European Urban Growth: throwing some economic light into the black box

By Paul Cheshire
London School of Economics
and
Stefano Magrini
University of Venice

Paper presented to 45th European Regional Science Association Congress, Amsterdam

April 2005

Corresponding author:
Paul Cheshire
Department of Geography & Environment
London School of Economics
Houghton St
London WC2A 2AE, U.K.
p.cheshire@lse.ac.uk

Università di Venezia - Dipartimento di Scienze Economiche
San Giobbe, Cannaregio 873, 30121 VENEZIA (ITALY)
Tel: (0039) 041 2349194
email: s.magrini@unive.it

European Urban Growth: throwing some economic light into the black box

by Paul Cheshire, London School of Economics & Stefano Magrini, University of Venice

This paper investigates growth differences in the urban system of the EU12 between the means of 1978/80 and 1992/94. Models in which growth of real GDP p.c. is the dependent variable perform well and make it possible to test significant hypotheses. The analysis supports the conclusion that systems of urban governance are strongly related to growth. The variables are formulated in a way which tests hypotheses derived from 'fiscal federalism' viewing growth promotion as the production of a local public good. Evidence is also found supporting a spatial adaptation of the endogenous growth model with the relative size of the university sector having a highly significant role in explaining growth differences. Careful testing for spatial dependence reveals that national borders are significant barriers to adjustment but including explicit spatial effects resolves the specification problems. Density of urbanisation in some parts of the EU12 produces a local 'growth shadow' effect consistent with dynamic agglomeration economies and with commuting flows having an important role in spatial economic adjustment processes where cities are densely packed. In addition, evidence is found supporting the conclusion that integration shocks in the EU favour core areas but that this effect tends to fade with time.

Key words: growth; cities; local public goods; human capital; convergence; territorial competition

JEL Codes: H41; H73; O18; R11; R50

1. Introduction[1]

In another paper (Cheshire and Magrini, 2004) we have shown that it is appropriate to analyse differential rates of growth of real GDP per capita if one is interested in investigating differences in welfare changes across Europe's cities. Despite a compensating variations approach showing that people adjusted to differences in quality of life between cities within countries, the evidence strongly supported the conclusion that no such pattern existed across the cities of Europe as a whole. In that sense city regions within the EU seem to behave like city-states, not as simply the spatial units from which a continental economy is constructed. The central assumption of perfectly mobile factors and the equalisation of real marginal returns across cities explicit in models of compensating variations (the Quality of Life approach developed on the basis of Roback's 1982 contribution) cannot reasonably be maintained in the European context.

This paper therefore returns to the analysis of differential rates of growth of real income across city regions (represented as Functional Urban Regions or FURs – used in Cheshire and Magrini 2000 and 2004). We focus on the role of three types of variable identified in economic theory as potentially important in explaining economic growth in a spatial context. The first is the systematic spatial effects of European integration. Interest in this empirically goes back at least to Clark et al (1969) and it is interesting to use the quantitative indicators actually derived by Clark and his associates before the impact of European integration was significantly felt. Interest in these factors has been given a significant boost as a result of the theoretical developments of New Economic Geography as summarised, for example, in Fujita *et al.*, 1999. The second variable we are interested in is the role of R & D and human capital. Here we are interested in testing a spatialised adaptation of endogenous growth theory (see Cheshire and Carbonaro, 1996 or, for a more rigorous development, Magrini, 1998). The third area we are interested in investigating is the relationship between systems of city government and city growth performance. Here we test one of the basic propositions of fiscal federalism: that 'the existence and magnitude of spillover effects clearly depends on the geographical extent of the relevant jurisdiction' (Oates, 1999). Specifically we test that there is a positive relationship between the degree of co-incidence of governmental boundaries with those of functionally defined city-regions and the growth performance of the city-region.

We have also paid particular attention to issues of spatial dependency. Spatial econometrics tends to exist as a separate area of interest in which a finding of spatial dependency is often an end in itself - sometimes to be 'corrected' by introducing spatial lags. Our views are somewhat different. It seems important to test for spatial dependency since, if it is present, and the analysis does not properly take it into account, parameter estimates can be biased just as they can be in time series analysis if there are problems of serial autocorrelation which are not offset for. However, it seems to us that the discovery of spatial dependence should trigger a further but economically inspired investigation. If, for example, a problem of spatial autocorrelation in the residuals is indicated this suggests there is a specification problem. Something which explains this pattern has been omitted and if the model is specified better then the problem should be resolved. This is particularly relevant in investigating spatial economic processes since theory suggests that there are important spatial adjustment mechanisms and other spatially determined features of economies. For example, labour markets and housing markets are likely to adjust to price and real wage differences in ways

[1] The authors have benefited from many discussions with colleagues as this work has developed. The authors retain responsibility for any remaining deficiencies or errors. This paper draws on work undertaken for a project within the ESRC's Cities Initiative under Award L 130251015 whose support is gratefully acknowledged.

conditioned on some measure of distance. Theoretical and empirical investigations of agglomeration economies, human capital and innovation suggest there are important spatial aspects of these features of economies. These are possible sources of spatial interaction between cities' economies which, if not represented in the model, would plausibly show up as spatial dependency.

As the results reported below suggest, there seems to be some validity to this viewpoint. When we estimate growth models in which no spatial adjustment processes are explicitly included, tests show that there are problems of spatial dependency which cannot be eliminated simply be estimating a spatially lagged model. However deliberately including measures of spatial economic adjustment processes, which are a function of the distance between cities, does appear to eliminate spatial dependence and specification problems.

In addition, the way in which the sensitivity of the models to measures of spatial dependence varies with the particular distance weights used provides, in our interpretation, insight into economic processes. Problems of spatial dependence only reveal themselves if an additional distance penalty to adjustment is included for national borders: this, we judge, tells one about the extent to which urban systems in Western Europe still adjust as a set of national urban systems rather than as a unified EU urban system.

We should clarify from the outset that we do not conceive of growth promotion policies in the narrow sense in which their advocates often speak of them: as policies aimed at the direct attraction of mobile investment. We have a much broader definition in mind. Such policies include: having a concern for efficient public administration so that uncertainty is reduced; making sure relevant infrastructure is provided and maintained; co-ordination between public and private investment; providing training which is relevant and effective; and ensuring that land use policies are flexible and co-ordinated with infrastructure provision and the demands of private sector investors. It could also involve giving a higher priority to output growth as opposed to equity or environmental outcomes. It need not involve spending more, even on infrastructure, so a simple measure of local expenditure is unlikely to be an appropriate measure of the efficacy of growth promotion efforts even were such a variable available. Grand projects such, perhaps, as the Guggenheim museum in Bilbao, London's Millennium Dome or a trophy metro system in Toulouse – may be expensive but not productive; efficient public administration and reduction of uncertainty for private investment by rapid decision-making, clearly defined land use policies and infrastructure planning, may cost less than their inefficient alternatives.

Since the output of such policies is the impact they have on local growth performance they can be viewed as the provision of a pure local public good[2]. It will be hard to impossible to exclude agents who have not contributed to the policy from any benefits the policy generates; and there will be a zero opportunity cost in consumption: if your rents rise so do mine and the increase in yours is not a cost to me; if your employment opportunities improve that, too, is not a cost to mine. The closer the coincidence in the boundaries of the governmental unit providing such policies with those of the economic region within which their impact is contained, the less will be the spatial spillovers to non-contributors. In addition, the larger is the central unit of government of an economically self-contained urban region relative to the size of that region as a whole, the lower will be the transactions costs in building a 'growth-coalition' or territorially competitive club.

[2] The local public good, non-excludable and non-rival in consumption, is, of course the growth they may produce. Resources employed in the promotion of growth are simply a cost.

Our analysis of the data presented in section 3 below, suggests there is evidence of a strong relationship between the degree of coincidence of governmental and economic boundaries in EU cities and the city's growth performance. Our evidence is consistent with both the basic premises of fiscal federalism, therefore, and the conditionality of the provision of local public goods. It is, furthermore, consistent with there being some systematic contribution that local public administration can make to local growth performance.

2. Data and variables

All the analysis is performed on a data set built up over a 25 year period relating to Functional Urban Regions (FURs) defined[3] so far as possible according to common criteria across the EU of 12. Such FURs correspond to the economic spheres of influence of significant employment concentrations and are relatively self-contained in economic terms. The analysis is conducted only for FURs with a population of more than one third of a million and a core city which exceeded 200 000 at some date between 1951 and 1981. Cities of the former eastern Länder of Germany and Berlin have to be excluded because of lack of data. The new basis on which Eurostat estimated regional GDP from 1995 onwards means that the analysis stops then. The variables used are defined in Appendix 1 which also provides a brief description of how they were measured and the sources used. All data are defined to common statistical concepts either weighting data available from the Eurostat REGIO database to estimate values for FURs or collected directly from national statistical offices or common data providers and adjusted where necessary to common definitions. There is necessarily some imperfection and imprecision in such data but they have the merit of not only allowing analysis of specifically European cities but also of allowing the investigation of questions which, because of lack of variation, simply could not be investigated in the context of the US urban system.

Since the focus of this paper is regional fixed effects, the analysis employs OLS but we provide substantial testing to ensure the results are not subject to econometric problems. Since the observations represent the population of West European city-regions the other objections raised by Levine and Renelt (1992) or Levine and Zervos (1993) to the use of cross sectional OLS in cross country growth studies do not seem to apply.

We have still not managed to find a satisfactory way of bridging the Eurostat regional GDP series across the difference in estimation methodology introduced in 1995. Thus, we are still analysing the rate of growth of GDP at common PPS values estimated for each FUR based on Eurostat GDP for Level 3 regions. Estimates of GDP p.c. for FURs are derived by using the distribution of FUR population between Level 3 regions at the closest Census dates as weights and then applying those weights to the relevant Level 3 GDP p.c. data[4]. Because of

[3] For a detailed discussion of the definition of the FURs used throughout this paper see Cheshire and Hay (1989). They are defined on the basis of core cities identified by concentrations of employment and hinterlands from which more commuters flow to the employment core than to any other subject to a minimum cut off. They were defined on the basis of data for 1971. They are broadly similar in concept to the (Standard) Metropolitan Statistical Areas used in the US. As has been argued elsewhere (Cheshire and Hay, 1989) the great variability in the relationship between administrative boundaries and the economic reality of European cities and regions introduces serious error and a strong likelihood of bias into data reported for administratively defined cities. The FUR/city and region of Bremen provide an extreme but not wholly unrepresentative example. Because of population relative to employment decentralisation over the relevant period the growth of GDP p.c. is overstated by some 40% if the published Eurostat data for the administrative region is relied on.

[4] The EU institutions deal in so-called 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

measurement error and short run fluctuations in Eurostat data, we take the start point of the series as the mean for 1978-80 and the end point as the mean for 1992 to 1994. We are thus analysing a period too short to correspond to a conceptual long run. Even if the system did tend to equalisation of returns to factors on the margin new shocks and disturbances will occur long before such a position is reached. We need therefore to model a system in which real incomes can permanently (in the sense of any period we can observe) vary between cities.

The data used are derived mainly from Eurostat, accessed via REGIO. Regional GDP data have been published for most Level 1, 2 and 3 regions since 1978 although for some it is available from 1977. There are however gaps – data for Greek and Portuguese regions for example only became available later. In both cases, REGIO data have been supplemented with national data. For some countries, such as Italy, data for earlier years were only published for Level 2 regions. National sources, for example of value added in Italy, have been used to disaggregate from Level 2 to Level 3 values where none are published by Eurostat. Other data come from a number of sources including Eurostat (for example the employment by sector and the unemployment data) as well as other sources. All the variables used are defined in Appendix 1.

The same control variables are used for industrial structure as have been used in previous work (see Cheshire and Magrini, 2000 for an explanation and justification). As before the more detailed measures relating to old resource-based industries work better than broader measures of specialisation in industry or initial unemployment rates. A measure of the rate of growth of GDP p.c. in the area of each country outside the major FURs is included as a control for national institutional, policy and other factors which may have led to countries having had country-specific differences in their growth rates over the period. The variable should also effectively control for national differences in the incidence of the economic cycle. Although national dummies have been the way in which this problem has frequently been handled in the literature it seems more elegant and powerful to use the continuous variable employed here. Besides being highly significant a further point of interest is that it eliminates the significance of any measure of the initial level of GDP p.c. Previous work has shown that both the significance and even sign of this commonly used variable were highly dependent on model specification (Cheshire and Carbonaro, 1996) and this confirms that result. It suggests that there is more variance in FUR growth rates across countries than within them and that the initial level of GDP p.c. acts in large measure as a national dummy. This finding is one factor underlying our scepticism with respect to the many estimates of so-called β-convergence following Barro (1990) and Barro and Sala-i-Martin (1991; 1992; 1995). All the results of models which included the initial level of per capita income were unsatisfactory, with highly unstable co-efficient estimates associated with the variable and problems of collinearity.

The log of population size is included with the expectation that larger cities will have grown faster in terms of GDP p.c. because of productivity gains in larger urban areas (see Costa and Kahn, 2000 for a convincing account of at least one important source of such productivity gains in larger cities). Dynamic agglomeration economies are another possible explanation. Initial population density is also included since, other things equal, cities with higher density will have higher rents and greater congestion. A negative relationship is expected. In our judgement, initial population density is likely mainly to reflect differences between FURs in the constraint on urban land supply produced by land use regulation policies. Higher density other things equal signals a tighter constraint imposed on development. Topography and the inertia of inheritance embodied in the built environment no doubt contribute to differences in densities but probably

smallest for which a reasonable range of data is available are Level 3. These correspond to Counties in the UK, Départements in France; Provincies in Italy or Kreise in Germany.

less than land use policy which varies substantially both across countries and between cities in Europe.

Given that our observational units represent sub-national economic regions as self-contained as are likely to exist, what basis is there for hypothesising that their form of government – specifically the degree of co-incidence of the spatial boundaries of government to those of the FUR – are likely to be directly related to observed differences in growth rates? It is reasonable to think of any FUR as being made up of one or more administrative units and that a 'club' of administrative units (whether including private sector actors or not) will have to be formed to provide growth promotion policies. It is also reasonable to assume that the largest unit within the FUR – the central unit – will always be a part of such a club, either alone or together with other administrative units, so the territory of a FUR is made up of two potential sets of governmental units: the policy club members and the group of non-participating units.

With EU integration over the past 20 years there has been an associated development of *territorial competition* or competition between regions to promote local growth. To the extent that there is an ‘output’ from such activities, it is local economic growth which as was argued above is the provision of a pure local public good. There are, therefore, the usual problems associated with the provision of (local) public goods, including a classic problem of spatial spillovers. Whether or not such policies are engaged in will be conditioned primarily on the structure of the incentives faced by the economic actors who may attempt to form a public/private consortium or ‘growth promotion club’.

The expected gross payoff will be a direct function of the additional growth that a given club expects it can generate. Since FURs are defined to be economically self-contained, it is reasonable to assume that the territory their boundaries identify contains any the benefits that might be generated by local growth promotion policies. For a given potential growth gain for a FUR - which contains the benefits of the growth - the expected payoff for any growth club will fall as the size of the territory falls in relation to that of the FUR within the boundaries of which the ‘club’ is located. This is because the spillover losses to areas of the FUR not represented in the club increases. Equally, assuming other factors are constant, the expected net payoff would fall as the transactions costs necessarily incurred to form the club increase. Transactions costs will be positively related to the number of relevant potential members and the institutional dominance of the lead actor (which we can assume will be a governmental unit). Thus expected net benefits will increase and costs fall as the size of the largest (normally that representing the central unit or urban core) governmental unit increases relative to the size of the FUR. Arguments such as these led Cheshire and Gordon (1996, page 389) to conclude 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...'.

Applying this analysis it is possible to specify a variable closely reflecting this feature of FURs: the ratio of the total population of the largest (relevant) unit of government representing the FUR to the population of the FUR as a whole. We are implicitly assuming this will be the governmental unit with the largest population, usually representing the central administrative unit of the FUR, but this is qualified by 'relevant': by which we mean that the governmental unit concerned must have significant powers of action. Even though it might be the largest N.U.T.S. region with a territory overlapping that of the London FUR, for example, the South East Region would not have been a 'relevant' governmental unit because it had essentially no powers[5]. The rules by which such 'relevant' local government units were identified were established before any models including the variable were estimated so that the variable could be defined blind of the data. The rules used are set out in Appendix 1.

We call this the ***policy capacity*** variable because it is designed to measure the capacity to prosecute policies promoting growth at the FUR level[6]. In identifying the largest 'relevant' unit of government, 'relevant' is defined as a sub-national unit of government with an administrative area encompassing or corresponding to (some proportion of) the territory of a FUR and which has significant administrative and decision-making powers. Since the largest 'relevant' unit was selected, it was also in all cases the highest tier of sub-national government relating to the territory of the FUR. Since one criterion was that the unit of government selected should have significant administrative and decision making powers the Level 1 regions were potentially available for selection in European countries with a regional level of government. In practice, this means that the value of the variable can range from only about 0.125 to over 2. We might further hypothesise that if the value of the variable were very high, so that the size of the 'relevant' unit of government considerably exceeded the size of the FUR, then the capacity to generate local growth promoting policies would begin to weaken. This is because the interests of the FUR would begin to be lost in those of the larger unit which might pursue policies favouring rural areas or smaller centres. If this were the case then we would expect to observe a quadratic functional form with a maximum positive impact where the value of the policy capacity variable was between 1 and 2.

The concentration of the R & D facilities of large companies and of university students per employee (both measured for the start of the period analysed) are included to test for the influence on local growth of highly skilled human capital and specialisation in R & D. The theoretical reasons for focusing on these factors follow the analysis of Romer (1990) as adapted to a spatial context by, for example, Cheshire and Carbonaro (1996) and Magrini (1998). There is an extensive literature on the role of human capital in economic growth so the inclusion of these variables requires little justification.

At least since the 1960s there have been arguments that (European) integration would have systematic spatial effects, economically favouring 'core' regions. An early empirical attempt to quantify such effects was embodied in the work of Clark *et al.,* (1969). More recently theoretical work by Krugman and Venables has produced formal models with essentially the same conclusions (see Fujita *et al.,* 1999, for an up to date survey). The Integration Gain variable, selected to measure the direct spatial impacts of European integration, is calculated from the work of Clark *et al.,* (1969) supplemented with the estimates for the regions of Spain and Portugal provided by Keeble *et al.,* (1988) and scaled to Clark *et al*'s values. Values for Athens, Lisboa, Porto and Saliniki were interpolated to provide coverage of all the regions of the EU of 12. Since our interest is in growth we have calculated the *change* in the values of 'economic potential'[7] from the pre-Treaty of Rome values to those estimated as being associated with an elimination of tariffs, the EU's enlargement of the 1980s and a reduction in transport costs following the introduction of roll-on roll-off ferries and containerisation.

---

[5] During the period analysed there was a South East Regional Planning Council (SERPLAN) but this was effectively no more than a forum for discussion.
[6] Implicitly we assume FURs – since they are defined to be economically self-contained and therefore minimise spillover losses of growth to politically defined territories outside their boundaries – approximate to the 'most appropriate territorial units' at which to pursue local growth promotion policies.
[7] Economic potential is a measure of the accessibility at any point to total GDP allowing for costs of distance including tariffs. For further discussion see Clark *et al.,* 1969

The theoretical arguments as to why integration should favour core regions do not imply that the relationship measured for the 1980s or the 1990s should necessarily be linear with respect to the variable used here. Clark's calculations are for different hypothetical states of the world but with regional GDP data estimated for, and fixed at, 1966. Any differential spatial growth induced by integration might have been fastest where economic potential increased most in the initial stages. But such growth would tend to bid up local factor costs and produce additional congestion, other things equal. In turn, with a fixed and single integration shock, this would tend to produce deconcentration over time from the core to surrounding regions. Therefore, in the absence of further integration shocks, by the 1980s the relationship between differential urban growth and Clark *et al*'s (1969) estimates of the change in economic potential might be expected to be quadratic. The greatest gains would no longer have been in the core regions but in the outer core/near periphery. The introduction of the Single European Market (SEM) and then of monetary union might be expected to have provided new integration shocks, however, and so have given additional impetus to the spatial impact of European integration. Thus with the extension of the observations into the 1990s and so including data for the period leading up to and immediately following the SEM, there might be a reinforcing of the influence of the change in economic potential on FUR growth. Such an increase in the influence of European integration on local growth would be reflected in an increased significance of the estimated co-efficient of the Integration Gain variable and a reversion to a linear functional form. This would reflect a re-concentration of the strongest impact in the inner core regions. This is exactly the result reported in Tables 1a and 1b where the variable is significant and the functional form linear (compared to the results reported in Cheshire and Carbonaro, 1996, using data only to 1990, in which the functional form was quadratic and the variable only weakly significant).

3. Results of modelling urban growth rates

The results of three basic models, which do not include explicit spatial factors beyond the Integration Gain variable, are reported in Table 1a. It will be seen that all variables are significant and have the expected sign[8]. As in previous work, the functional form relating to the initial size of the port industry is quadratic implying that the transformation of the port industry since about 1970 may have at least relatively favoured the very largest ports. The three sets of variables which are the focus of our attention here are all significant. Also, as expected, there is a quadratic functional form between the observed rate of growth of a city and its policy capacity.

Thus, these results appear acceptable. The adjusted R^2, with 121 observations in a cross sectional analysis, is 0.65 and all variables are significant with the expected signs; nor are there are any problems of non-normality of errors or heteroskedasticity. The results, moreover, are consistent with economic theory and suggest interesting new insights as to the potential role of both human capital and growth promotion policies in accounting for growth differences between EU city regions.

However, inspection of Table 1b, which reports the key results of diagnostic tests, suggests there may be problems: there are signs of spatial dependence. As is well known a key problem in testing for spatial dependence compared to serial autocorrelation is the specification of the 'proximity' of one observation to another. There is no obvious basis upon which distance weights can be determined. Tests were conducted using 28 different distance weight matrices. We report only the results for which the greatest sensitivity was found. Measuring distance as the inverse of time distance using the standard road freight software to estimate the time distance between FURs always provided the measure most sensitive to spatial dependency. In

[8] Models were estimated in Stata using robust standard errors.

Tables 1b and 3b, we report results for two formulations - the inverse of time distance and the inverse of time distance squared.

Tables 1a & 1b about here

An innovation in the present paper, however, is that we have also included an additional 'time distance penalty' if FURs are separated by a national border. This partly reflects recent work reported in Cheshire and Magrini (2004) which found that there was adjustment within countries but not between them to differences in quality of life. The implication is that national borders in Europe still represent substantial barriers to spatial adjustment. Border time-distance costs from 0 to 300 minutes were experimented with and the results were most sensitive if it was implicitly assumed a national border represented a time-distance of 300 minutes.

If we look at the results for Model 3, the diagnostics for spatial dependence most obviously suggest the presence of spatial lag dependence using the inverse of time distance squared plus a border penalty of 300 minutes[9]. This is of interest in itself since it underlines how important the choice of the distance weights is. In many previous tests on similar models in which no time-distance penalty was imposed for national borders, no problems of spatial dependence were evident. If the standard remedy is applied and a maximum likelihood model is estimated with spatial lags, using the same independent variables, the model appears to work in much the same way although two estimated parameters – for policy capacity squared and integration gain – are now only significant at the 10% level. The results are reported in Table 2 which also reports results from further diagnostics for the spatially lagged model.

Table 2 about here

Although indications of spatial dependence are less obvious, a significant new problem emerges. The ordering of the values of the Wald, LR and LM_{LAG} statistics is unsatisfactory suggesting specification problems. Although the LR, Wald and LM tests are all asymptotically equivalent, they tend to yield different results in finite samples. In particular, the ordering of statistics in terms of their magnitude should be:

$$\mathbf{W \geq LR \geq LM}$$

This suggested the need to try to represent the spatial interactions more directly within the model itself. Table 3a reports some results from such experiments with Table 3b reporting the corresponding diagnostic test results. These models include three additional variables. The first is a spatial version of the university student variable. The rationale for this is that previous analysis (see, for example, Cheshire and Magrini, 2000) found that a concentration of university students within a local economy had a positive effect on its growth. Workers embodying greater human capital commute longer distances and so a proportion of those living in FURs close to other, more dynamic ones, may commute to work in the more prosperous region. In addition, Costa and Kahn (2000) found an increasing concentration over time of more couples embodying more human capital where opportunities were greatest (and bearing in mind that our university students measure relates to the start of the period so does not reflect any tendency for such workers to concentrate where opportunities are greatest).

[9] Other values for the border penalty are available from the authors but for Model 3 the test statistics revealed no problems of spatial dependence if the border penalty was assumed to be less than 40 minutes and signs of spatial dependence became stronger as the penalty was 'increased' to 300 minutes. Results were always more sensitive if the inverse of time distance squared was used rather than the inverse of time distance.

These factors suggest we might expect faster growing FURs to attract human capital from surrounding ones increasing their growth further. So we constructed a variable, for each FUR, measuring the distance discounted concentration of university students in all other FURs within 150 minutes travel time (other cutoffs were tried but 150 minutes worked best) of the FUR in question. The prior is that, other things being equal, the stronger the concentration of university students in surrounding FURs, the slower should be growth in the observed FUR. A negative coefficient would also be consistent with the idea that human capital has a tendency to concentrate over space.

Tables 3a & 3b about here

Model 4 in Table 3a includes this variable plus a dummy for the FURs of North East Italy, previous work having suggested that while there might not be 'two Italies' it was difficult to account for the growth performance of three Italian cities – Padua, Venezia and Verona on the basis of their characteristics alone. The variable measuring the distance-discounted concentration of university students in surrounding FURs is significant and has a negative sign. More generally, this specification appears to improve the econometric problems associated with Model 3. Measures of fit increase substantially and the model passes normality and heteroskedasticity tests at usual confidence levels. Perhaps more interesting are the results of the tests on spatial dependence; while there was a problem of spatial **lag** dependence in Models 1, 2 and 3, there is now only spatial **error** dependence, a substantially less serious problem.

These encouraging results prompted further experimentation with devising explicitly spatial variables. The next variable, included in Model 5, is a measure of the spatial concentration of unemployment at the start of the period in the FURs surrounding the observed FUR. Because of the concentration of unemployment on less skilled workers who have smaller labour market search areas and shorter commutes, we should expect a stronger distance decay effect and a cutoff of 60 minutes commuting time gives the best results. As would be expected the parameter estimate for the variable measuring the concentration of unemployment in a FUR compared to its neighbours has a negative sign: the higher the initial level of unemployment in a FUR compared to its neighbours, the slower the FUR's growth over the subsequent period. Other co-efficient estimates remain significant and are numerically little changed.

As in Model 4, however, there are signs of spatial error dependence so we have estimated a corresponding spatial error model using maximum likelihood. This is reported in Table 4. In this all variables are highly significant (at 3% or better), with no signs of misspecification and, in particular, the ordering of the Wald, LR and LM_{ERR} tests is as expected, indicating no apparent specification problems.

Table 4 about here

The final variable is added in model 6. This is a measure of the differential growth in the observed FUR compared to all its neighbouring FURs over the first six years of the period. The sum of the differential growth rates in surrounding FURs is discounted by distance and summed to a 150 minute time-distance. In principle, therefore, there is little chance of endogeneity: although the growth rate of the observed FUR is in a sense on both sides of the estimated model, on the right hand side it is over the first six years only and it is the sum of the differences in the growth rates discounted to a maximum of 150 minutes travelling time. Thus, for some 10 percent of FURs the value of the sum of the differential growth variable is zero and the correlation coefficient between this variable and the dependent one is only 0.43.

This growth differentials variable represents a 'growth shadow' effect: the expectation is that if a FUR is growing faster than its neighbours in the early part of the period it will grow even faster over the period as a whole than it otherwise would. This will be for any or all of three reasons. The first is that its commuting area will be expanding, as opportunities within it will have improved relative to surrounding cities, attracting more workers. Since output is counted at workplaces but people at their homes, measures of GDP p.c. are liable, therefore, to become upwardly biased and the measured growth rate correspondingly inflated. As we have shown in Cheshire and Magrini (1998) however this does not account for all of the effect of the growth differential variable since its statistical impact remains even when the model is re-estimated on growth in GDP per employee rather than GDP per capita. A second possible reason to expect a significant relationship is that workers attracted to commute to the faster growing FUR will travel longer distances and longer distance commuters are likely to embody more human capital on average so there may be a favourable composition effect on the workforce of the FUR growing faster at the start of the period and a corresponding negative composition effect on the labour force of FURs which were slower growing. The final possible reason for expecting a 'growth shadow' effect is that there may be dynamic agglomeration economies. The initially faster growing FUR gains productivity and jobs and this in turn helps raise productivity and jobs along the lines investigated by Ciccone and Hall (1996).

Including the sum of growth differentials variable makes the spatial unemployment variable non-significant, so that is dropped from Model 6. Using robust standard errors, all other variables are significant and have the expected sign. Looking at the regression diagnostics, there are now no signs of significant spatial dependence in terms of either lags or errors although there are signs from the Jarque-Bera test that the errors are not normal (see Table 3b). This should not, however, be too serious a problem leading to biased estimates and other tests, such as the Shapiro-Wilk, indicate no problem of non-normality in any case.

Our conclusion is, therefore, that by including variables reflecting theoretically relevant spatial adjustment mechanisms and features of the world it is possible effectively to eliminate apparent problems of spatial dependency. Spatial dependency largely reflects model specification and if explicit spatial factors are included, such problems are resolved. Furthermore testing for spatial dependency is itself very demanding. No problems had been indicated in earlier work and it was only when the lessons of Cheshire and Magrini (2004) were applied and a substantial time penalty for national borders was introduced into the distance weights matrix that problems of spatial dependency appeared anyway.

From an economic perspective the main conclusions are to re-enforce previous findings that local differences in human capital and R & D activity are important factors in explaining differential rates of urban economic growth and that European integration has had a significant impact in accelerating growth in core regions of Europe. In economic terms, there is evidence that the gains of integration have been unevenly distributed spatially. Finally, there is new evidence strongly supporting the conclusion that administrative and government arrangements for cities systematically influence their growth. Where there is a governmental unit approximating to the economic boundaries of an economically self-contained city-region, growth is stronger. This is consistent with the expectations relating to the promotion of growth as a local public good and the resulting advantage if spillover losses and transactions costs are minimised.

6. Conclusions

This paper tests a series of propositions relating to the European spatial economy and particularly to the mechanisms of adjustment within it (implicitly contrasted with those in the US). We investigate, in particular, the effects on urban growth performance of European integration, human capital endowments and concentration on R & D and the impact variation in the arrangements for urban government may have. Policies that encourage local economic growth can be seen as the provision of a local public good. Conditions increasingly favour the development of growth promoting clubs, therefore, as spillover losses and transactions costs fall. The policy capacity variable, measured as the ratio of the size of the largest governmental unit to that of the economic region (FUR) is designed to reflect this capacity to develop local growth promotion clubs and produces statistically powerful results.

Policies encouraging local economic growth are not here conceived of as being particularly concerned with inward investment nor even, necessarily, with explicitly promoting growth at all. They may consist mainly of efficient local public administration, the avoidance of waste and a focus on activities that government at an urban level can effectively influence, such as the supply of skills or infrastructure planning, rather than redistribution. It is not possible to measure these factors comparably across the urban areas of the EU as a whole. Indeed, it is difficult to think of any general direct quantitative indicator. Work in the US, for example Rappaport 1999, has used measures of individual policies, such as expenditures on elementary and secondary school education. The variable used in the present paper seems justified on theoretical grounds but is an indirect measure designed to reflect not the policies themselves but the capacity of an urban government to generate such policies. There is a strong positive association between this variable and economic growth performance. This is apparent even in a very simple model but more fully specified models and further testing confirm its statistical significance and provide evidence of a quadratic functional form. This suggests that if the government unit is too large relative to the FUR concerned the interests of the FUR may tend to get lost in those of the larger region.

The results also support the conclusion of Cheshire and Magrini (2004). A compensating variations model across the whole territory of the EU of 12 is not appropriate because while adjustments do occur they occur strictly within nations not across the EU as a whole. Here we find that indications of spatial dependence in the results are only observed if a substantial time-distance penalty is added where FURs are separated by national boundaries. Results are most sensitive if national boundaries are represented by a penalty equivalent to 300 minutes travel time.

One conclusion from this pair of findings is that in a European context of restricted labour mobility, income growth rather than population growth is a more appropriate indicator of improvements in welfare in a city. Furthermore we find that the resulting econometric problems are best resolved if explicit spatial economic effects are included in the model rather than simply resorting to technical fixes such as estimating models with a spatial lag. These spatial effects include one derived from the assumption that commuting flows (in contrast to migration) play a significant role in Europe in spatial adjustment between neighbouring FURs. We observe a significant 'growth shadow' effect with cities in contiguously urbanised regions (such as most of the Benelux countries or large areas of Germany, northern Italy or England) growing faster the closer they are to other less rapidly growing cities. This seems to reflect adjustment in commuting patterns to take advantage of changing patterns of spatial economic opportunity.

The empirical results also provide support for the theoretical work of Magrini (1997; 1998) on the role of human capital in regional growth and its interaction with the effects of integration. In this, a plausible outcome of the process of European integration is that regional economic growth diverges and the disparities in per capita income increase rather than converge. Integration similar to that which has characterised recent European history is seen as a possible cause for the emergence of a new steady-state equilibrium characterised by a further concentration of research activities in the regions which were already relatively specialised in research. While the adjustment takes place through the spatial reallocation of unskilled labour and human capital, the average per capita income in the more innovative, relatively research-intensive region(s) grows at a faster rate than in the other region(s). At the same time 'unskilled' labour (and population) increases in the non-research specialised regions. This leads to a new steady-state distribution of per capita income characterised by an increase in spatial disparities.

The results do not identify a policy lever one could pull to change the outcomes observed. It does not follow, for example, that if every city were given the same proportion of university students per employee they would all have grown at the same rate as the actually best endowed with universities did. While true that the differences in endowment with universities was one factor in explaining growth differences - and that helps understand what was going on - there is no necessary symmetry about the impact of giving all cities the same sized relative university sectors. It is probable that the unobserved characteristics of the cities with the highest ratios of university students were, and still are, different in important ways from cities with the lowest ratios; and were not independent of the concentration of universities in them. Nor is it possible to think in practical terms of providing all cities with equally high ratios of university students per total employee and maintaining a constant quality of university students (and students who then disproportionately join the local labour force).

It is much more plausible to think of the findings on the policy capacity variable as identifying a ‘policy lever’. Local and regional government boundaries and functions could be restructured and, if an important element of the disadvantage FURs with fragmented local government structures face results from the problems of spillovers and transaction costs entailed in forming effective growth clubs, the outcome should be more effective growth policies all round. A problem is that, of course, ‘effective’ local growth promotion policies at present, in circumstances in which not all city regions are equally well endowed with the capacity to develop them, may be significantly competitive and diversionary. Some local growth may be zero sum. The success of the successful may significantly be a function of the poor performance of the unsuccessful. It does not follow that all policies designed to promote local growth are zero sum, however. It is reasonable to expect that there could be net efficiency gains for the EU's urban system as a whole if government boundaries – at least for the highest strategic tiers of local government – were aligned more closely with those reflecting economically relevant patterns of behaviour and spatial economic organisation.

References

Alonso, W. (1964) ‘Location Theory’, in *Regional Development and Planning*, (J. Friedmann and W. Alonso, Eds.), Cambridge MA: MIT Press.

Barro, R.J. (1990) ‘Government Spending in a Simple Model of Endogenous Growth’, *Journal of Political Economy*, **98**, S103-S125.

Barro, R. J. and Sala-i-Martin, X. (1991), “Convergence across States and Regions” *Brooking Papers on Economic Activity*, 1: 107-182.

Barro, R. J. and Sala-i-Martin, X. (1992), “Convergence” *Journal of Political Economy* 100 (2), 223-251.

Barro, R.J. and X. Sala-i-Martin, (1995) *Economic Growth*, New York: McGraw-Hill.

Cheshire, P.C. and D. G. Hay, (1989), *Urban Problems in Western Europe: an economic analysis*, Unwin Hyman: London.

Cheshire, P.C. and G. Carbonaro, (1996), 'European Urban Economic Growth: testing theory and policy prescriptions', *Urban Studies*, **33**, 7, 1111-28.

Cheshire, P.C. and I.R. Gordon (1996) 'Territorial Competition and the Logic of Collective (In)action', *International Journal of Urban and Regional Research*, **20**, 383-99.

Cheshire, P.C. and S. Magrini, (1998) ‘Investigating the Causes and Effects of Localised Income Divergences in the EU’**,** paper given at *39th European Regional Science Association Congress*, Dublin, August.

Cheshire, P.C. and S. Magrini, (2000) ‘Endogenous Processes in European Regional Growth: Implications for Convergence and Policy’, *Growth and Change*, **32**, 4, 455-79.

Cheshire, P.C. and S. Magrini, (2004) ‘Population Growth in European Cities: weather matters – but only nationally’, paper given to 43rd European Congress of Regional Science, Porto.

Ciccone, A. and R.E. Hall (1996) ‘Productivity and Density of Economic Activity’, *American Economic Review*, **86**, 54-70.

Clark, C., F. Wilson, and J. Bradley, (1969) ‘Industrial location and economic potential in Western Europe’ *Regional Studies*, **3**, 197-212.

Costa, D.L.and M.E. Kahn (2000) 'Power Couples: Changes in the Locational Choice of the College Educated, 1940-1990', *Quarterly Journal of Economics* **115**(4), 1287-1315.

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

Glaeser, E.L., J.A.Scheinkman and A. Shleifer (1995) 'Economic Growth in a Cross-Section of Cities', *Journal of Monetary Economics*, **36**, 117-43.

Keeble, D., J. Offord and S. Walker (1988) *Peripheral Regions in a Community of Twelve Member States*, Office of Official Publications, Luxembourg.

Levine, R. and D. Renelt (1992) ‘What have we learned about Policy and Growth from Cross-Country Regressions?’, *American Economic Review*, **83**, 4, 942-63.

Levine, R. and S.J. Zervos (1993) ‘A Sensitivity Analysis of Cross-Country Growth Regressions?’, *American Economic Review*, **82**, 2, 426-30.

Magrini, S. (1997) ‘Spatial Concentration in Research and Regional Income Disparities in a Decentralised Model of Endogenous Growth’, *Research Paper in Environmental and Spatial Analysis No. 43*, London School of Economics

Magrini, S. (1998) *Modelling Regional Economic Growth: The Role of Human Capital and Innovation*, Ph.D. Thesis, London School of Economics.

Olson, M. (1965) The Logic of Collective Action, Public Goods and the Theory of Groups, Harvard University Press: Cambridge, Mass.

Roback, J. (1982) ‘ Wages, rents, and the quality of life’, *Journal of Political Economy*, **90**, 1257-1278.

Rodriguez-Pose, A. (1998) *The Dynamics of Regional Growth in Europe: social and political factors*, Oxford: Clarendon Press.

Romer, P. (1990) 'Endogenous Technological Change', *Journal of Political Economy*, **98**, S71-S102.

Table 1a: Dependent Variable Annualised Rate of Growth of GDP p.c. Mean 1978/80 to mean 1992/4: Basic Models: robust standard errors

Model	1	2	3
R2	0.5903	0.6296	0.6896
R2-adj	0.5570	0.5922	0.6486
LIK	485.560	491.662	502.356
Constant	-0.0204808	-0.023909	-0.0363739
t	-2.35	-2.95	-4.42
prob	0.02	0.00	0.00
Coalfield: core	-0.0053883	-0.0057917	-0.005883
t	-5.08	-5.21	-5.74
prob	0.00	0.00	0.00
Coalfield: hint'land	-0.0057241	-0.0049746	-0.0045517
t	-3.64	-2.94	-2.34
prob	0.00	0.00	0.02
Port size '69	-0.0013639	-0.0014127	-0.0014162
t	-3.18	-3.23	-3.39
prob	0.00	0.00	0.00
Port size '69^2	0.0000617	0.0000662	0.0000696
t	2.88	3.06	3.27
prob	0.01	0.00	0.00
Agric Emp.'75	0.0004087	0.000425	0.0005766
t	2.59	2.85	4.01
prob	0.01	0.01	0.00
Agric Emp.'75^2	-0.0000113	-0.0000114	-0.000013
t	-2.54	-2.79	-3.87
prob	0.01	0.01	0.00
Nat Ex-FUR GDP Grow '79-'93	0.8600302	0.8586037	0.9644929
t	9.84	9.88	9.53
prob	0.00	0.00	0.00
Ln Population 1981	0.002082	0.0020731	0.0020723
t	3.73	4.32	4.57
prob	0.00	0.00	0.00
Population Density 1981	-0.0000015	-0.0000014	-0.0000016
t	-3.41	-3.34	-3.22
prob	0.00	0.00	0.00
Policy Capacity		0.0094361	0.010123
t		3.15	2.88
prob		0.00	0.01
Policy Capacity^2		-0.0031355	-0.0030385
t		-2.42	-2.09
prob		0.02	0.04
University Students ratio 1977/78/79			0.0000292
t			2.10
prob			0.04
R&D Facilities per million			0.0009666
t			4.40
prob			0.00
Integration Gain			0.0028733
t			2.07
prob			0.04

Table 1b: Regression diagnostics for : Basic Models

REGRESSION DIAGNOSTICS (SpaceStat)	**Models**	**1**			**2**			**3**	
MULTICOLLINEARITY CONDITION NUMBER	67.27			74.09			85.33		
TEST ON NORMALITY OF ERRORS									
TEST	DF	VALUE	PROB	DF	VALUE	PROB	DF	VALUE	PROB
Jarque-Bera	2	1.627573	0.44	2	4.328227	0.11	2	3.703177	0.16
DIAGNOSTICS FOR HETEROSKEDASTICITY									
RANDOM COEFFICIENTS									
TEST	DF	VALUE	PROB	DF	VALUE	PROB	DF	VALUE	PROB
Breusch-Pagan test	9	5.9155	0.75	11	9.0012	0.62	14	19.4136	0.15
Koenker-Bassett test									
DIAGNOSTICS FOR SPATIAL DEPENDENCE									
FOR WEIGHT MATRIX (row-standardized)	Inverse of time-distance with 300 minute national border effect								
TEST	MI/DF	VALUE	PROB	MI/DF	VALUE	PROB	MI/DF	VALUE	PROB
Moran's I (error)	0.041414	3.559738	**0.00**	0.050933	4.20115	**0.00**	0.01725	2.456196	**0.01**
Lagrange Multiplier (error)	1	3.591981	*0.06*	1	5.433091	**0.02**	1	0.623166	0.43
Robust LM (error)	1	0.557836	0.46	1	2.578361	0.11	1	0.728593	0.39
Kelejian-Robinson (error)	10	1.700541	1.00	12	2.255538	1.00	15	3.917696	1.00
Lagrange Multiplier (lag)	1	3.706845	*0.05*	1	2.864066	*0.09*	1	3.762118	*0.05*
Robust LM (lag)	1	0.672701	0.41	1	0.009337	0.92	1	3.867544	**0.05**
Lagrange Multiplier (SARMA)	2	4.264681	0.12	2	5.442427	*0.07*	2	4.490711	0.11
FOR WEIGHT MATRIX	Inverse of time-distance squared with 300 minute national border effect								
TEST	MI/DF	VALUE	PROB	MI/DF	VALUE	PROB	MI/DF	VALUE	PROB
Moran's I (error)	0.095431	2.319449	**0.02**	0.117959	2.783896	**0.01**	0.032549	1.277086	0.20
Lagrange Multiplier (error)	1	3.016293	*0.08*	1	4.60844	**0.03**	1	0.350882	0.55
Robust LM (error)	1	0.23616	0.63	1	0.169885	0.68	1	2.367267	0.12
Kelejian-Robinson (error)	10	1.700541	1.00	12	2.255538	1.00	15	3.917696	1.00
Lagrange Multiplier (lag)	1	6.704261	**0.01**	1	5.948594	**0.01**	1	4.813978	**0.03**
Robust LM (lag)	1	3.924129	**0.05**	1	1.510038	0.22	1	6.830363	**0.01**
Lagrange Multiplier (SARMA)	2	6.940421	**0.03**	2	6.118478	**0.05**	2	7.181245	**0.03**

*Results in italics are significant at 10% level; Results in bold are significant at 5% level

Table 2: Dependent Variable Annualised Rate of Growth of GDP p.c. Mean 1978/80 to mean 1992/4: Best Basic Model 3 with Spatial Lag: Maximum Likelihood estimate

	Model 3
Log Lik	504.504
Constant	-0.03957020
z	-4.47
prob	0.00
Spatial lag of Dep. Variable	0.21321500
z	2.07
prob	0.04
Coalfield: core	-0.00556043
z	-4.99
prob	0.00
Coalfield: hint'land	-0.00427724
z	-2.93
prob	0.00
Port size '69	-0.00144035
z	-3.99
prob	0.00
Port size $'69^2$	0.00007244
z	3.18
prob	0.00
Agric Emp.'75	0.00043412
z	2.87
prob	0.00
Agric $Emp.'75^2$	-0.00000995
z	-2.58
prob	0.01
Nat Ex-FUR GDP Grow '79-'93	0.86257600
z	8.12
prob	0.00
Ln Population 1981	0.00194793
z	3.59
prob	0.00
Population Density 1981	-0.00000165
z	-2.72
prob	0.01
Policy Capacity	0.00895096
z	2.75
prob	0.01
Policy $Capacity^2$	*-0.00261072*
z	*-1.76*
prob	*0.08*
University Students ratio 1977/78/79	0.00003085
z	2.93
prob	0.00
R&D Facilities per million	0.00089284
z	3.35
prob	0.00
Integration Gain	*0.00230783*
z	*1.81*
prob	*0.07*

REGRESSION DIAGNOSTICS

Diagnostics for Heteroskedasticity Random Coefficients Test

	DF	Value	Prob.
Breusch-Pagan test	14	18.4627	0.19
Spatial B-P test	14	18.4628	0.19

Diagnostics for Spatial Dependence:: weights matrix = inverse of time distance squared + 300 minute border penalty

	DF	Value	Prob.
Likelihood Ratio test	1	4.2962	**0.04**
Lagrange Multiplier Test	1	2.6522	0.10

WALD test	18.4575
LR test	4.2962
LM (lag) test	4.8140
ORDERING: W ≥ LR ≥ LM	**NO**

Table 3a: Dependent Variable Annualised Rate of Growth of GDP p.c. Mean 1978/80 to mean 1992/4: Models with Spatial Effects: robust standard errors

Model	4	5	6
R2	0.7373	0.7485	0.8017
R2-adj	0.6969	0.7069	0.7690
LIK	512.457	515.0790	529.4770
Models 4, 5 & 6 include a constant and the control variables included in Models 1, 2 & 3			
Policy Capacity	0.0096869	0.0107756	0.0099736
t	3.06	3.35	3.54
prob	0.00	0.00	0.00
Policy Capacity^2	-0.0029130	-0.0033664	-0.003310
t	-2.20	-2.51	-2.95
prob	0.03	0.01	0.00
Integration Gain	0.0036095	0.0037506	0.002826
t	2.58	2.71	2.27
prob	0.01	0.01	0.03
University Students ratio 1977/78/79	0.0000281	0.0000255	0.000027
t	2.69	2.41	2.78
prob	0.01	0.02	0.01
R&D Facilities per million	0.0008321	0.0008687	0.000640
t	4.38	4.51	3.56
prob	0.00	0.00	0.00
University Student density in neighbouring FURs within 150 minutes	-0.0002478	-0.0002574	-0.000184
t	-2.26	-2.51	-2.13
prob	0.03	0.01	0.04
Dummy for FURs in N.E.Italy	0.0090491	0.0091916	0.0076496
t	4.67	4.82	4.71
prob	0.00	0.00	0.00
Density of Unemployment in FURs within 60 minutes		-0.0056571	
t		-2.20	
prob		0.03	
Differential GDP growth 1980-86 in FURs within 150 minutes + 300 minute border effect			0.2176448
t			6.40
prob			0.00

Table 3b: Regression diagnostics for Models with Spatial Effects

REGRESSION DIAGNOSTICS (SpaceStat)	**Model**	**4**			**5**			**6**	
MULTICOLLINEARITY CONDITION NUMBER	88.73			88.80			89.29		
TEST ON NORMALITY OF ERRORS									
TEST	DF	VALUE	PROB	DF	VALUE	PROB	DF	VALUE	PROB
Jarque-Bera	2	2.667858	0.26	2	2.039287	0.36	2	10.821618	**0.00**
DIAGNOSTICS FOR HETEROSKEDASTICITY									
RANDOM COEFFICIENTS									
TEST	DF	VALUE	PROB	DF	VALUE	PROB	DF	VALUE	PROB
Breusch-Pagan test	16	23.07811	0.11	17	21.7728	0.19			
Koenker-Bassett test							17	24.250418	0.11
DIAGNOSTICS FOR SPATIAL DEPENDENCE									
FOR WEIGHT MATRIX (row-standardized)	Inverse of time-distance with 300 minute national border effect								
TEST	MI/DF	VALUE	PROB	MI/DF	VALUE	PROB	MI/DF	VALUE	PROB
Moran's I (error)	-0.038954	-1.125909	0.26	-0.04088	-1.309675	0.19	-0.025991	-0.213808	0.83
Lagrange Multiplier (error)	1	3.177893	*0.07*	1	3.499981	*0.06*	1	1.414823	0.23
Robust LM (error)	1	4.861535	**0.03**	1	5.63534	**0.02**	1	2.601492	0.11
Kelejian-Robinson (error)	17	4.131198	1.00	18	4.321249	1.00	18	3.539844	1.00
Lagrange Multiplier (lag)	1	0.046442	0.83	1	0.018927	0.89	1	0.020794	0.89
Robust LM (lag)	1	1.730085	0.19	1	2.154286	0.14	1	1.207463	0.27
Lagrange Multiplier (SARMA)	2	4.907977	*0.09*	2	5.654267	*0.06*	2	2.622286	0.27
FOR WEIGHT MATRIX	Inverse of time-distance squared with 300 minute national border effect								
TEST	MI/DF	VALUE	PROB	MI/DF	VALUE	PROB	MI/DF	VALUE	PROB
Moran's I (error)	-0.096353	-1.105745	0.27	-0.103981	-1.286353	0.20	-0.068779	-0.556454	0.58
Lagrange Multiplier (error)	1	3.074883	*0.08*	1	3.580986	*0.06*	1	1.566769	0.21
Robust LM (error)	1	6.629331	**0.01**	1	7.707307	**0.01**	1	3.596428	0.06
Kelejian-Robinson (error)	17	4.131198	1.00	18	4.321249	1.00	18	3.539844	1.00
Lagrange Multiplier (lag)	1	0.01904	0.89	1	0.035026	0.85	1	0.115314	0.73
Robust LM (lag)	1	3.573489	*0.06*	1	4.161348	**0.04**	1	2.144973	0.14
Lagrange Multiplier (SARMA)									

*Results in italics are significant at 10% level; Results in bold are significant at 5% level

Table 4: Dependent Variable Annualised Rate of Growth of GDP p.c. Mean 1978/80 to mean 1992/4: Model 5 with Spatial Error correction: Maximum Likelihood estimate

	Model 5e
Log Lik	519.695
Constant plus:	
lambda	-0.601453
z	-3.79
prob	0.00
Control variables as per model 3	
Plus:	
Nat Ex-FUR GDP Grow ’79-’93	0.9732780
z	12.85
prob	0.00
Ln Population 1981	0.0021748
z	4.34
prob	0.00
Population Density 1981	-0.0000013
z	-2.28
prob	0.02
Policy Capacity	0.0123599
z	4.27
prob	0.00
Policy Capacity^2	-0.0042157
z	-3.19
prob	0.00
University Students ratio 1977/78/79	0.0000221
z	2.38
prob	0.02
R&D Facilities per million	0.0010454
z	4.94
prob	0.00
Integration Gain	0.0043989
z	4.41
prob	0.00
University Student density in neighbouring FURs within 150 minutes	-0.0002801
z	-3.64
prob	0.00
Dummy for FURs in N.E.Italy	0.00977223
z	6.53
prob	0.00
Density of Unemployment in FURs within 60 minutes	-0.00661023
z	-2.61
prob	0.01
Differential GDP growth 1980 -86 in FURs within 150 minutes + 300 minute border effect	
z	
prob	

REGRESSION DIAGNOSTICS

Diagnostics for Heteroskedasticity Random Coefficients Test

	DF	Value	Prob.
Breusch-Pagan test	17	19.2302	0.32
Spatial B-P test	17	19.2317	0.32

Diagnostics for Spatial Dependence:: weights matrix = inverse of time distance squared + 300 minute border penalty

	DF	Value	Prob.
Likelihood Ratio test	1	9.231219	**0.00**
Lagrange Multiplier Test	1	1.6096	0.20

WALD test	14.3327
LR test	9.2312
LM (lag) test	5.6896
ORDERING: W ≥ LR ≥ LM	**YES**

Appendix

Appendix 1: Variable Definitions and data

Table A1: The dependent variable was in all cases the annualised rate of FUR growth in GDP p.c. converted at OECD PPS. Growth measured either between means of 1978/80 and 1992/94.

Variable Name	Description
Ln Population	Natural log of population in 1979
Population density	Density of population in FUR in 1979
Industrial Emp.'75	Percentage of labour 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 labour force in agriculture in surrounding Level 2 region in 1975
Nat Ex-FUR GDP Grow '80-'00	Annualised rate of growth of GDP p.c. in the territory of each country outside major FURs between 1979 and 1993
Policy Capacity	Ratio of FUR population to the population of the largest governmental unit associated with the FUR (1981): see below for details.
Integration Gain	Change in economic potential for FUR resulting from movement from individual nation-states to post enlargement EU with reduced transport costs (estimated from Clark *et al* 1969 and Keeble *et al* 1988)
University Students ratio 1977/78/79	Ratio between university and higher education students (1977-1978) and total employment (1979)
R&D Facilities per million population	R&D laboratories of Fortune top companies per million population (1980)
University Student density in neighbouring FURs within 150 minutes	Sum of university and higher education students per 1000 employees in neighbouring FURs (150 minutes)
Dummy for FURs in N.E.Italy	Dummy for Padua, Venezia and Verona
Density of Unemployment in FURs within 60 minutes	Sum of differences between the unemployment rate (average between 1977 and 1981) of a FUR and the rates in neighbouring FURs (60min) weighted by the distance
Differential GDP growth 1980-86 in FURs within 150 minutes + 300 minute border effect	Sum of difference in growth of per capita GDP (1980-1986; 3-year averages) between the FUR and those within 150 min weighted by distance (border effect = 300min

To estimate the **Policy Capacity** variable the rules determining the selection of the largest 'relevant' governmental unit were:

Belgium	The central communes for all except Bruxelles for which the capital region (Arrondissement) was taken;
Denmark	Central Municipality;
Germany	The Kreisfreie Stadte except for Bremen and Hamburg where the Land (a NUTS 1 region) was taken and Frankfurt where the Umlandverband was taken;
France	Since there is a NUTS 1 region, the Ile de France, which has significant powers, was selected for Paris. Elsewhere in France the central Commune was selected except for those FURs for which a Communité Urbaine exists; in those cases the Communité Urbaine was selected
Greece	The central Municipality;
Ireland	The County Borough (of Dublin);
Italy	The central Commune was selected in all cases. Unlike the situation in France (Paris) or Germany (Bremen and Hamburg) there is no NUTS 1

	or 2 region corresponding to any city nor is there any city with a city wide tier of government (such as the Communité Urbaine).
The Netherlands	The central Municipality (as Italy);
Portugal	The central Municipality (as Italy);
Spain	Where there was one major FUR in a Communidad Autonoma (a NUTS 2 region), the Communidad Autonoma was selected; where there was more than one major FUR in the Communidad Autonoma but only one in the Provincia (a NUTS 3 region), the Provincia was selected; where there was more than one major FUR within a Provincia then the central Municipio was selected;
United Kingdom	In England, the District was selected except in London where Inner London was used; in Scotland, the regions of Lothian and Strathclyde were taken and for Belfast the NUTS 1 region of Northern Ireland was the government unit identified.

The only case, then, for which no obvious rule was available, was that of London because of the radical change to the system of government in the middle of the period. The Greater London Council was abolished in 1985 and local government powers were re-assigned down to the 32 boroughs and up to committees of boroughs and to central government. There were further changes to this system in the later part of the period when the Government Office for London was set up. The only stable unit of government relating to London was the City of London or the individual London boroughs but there was a regional authority – Greater London – for half the period. The selection of Inner London - not really a governmental unit at all - represented no more than the most reasonable compromise. We tested alternatives and as might be expected, substituting the value for the largest borough or the GLC as a whole made no material difference to the results reported here.