for all variables are shown in Cheshire and Magrini, 2006 and 2009.

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