European Urban Growth: now for some problems of spaceless and weightless econometrics

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

Paper prepared for the 46th Congress of the European Regional Science Association, Volos, Greece, 30th August-3rd September, 2006

March 2006

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: now for some problems of spaceless and weightless econometrics

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 for a data set relating to Functional Urban Regions rather than the more normal NUTS regions comparing the results of 'artisanal' methods of model selection with those obtained using general to specific model selection with PcGets. The artisanal approach tests hypotheses relating to the role of human capital, EU integration and fragmentation of urban government. The paper also explores issues of spatial dependence and mechanisms of spatial interaction. Using PcGets as suggested by Hendry and Krolzig (2004) to optimise model selection yields a model acceptable on the basis of standard econometric tests and similar in terms of basic results to the artisanal approach if mechanisms of spatial interaction are ignored. Testing, however, reveals problems of spatial dependence. We interpret this as indicating that significant variables reflecting mechanisms of spatial economic adjustment have been omitted. Including such variables in the data set available to PcGets leads to the inclusion of three measures of spatial adjustment. Further testing shows that problems of spatial dependence are now eliminated. We interpret this result as evidence that while PcGets provides a powerful tool for model selection when applied to cross sectional data, caution is necessary to ensure that variables relating to spatial adjustment processes are included and spatial dependence is avoided. Not only do the results provide consistent estimates of parameters but they also support relevant theoretical insights. Moreover careful testing for spatial dependence reveals that national borders are still significant barriers to adjustment within the EU.

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

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

12357 words

1. Introduction[1]

This paper analyses the growth of GDP p.c. across functionally defined metropolitan regions - represented as Functional Urban Regions (FURs - see section 2) - in the EU of 12 between 1978 and 1994. We have two purposes: the first is to test some propositions about sources of urban growth derived as tightly as possible from underlying theory. The second – prompted by Hendry and Krolzig (2004) - is to explore the application of general to specific model selection (using the PcGets software) when applied to spatial cross sectional data. Being primarily designed for time series analysis, PcGets does not consider issues of spatial dependence. We find that this could lead to inconsistent estimates unless the General Underlying Model (GUM) data set includes variables specifically designed to reflect appropriate spatial economic mechanisms. When suitable variables are included in the GUM, however, we find that PcGets selects a specific model including them and problems of spatial dependence are eliminated. In contrast to the more orthodox spatial dependence literature (see, for example, Rey and Montouri, 1999 or Florax *et al*., 2003) we view indicated problems of spatial dependence as signs of omitted variables in the underlying GUM – the data set does not include variables underlying one of the significant classes of relationships. This should prompt researchers to re-specify their models finding suitable (spatial) variables to reflect the economic mechanisms giving rise to the spatial dependence. The need for such an approach is, in our judgement, re-enforced by the fact that we only find indications of spatial dependence when the spatial weights matrix is formulated in an economically meaningful way, including a specific and substantial distance penalty for spatial interactions across national borders.

A difference from Hendry and Krolzig (2004) is that we do claim inference for our final models. We fully recognise the set of conditions they identify[2] which, in principle, have to hold if the traditional cross sectional growth models are to be used for inference. We would, however, argue that i) it is inappropriate to invoke such conditions in a categorical sense. In actual applied econometrics the issue is not an absolute one but one of degree. No specification can claim a priori to satisfy conditions for inference if for no other reason than that the DGP is fundamentally unknown; as applied economists, we inevitably rely on theory and knowledge to guide us to the best approximation we can specify. It is inevitably a matter of judgment (conditioned on the knowledge

[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.

[2] "The validity of a selected model depends primarily on the adequacy of the general unrestricted model (GUM) as an approximation of the data generating process (DGP). In turn, that involves the measurement accuracy of the data series, the representation of the underlying causal effects, the completeness of the information (both variables and observations), the homogeneity of the sample; the independence assumptions justifying regression; the weak exogeneity of the regressors (instruments); and the constancy of the parameters across the observations. Every one of these assumptions is open to legitimate doubt in the 'growth regressions' context." (Hendry and Krolzig, 2004, page 800)

we have) whether the proposed specification can be accepted as an adequate approximation of the (unknown) DGP. The relevant question is always: in the particular case, is the departure from the ideal with respect to all conditions sufficient to raise serious doubts as to the use of the model for purposes of inference? While sharing a substantial degree of scepticism with respect to the great bulk of the 'growth regressions' literature, it is our judgement that its majors sources of problems lies with the application of the methodology to cross country analysis (in which case there is a serious doubt about both the homogeneity of the sample and the accuracy of the data) and cross regional analysis when those regions are neither economically self contained nor homogeneous. With respect to the other conditions we have simply done our best but would argue that by using large urban regions in relatively homogeneous Western Europe as our units of observation and attempting to include data informed as clearly as possible by urban economic theory, we minimise (but do not categorically eliminate) the departure from the ideal conditions necessary for inference to be valid. With that admission, it is clear that when we move from drawing conclusions about the need to include spatial processes in cross sectional analysis to drawing conclusions with respect to hypothesis testing we cross a line and need to be more cautious in our claims.

In a previous paper (Cheshire and Magrini, 2006), we tested the extent to which it is reasonable to assume that there is a unified European urban system within which there is enough factor mobility to generate a spatial equilibrium between cities and regions. Spatial equilibrium was defined in the usual way as a situation in which individuals cannot improve their welfare by moving to another city or region. We rejected such a 'compensating differentials' worldview as a maintained assumption for the EU's major city regions because the evidence not only shows that migration flows are relatively small but those associated with quality of life differences are confined to national borders. In that sense, city-regions within the EU seem to behave like city-states, not as simply the spatial units from which a homogeneous 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 (see Roback 1982 or, for a more recent application to US urban growth, Glaeser *et al*., 1995) cannot reasonably be maintained in the European context. This implies that differences in GDP per capita between the major city-regions of the EU not only reflect differences in productivity but also differences in welfare.

We must emphasise at the outset that we are not taking the convergence approach applied in the numerous studies in the vein of Barro (1990) and Barro and Sala-i-Martin (1991). Indeed the initial level of GDP per capita does not feature in any of the GUM data sets the analysis of which is reported in the paper although for completeness we did include it in an unreported analysis of a

GUM1. The variable was not selected for any specific model. For recent surveys of the β-convergence literature see, for example, Durlauf and Quah, 1999; Temple, 1999; or Magrini, 2004.

We are interested in testing theoretically derived ideas about urban growth. We have three groups of variables designed to test these hypotheses. The first group relates to the impact of systematic spatial effects of European integration on urban growth. Concern about the spatial effects of European integration go back at least to Clark *et al* (1969) and it is interesting to use as independent variables the quantitative measures 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. In addition to the variable measuring Clark et al's (1969) change in regional economic potential associated with EU integration we have a 'peripherality' dummy.

The second group of variables we are interested in attempts to capture the role of R & D and human capital in urban growth processes. Here we are interested in testing a spatialised adaptation of endogenous growth theory (see Cheshire and Carbonaro, 1995 or, for a more rigorous development, Magrini, 1997 and 1998). The third area we are interested in investigating is the relationship between systems of city government and city growth performance. If we suspend our disbelief and assume that local policies might influence FUR growth rates - abstracting for the moment from what form such policies might take - then it is clear that local policy makers would be producing a pure local public good. So, the relevant issue is what factors favour the formation of more effective growth promotion 'clubs'. Since our FUR boundaries (see Section 2) are by definition designed to maximise self-containment, any positive impact of local growth promotion will be contained with them. 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). Moreover, the larger the main unit of government is relative to the FUR as a whole, the lower transactions costs are likely to be in forming a growth promotion club. So, we test whether 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.

Since we are analysing urban growth in a cross sectional model we might reasonably expect to find interactions between the growth performance of neighbouring cities. As a result, we have paid particular attention to issues of spatial dependence. Spatial econometrics tends to exist as a distinct field of interest in which a finding of spatial dependence is often an end in itself - to be 'corrected' sometimes by introducing spatial lags or by other appropriate econometric techniques depending on the exact nature of the problem. Our views are somewhat different. It seems important to test for spatial dependence since, if it is present, and the analysis does not properly take it into account, we will not get consistent estimates of the effects of the variables we are interested in. 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. Both theory and empirical evidence suggest that there are important spatial adjustment mechanisms and other spatially determined features of urban and regional economies. For example, labour markets and housing markets are likely to adjust to price and real wage differences in ways conditioned on some measure of accessibility. Both migration and commuting patterns are known to respond to spatial differences in economic opportunities – whether of money incomes or house prices – but the impact of a given differential in economic opportunities declines with 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 dependence.

As the results reported below suggest, there seems to be some evidence in support for this view. When we estimate growth models using a GUM which has no variables designed to reflect these spatial adjustment processes, tests show that the specific model selected embodies problems of spatial dependence. The conventional solution would be to fix the problem by including an appropriate (spatial) econometric procedure. However, deliberately including in the GUM variables designed to reflect specific spatial economic adjustment processes (which are a function of the distance between cities) allows PcGets to select a specific model for which there are no indications of spatial dependence.

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.

2. The data

All the analysis is performed on a data set built up over a 25 year period relating to Functional Urban Regions (FURs) defined so far as possible according to common criteria across the EU of 12. For a detailed discussion of how the FURs we use were defined see Cheshire and Hay (1989). The basic principle was to identify core cities using the criterion of at least 20 000 jobs. For each of these concentrations of employment, hinterlands were defined from which more commuters flow to the employment core than to any other, subject to a minimum cut off level of commuting. The FURs used here were defined on the basis of 1971 employment and commuting data[3]. They are broadly similar in concept to the (Standard) Metropolitan Statistical Areas used in the US although hinterlands tend to be extensive where there are no competing employment centres (examples are Lisbon or Dublin). The data set only has the full set of variables for the largest FURs – those with a total population of a third of a million or more in 1981 and a core city which exceeded 200 000 at some date since 1951. The unification of Germany means that comparable data for the current FUR of Berlin are only available since 1990. So, Berlin is excluded, as are the FURs in the territory of the former GDR. This leaves a total 121 FURs which constitute our observations - so in all statistical estimation N=121.

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 regions and cities. The EU institutions deal in so-called Nomenclature des Unités Territoriales Statistiques (NUTS) regions. This is a nesting set of regions which tries to reconcile different national territorial divisions. The largest are Level 1 regions; the 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. The size of these NUTS regions – even within the same 'Level' – is highly variable across Europe and even within countries. A further problem is that no 'Level' is actually represented in every country: in many countries they exist only for purposes of reporting data to Eurostat and other EU institutions. Thus, the most widely used regions – the Level 2 – do not exist for Germany or the UK. Particularly in Germany, this presents serious problems of data availability and comparability because the Level 1 regions correspond to the Länder which not only have considerable independence but also their own statistical services. In addition,

[3] There are arguments both for and against using fixed boundaries. An argument against is that actual boundaries change over time as the location of employment and people changes. The impact of such changes has been investigated for a subset of 25 FURs in the course of an INTERREG IIB Project (GEMACA 2003). Details are available from the authors but the range of changes in total population estimates for 1991 using first boundaries defined on 1971 employment and commuting then boundaries defined on 1991 data was mainly from 5 to 10 percent. London was an outlier with population some 35 percent greater on its 1991 patterns of employment location and commuting. Changes in estimated employment were always considerably smaller than for population. In practical terms we can anyway do no better than use the fixed if obsolescent boundaries. Re-estimating boundaries for all EU FURs would require resources on the scale of a National Statistical Office.

Germany has not had a population census since 1987 and uses its own labour market regions to collect most labour market data.

One of the variables most subject to distortion is GDP p.c. because GDP is estimated at workplaces while people are counted where they live. Because people commute to work across administrative boundaries this means GDP p.c. is systematically overestimated in cities which are also NUTS regions where the administrative boundaries exclude significant dormitory areas. In reality, this happens for a large number of bigger European cities (Madrid and Paris are two exceptions if the NUTS 1 regions are used) meaning that official figures systematically overstate GDP p.c. for large cities[4]. At last, this distortion of GDP p.c. data the present NUTS system generates has been recognised by Eurostat (Eurostat, 2005). Following the 1998 split of Greater London into two official regions[5] – Inner and Outer London – the absurdity of the resulting GDP p.c. measures – with Inner London having a reported per capita GDP 3.15 times the EU mean - became too great to continue to ignore.

> …in some regions the GDP per capita figure can be significantly influenced by commuter flows….[so] that GDP per capita can be overestimated in these regions (e.g. Inner London) and underestimated in the regions where commuters live (e.g. Outer London, Kent and Essex). (Eurostat, 2005)

The FUR and NUTS region of Bremen provide an extreme but not wholly unrepresentative example of how this distorts measured growth rates as well as levels of GDP p.c. as over time people move relative to the location of jobs. Because of strong relative population decentralisation over the relevant period the growth of GDP p.c. is overstated by some 40% for the period of the 1980s if the published Eurostat data for the NUTS Level 1 region identified as Bremen[6] are relied on.

As defined, FURs correspond to the economic spheres of influence of significant employment concentrations and are relatively self-contained in economic terms. The variables used are identified in Table 1 which also indicates how the automated model selection procedures were structured. They are defined more fully in Appendix Table 1 which also provides a brief description of how they were

---

[4] This potential for distortion is used for political purposes. In 1988 when the criteria for regional assistance were defined and the threshold was set at 75% of the EU mean, the Dutch created a 'poor' region, Flevoland, by combining the suburbs of Amsterdam with the agricultural areas to the north. The British were not dissatisfied with the split of London into two regions in 1998.

[5] The FUR of London used here was nearly 30% larger in population terms than the NUTS Level 1 region of Greater London.

[6] A curious fact is that Bremen as a Hanseatic League state retained its historic independence so it is a Land – so a NUTS 1 regions. This is despite the fact that its territory is split between two separate enclaves and in 2001 its reported NUTS population was 660 000: while its estimated FUR population was 1 305 000.

measured and the sources used. Appendix 2 explores some of the differences between our estimated FUR GDP p.c. and its growth and equivalent NUTS 3 data[7]. Two pairs of FURs – Lille and Valenciennes and Portsmouth and Southampton – are entirely contained within two NUTS 3 regions so their GDP p.c. estimates were the same. One other pair of FURs – Sunderland and Newcastle – is mainly within a single NUTS 3 region.

Table 1 about here

Because of 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 1992-94. 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 from a later date. In both cases, Eurostat 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 available from Eurostat.

One final point relating to Eurostat regional GDP data is that the basis on which values were estimated was substantially revised in 1995. Eurostat switched from a 1979 base for disaggregating national data (ESA79) to a base-year of 1995 (ESA95). The differences between the two sets of values are remarkable - not even country totals coincide. Although some claim to have successfully bridged this discontinuity in the regional GDP data (particularly affecting Germany) we have not been able to do so to our satisfaction. So our analysis finishes in 1994.

All data are defined to common statistical concepts either weighting data available from the Eurostat REGIO database to estimate values for FURs (as with GDP p.c.) or collecting data directly from national statistical offices or common data providers and adjusting where necessary to common definitions.

There is necessarily some imperfection and imprecision in the estimated data we use but they have the merit of relating to functionally defined city-regions which are so far as possible self contained in economic terms. This allows us to estimate our policy incentive variable. The FURs, all being large

[7] FUR GDP p.c. was estimated from NUTS 3 data. To illustrate this process of estimation with the example of Bremen: the population of our FUR was divided between seven NUTS 3 regions for which we had Eurostat GDP p.c. data. In 1991, the proportionate distribution of Bremen's population between these NUTS regions was 0.4345, 0.1508, 0.1128, 0.0942, 0.0767, 0.0713 and 0.0597. These proportions were applied as weights to each of the seven NUTS regions' GDP p.c. to estimate the value of GDP p.c. for the FUR of Bremen. We also have the proportionate distribution of FUR populations between NUTS 3 regions as at 1981. The FUR data for any year were estimated using population weights calculated from national population censuses or registration data closest in time to that for which the Level 3 regions' data (e.g. GDP p.c.) related.

metropolitan regions, are also substantially more homogenous than either NUTS regions or countries, which is econometrically helpful; and they do not exhaust national territories. This last property allows us to calculate another useful variable – the rate of growth in the area of each country outside its major city-regions.

3. The 'artisanal' approach

The authors' first approach to testing the hypotheses relating to the role of European integration, human capital and R & D and arrangements for local government was a traditional 'artisanal' approach building on previous work (see Cheshire and Magrini. 2000 or 2006). We found 'base models', then included the variables designed to test the three hypotheses; and then tested the resulting fitted models for a range of econometric problems critically including testing for spatial dependence. Such tests showed that while traditional standards for normality, functional form and heterskedasticity were satisfied, if the spatial weights matrix was formulated in an economically meaningful way (with an added time-distance penalty for interactions across national frontiers) problems of spatial dependence remained. While in this particular case these could be resolved by including a spatial lag and employing a maximum likelihood estimator, as noted above, this was not our preferred strategy. So, a significant effort was put into formulating variables designed to reflect known information on spatial adjustment processes. Such variables turned out to be significant and to resolve problems of spatial dependence.

This section very briefly explains the main variables used in this artisanal approach and summarises the results in order to be able to compare the results with those obtained using automated model selection with PcGets. As noted above, the independent variable was the annualised rate of growth of GDP pc in each FUR in the EU of 12 over the period 1979 to 1994, using the mean of the first and last three years as the start and end dates. The 'base model' then used a set of control variables relating to each FUR and the rate of growth of GDP pc over the same period in the areas of each country outside the major FURs. The same control variables were used for industrial structure as had been used in previous work (see Cheshire and Magrini, 2000). These detailed measures, relating to old resource-based industries – coalmining and ports - work better than broader measures of specialisation in industry and, moreover, make better sense in economic terms.

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, incidence of the economic cycle and other factors associated with country-specific differences in growth rates over the period. Although national dummies have been the way in which this problem has frequently been handled in the growth regression literature dealing with regions it seemed to us both more elegant and powerful to use this continuous variable as well as more consistent with the underlying assumption that we were analysing a homogeneous sample[8]. 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, 1995) and this confirms that result. 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.

Other controls included in the base model were designed to reflect as far as possible underlying (urban) economic theory and evidence. 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 was included since, allowing for agglomeration economies, cities with higher density will have higher costs of space 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. 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 less than land use policy which varies substantially both across countries and between cities in Europe.

We then move to independent variables designed to test our hypotheses. Our observational units represent sub-national economic regions, as economically self-contained as are likely to exist, so any impacts of local policy which influence the relative costs or competitiveness of economic agents (whether intended to stimulate local growth or not) will be confined to economic actors living or operating within them. Spillovers will be minimised and externalities internalised within our FURs. Any local policy action which increases local growth involves the provision of a local public good: the benefits of growth are non-excludable and have a zero opportunity cost in consumption. This

[8] Another problem with national dummies in the present context is that in several countries there are not enough observations (one in Ireland, two each in Denmark, Greece and Portugal) for national dummies to be appropriate so some grouping of countries is essential. Since any grouping is arbitrary, the dummies do not do what they should. This objection does not apply to the continuous variable used here, possible because the major FURs do not exhaust national territories. In population terms they account for about half of the aggregate.

characteristic generates the usual problem of how 'local growth' may be generated. 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 (usually including private sector actors) will have to be formed to provide growth promotion policies: these are, in essence, what regional development agencies and lobby groups such as London First for example, are. They are local growth promotions 'clubs'.

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. Whether or not such growth promotion policies are engaged in will be conditioned primarily on the structure of the incentives faced by these governmental and other 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 a FUR's boundaries compared to any others that might exist for an urban area – most obviously political boundaries - contain the maximum proportion of any the benefits that might be generated by local growth promotion policies, for a given potential growth gain 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 increase. Equally, assuming other factors are constant, the expected net payoff would fall as the transactions costs 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 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...'.

With these arguments in mind, 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 NUTS 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[9]. 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 should stress 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 public decision-making, clearly defined land use policies and infrastructure planning, may cost less than their inefficient alternatives and be beneficial in terms of local growth.

Since any output of such policies is a pure local public good[10] 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 promotion’ club.

[9] During the period analysed there was a South East Regional Planning Council (SERPLAN) but this was effectively no more than a forum for discussion.
[10] The local public good is, of course any growth they may produce. Resources employed in the promotion of growth are simply a cost.

We call this the ***policy incentive*** variable because it is designed to measure the incentive to implement policies promoting growth at the FUR level. Since one criterion used to select the ‘relevant’ governmental unit for each FUR was that it 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 meant that the value of the variable could range from only about 0.125 to over 2 (in Spain). We might further hypothesise that if the value of the variable were very high, so that the size of the ‘relevant’ unit of government substantially exceeded the size of the FUR, then the incentive 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 incentive variable was rather more than 1 but less than 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 (1995) and Magrini (1997; 1998). There is an extensive literature on the role of human capital in economic growth and the tendency for innovation to be localised with respect to R&D 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 a survey). The Integration Gain variable, is designed to measure the direct spatial impacts of European integration and 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), 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 calculated the *change* in the values of 'economic potential'[11] 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.

[11] 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

As elaborated in Cheshire and Magrini (2000) 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 so a quadratic term was included.

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. As is often the reality with applied work, insight and experimentation are complementary. Our insight grew with experiment and tests were conducted using 28 different distance weight matrices. In this paper, we report only the results for which the greatest sensitivity was found and which seem most faithfully to represent underlying spatial processes. Full results are available from the authors. Measuring distance as the inverse of time-distance between FURs, using the standard road freight software, not only seems to represent 'proximity' in the most economically meaningful way but always provided more measured sensitivity to spatial dependence than distance measured as the crow flies or as road kilometres. In Tables 2b, 3b and 4b, we report results for two formulations - the inverse of time-distance and the inverse of time-distance squared.

An innovation, 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 (2006) 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 zero to infinity were experimented with and the results were generally most sensitive if it was implicitly assumed a national border represented a time-distance of 600 minutes.

If we look at the test results reported in Tables 3b and 4b, which include specifications in which we expect to find problems of spatial dependence, we see that if no time-distance penalty is included for national borders it is easy to conclude that there are no problems of spatial dependence. Such problems are only indicated for the simplest specifications using restricted GUMs - Models 1a and b. Equally results seem most sensitive to spatial dependence if distance is measured as the square of the inverse of time-distance.

As noted above the authors' preferred approach is not to attempt to resolve problems of spatial dependence with the technical fix but rather to interpret such test results as indicating an underlying problem of omitted variables. We should not expect the growth behaviour of a FUR to be independent of that of its neighbours. The most obvious reason is the literature on labour market search behaviour. If productivity, wages or job opportunities are relatively improving in one urban area then those who can access those opportunities at the lowest cost – who live nearest – will tend to do so. Migration is expensive but changes in commuting patterns respond to only small differences in opportunities (see, for example, Gordon and Lamont, 1982 or Morrison, 2006). We should expect that if a FUR's growth rate were negatively influenced by a concentration of unemployment in it at the start of the period then a concentration of unemployed in closely surrounding FURs would also have a negative impact. Given the possibility of job search in surrounding nearby labour markets we would expect higher unemployment not to be just localised, moreover, but in densely urbanised regions, we would expect unemployment rates for workers of comparable skill levels to even out between neighbouring FURs. Since job search areas and commuting distances of the less skilled (proportionately more strongly represented among the unemployed) are relatively shorter we should also expect the influence of localised unemployment to be relatively short range.

Similarly the literature on the spatial pattern of innovation shows a distance decay effect, with patents tending to be applied more frequently nearer to the location of the patent and innovation rates declining with distance. So the impact of R&D with respect to innovation is subject to a distance decay effect (see for example Audretsch, 1998). This implies that we should expect R&D in one urban area to have some positive differential impact on innovation and growth in neighbouring urban areas compared to more distant urban areas. Such mechanisms, leading to systematic spatial dependence in the growth rates of FURs, will depend on the costs of commuting and perhaps communication. It, therefore, seems not only most appropriate to formulate these 'spatial' variables so that their impact declines with distance but also to include a specific time-distance penalty for national borders. We in fact experimented with alternative distance decay and national border factors but the best results were obtained using essentially the same formulae as employed to calculate the spatial weights matrix. The impact of unemployment and R&D on growth performance in neighbouring FURs was assumed to decline with the inverse squared of time-distance and be subject to a 600 minute national border time-distance penalty. For unemployment, an upper cut-off of 60 minutes and for R&D of 150 minutes was applied before adding the national border penalty. These spatial variables were calculated for all FURs by adding the observed value of the variable in FUR_i to that observed in FUR_{j-n} discounting by time-distance.

The third 'spatial' variable is the relative concentration of university students in neighbouring FURs at the start of the period. Here we expect a negative impact on growth in a particular FUR of a stronger relative concentration of university students at the start of the period in neighbouring FURs; and we also expect the distance over which such an effect would be measured to be longer than with unemployment. While a higher stock of unemployed within a tightly clustered set of urban areas should be expected to contribute to lower growth in all of them because of the way in which local labour markets work to even out unemployment rates for workers of given skill levels between areas open to commuting[12], the same is not true of a higher relative stock of university students in surrounding FURs at the start of the period. Here, there is no tendency for their distribution to be evened out by the operation of local labour markets: rather a higher stock within a given FUR at the start of the period represented a resource for future growth over the study period. A concentration of workers embodying greater human capital is associated with faster growth over the subsequent period in the FUR in which they are found. Not only should this be expected to increase the growth performance of the FUR (captured in our direct University Student variable) but also the additional growth will increase relative job opportunities and tend to suck in complementary labour including high human capital labour from surrounding FURs over the study period. Since the commuting range of higher skilled workers is greater, we should expect this effect to be measurable over a longer distance than was the case with unemployment. The best results were obtained if the cut off was set at 150 minutes to which was again added a 600 minute national border time-distance penalty.

The final 'spatial' variable was a dummy for peripherality. There has been much discussion in the literature of the impact of peripherality. We have already accounted for the impact of European integration via our Integration Gain variable but regions deemed peripheral may have common features (such as lower factor costs for example) and also have tended to be recipients of regional aid from the EU. Although the impact of such aid has been questioned (see, for example, Midelfart and Overman, 2002, or Fratesi and Rodriguez-Pose, 2004) still it is unlikely to have been systematically negative. To avoid subjective judgements about what regions are - or are not - peripheral this is formulated simply in terms of time-distance from Brussels; any FUR 600 minutes or more from Brussels is classified as peripheral.

Tables 2a & 2b about here

There was no theoretical basis on which to select the value of the cut-off thresholds for any of these 'spatial' variables. They were determined by a combination of knowledge of the empirical literature on, for example, spatial labour markets and by experiment. In all cases the selected cut-offs worked best in an empirical sense: either in the case of formulating the distance weights matrix to test for spatial dependence, they tended to produce the greatest sensitivity to tests; or, in formulating

[12] Although FURs are defined to be as self contained in commuting terms as possible where they are tightly packed (for example in the Ruhr region of Germany) it is virtually zero cost for a worker living on the edge of any FUR to change to commute to the neighbouring FUR(s).

variables to represent spatial processes, they produced the best results both in terms of significance and in terms of eliminating indications of spatial dependence. The final test results for the two 'artisanal' models reported in Table 2a, are shown in Table 2b. There are no signs either of classic econometric problems such as heteroskedasticity or non-normality of errors nor of spatial dependence. The models perform well and provide evidence consistent with the hypotheses we were interested in testing.

4. Results of automated model selection

As Hendry and Krolzig (2004) observe, the use of an appropriate algorithm to select a specific model does not absolve the researcher from the normal precautions and judgements needed: but it saves a lot of time and makes model selection less subjective. In this section, we report the results of applying such model selection procedures to the present data set, informed by our experience with a traditional, artisanal approach. We have two aims: the first is to see whether the best artisanal models are, or are close to, those which emerge from a sophisticated automated selection procedure. We should say that while our artisanal models benefited in our judgement from experimentation, they were not data mining in anything like the sense that is implied by Sala-i-Martin's 1997 claim to have run 'two million models'. While our variables were limited by data availability, we spent considerable efforts in trying to construct specific variables to test particular hypotheses and our choice of models was always guided by a view of underlying causal processes. The second aim is to test that model selection process in an application to cross sectional data where we would expect there to be underlying mechanisms generating spatial dependence. This later aim is met by a two-stage process in specifying the GUM indicated in Table 1. In the first, we exclude all those variables we had defined to try to reflect underlying spatial mechanisms, select a specific model, and then test for problems of spatial dependence. We then extend the set of variables in the GUM to include all the 'spatial' variables to see i) if such variables are selected by PcGets and ii) –if they are – whether the resulting best model is now free of problems of spatial dependence.

As recognised in Hendry & Krolzig (2001 and 2004) it is not always appropriate to simply throw all possible variables into the GUM and select the resulting model. For convenience we organised our data into the four groupings reported in Table 1: these were designed to explore 1) all the main economic variables included in the artisanal models; 2) then the use of country dummies as well as - or instead of - our non-FUR growth variable; 3) the role of additional variables available to us which we had not included in our data set for deriving the artisanal models; and then 4) as noted above, the full set of data except the country dummies which Models 2a and 2b showed not to be satisfactory, plus all the ‘spatial variables’.

The results are set out in Tables 3a and 4a while the tests results are in Tables 3b and 3c. Models 1a and 1b provide essentially the same results as the artisanal models do for all variables but in particular for three of those designed to test our main hypotheses. The Integration Gain variable, since it relates to spatial processes, is only included in GUM4 but the specific models 1a and 1b include our measures of highly skilled human capital and R&D facilities per employee and also our policy incentive variable. This latter is included in both linear and quadratic form but there is only weak evidence on which to select a quadratic form. The regression test results reported in Table 2b, however, show that while there are no real signs of non-normality of errors or heteroskedasticity, whenever a border distance penalty is included in estimating the distance weights matrix, problems of spatial dependence emerge.

Tables 3a & b and 4a & b about here

Models 2a and 2b explore the use of national dummies – most commonly used in the growth regression literature - compared to our non-FUR growth variable. If the observations truly reflect a homogeneous population then the non-FUR growth variable would seem to be appropriate. Results are significantly better if the non-FUR growth variable is included in the GUM. It is selected at the expense of all but one national dummy – that for Germany and Denmark combined. Moreover, the regression test statistics are generally more favourable. If the non-FUR growth variable is excluded from the GUM (Model 2b) then there are problems on non-normality of errors and heteroskedasticity in addition to spatial dependence.

For a priori reasons and on the basis of these results, the national dummies are excluded from subsequent GUMs but GUM3 then includes a set of climatic variables. There is substantial multicolinearity between these but it appears that warmer weather is associated with slower economic growth. Over the range of observations, the functional form is almost linear although the specific model selected includes the squared version. Performance with respect to normality of errors and heteroskedasticity is acceptable although there continue to be indications of spatial dependence if a time-distance border penalty is included.

GUM4 now includes all available variables except national dummies. The selected models are shown in Table 4a as Models 4a and b. It will be seen that the selected models include the full set of ‘spatial variables’ included in our artisanal models and, from Table 4b, that all signs of spatial dependence are eliminated. The conclusion would seem to be, therefore, that in cross sectional investigations there are likely to be spatial economic mechanisms which need to be explicitly included. They are in the underlying data generating process. Moreover, if they are included the general to specific model selection algorithm embodied in PcGets will select them - thus eliminating the need to find ways of (spatial) econometric methods to obtain consistent estimates.

Thus, with one exception, the results obtained using appropriate methods of automated model selection support the artisanal results and also the claim in Hendry and Krolzig (2004) that their use frees up research time for more useful tasks than even traditional methods relying only lightly on data mining necessitate. The exception is the fact that the final selected models – 4a and 4b - include climatic variables even when as full a range of 'spatial variables' as possible is included in the GUM. At first blush, it may not seem obvious why climate should systematically influence urban economic performance in any causal way; but drawing on the literature deriving from Roback (1982) and reviewed in Gyourko *et al* (1999) there is, in fact, a reasonable argument. A better climate will be capitalised into land prices and traded off by individuals against higher wages. In a previous and related paper (Cheshire and Magrini 2006) the present authors had, moreover, found that national climatic differences were very significant in explaining patterns of population growth and mobility between FURs within countries. There appeared to be a process of sorting between FURs, with concentrations of human capital and R&D facilities being negatively but not significantly associated with population growth, while a drier and warmer climate relative to a country's mean was strongly and significantly associated with population growth. This suggested that there was some selection process going on with people more motivated by quality of life and with lower skills tending to be differentially attracted to cities with a better relative climate. This implied, other things equal, that those more work and skill oriented – together with activities employing such labour – would find costs lower and welfare levels higher in FURs with relatively worse climates. Since this was a dynamic process – the dependent variable was a proxy for net migration – it would imply a faster rate of productivity and wage growth in FURs with climates worse than their countries' means. In essence, this is no more than the application of the insight that people who think they are likely to be unemployed anyway might as well live somewhere nice if there is a national system of welfare support.

5. Conclusions

One conclusion is, therefore, that by including variables reflecting theoretically relevant spatial adjustment mechanisms it is possible effectively to eliminate apparent problems of spatial dependence. This supports our view that spatial dependence largely reflects model specification and if explicit spatial factors are included, such problems are resolved. Furthermore testing for spatial dependence is itself very demanding. It was only when the lessons of Cheshire and Magrini (2006) were applied, and a substantial time penalty for national borders was introduced into the distance weights matrix, that tests revealed any problems of spatial dependence.

These conclusions are confirmed using automated model selection methods. If appropriate variables representing underlying spatial adjustment mechanisms are included in the GUM, they are selected in the specific model and tests reveal no problems of spatial dependence. These variables reflecting spatial adjustment mechanisms were formulated specifically to reflect the lessons derived from experimentation with the choice of weights in constructing the spatial weights matrix. Each 'spatial variable' imposed the same border distance penalty of 600 minutes.

This in turn lends credibility to our judgement that our GUM4 is a sufficiently good approximation of the underlying data generating process that we can gain insight into causal processes from our best models. Both the artisanal best models and the two specific models 4a and b, produce essentially the same result. They provide support for the hypotheses identified in the introduction. There is evidence 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. There is also evidence, however, that at the same time, once we had offset for all other factors including the systematic impacts of integration itself, all peripheral regions were on average growing relative to the rest of the EU. Finally, there is new evidence supporting the conclusion that administrative and government arrangements for cities systematically influence their growth. Where there is a governmental unit approximating the economic boundaries of an economically self-contained city-region, growth is stronger, other things equal. 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.

In this context, it should again be stressed that policies encouraging local economic growth are not 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 incentive for such policies to be generated. The significance of this variable is apparent even in a very simple model but more fully specified models and further testing confirm its statistical significance and provide some 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 (2006). A compensating variations model across the whole territory of the EU of 12 is not appropriate because while adjustments do occur, they occur mainly 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. On average results are most sensitive if national boundaries are represented by a penalty equivalent to 600 minutes travel time. The nature of our methodology, of course, does not allow us to discriminate so that is consistent with the barrier represented by a national border being greater in some contexts and less in others. The results reported in these papers taken together, however, lend support to the conclusion that in a European context of restricted labour mobility and continuing national border effects, income growth rather than population growth is a more appropriate indicator of improvements in welfare in a city.

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 temporally and the disparities in per capita income permanently 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. This may be stretching our results rather far but is consistent both with the significant positive impact of concentrations of R&D and highly skilled human capital and the significant negative effect of a better climate in explaining GDP pc growth.

The results do not identify an obvious lever policy makers 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 employee and maintaining a constant quality of university students (and students who then disproportionately join the local labour force).

It is perhaps more plausible to think of the findings on the policy incentive 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 pursuing effective growth policies, 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 incentive 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.

Audretsch, D. B. (1998), 'Agglomeration and the Location of Innovative Activity', *Oxford Review of Economic Policy*, **14** (2), 18-29.

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, (1995), 'Convergence-Divergence in Regional Growth Rates: An Empty Black Box?', In Armstrong, H.W. and Vickerman, R.W. (Eds.), *Convergence and Divergence Among European Regions*, London: Pion.

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, (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, (2006) 'Population Growth in European Cities: weather matters – but only nationally', *Regional Studies*, **40**, 1, 23-37.

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.

Durlauf, S.N. and D. Quah (1999) 'The new empirics of economic growth', In Taylor, J.B. and M. Woodford (eds) *Handbook of macroeconomics, Volume 1A*, 2335-308. North Holland, Amsterdam

Eurostat (2005) *News Release 47/2005*, 7th April.

Florax, R.J.G.M., H. Folmer and S.J. Rey (2003) 'Specification searches in spatial econometrics: the relevance of Hendry's methodology', *Regional Science and Urban Economics,* **33** (5), 557-579.

Fratesi, U. and A. Rodriguez-Pose (2004) 'Between Development and Social Policies: The Impact of European Structural Funds in Objective 1 Regions', *Regional Studies*, **38**, 1, 97-113.

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.

Gordon, I. and Lamont, D. (1982) A model of Labour-market Interdependencies in the London Region. *Environment and Planning A*, **14**, 238-64.

Gyourko, J., M. Kahn and J. Tracy (1999) 'Quality of Life and Environmental Comparisons' in P.C.Cheshire and E. Mills (Eds) *Handbook of Regional and Urban Economics, Vol. 3: Applied Urban Economics*, North Holland: Amsterdam.

Hendry D. F. and H-M. Krolzig (2001) *Automated Econometric Model Selection Using PcGets*, Timberlake Consultants.

Hendry D. F. and H-M. Krolzig (2004) 'We Ran One Regression', *Oxford Bulletin of Economics and Statistics*, **66** (5), 799-810.

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

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.

Magrini, S. (2004) 'Regional (Di)Convergence', In Henderson, V. and Thisse, J.-F.. (Eds.), *Handbook of Regional and Urban Economics*, Vol. 4. (Amsterdam: North-Holland, 2004).

Midelfart, K.H and H.G.Overman (2002) 'Delocation and European Integration: Is European Structural Spending Justified?', *Economic Policy*, **35**, 321-359.

Morrison, P. S. (2005) 'Unemployment and Urban Labour Markets', *Urban Studies*, **42,**12, 2261-2288.

Oates, W.E. (1999) 'An Essay on Fiscal Federalism', *Journal of Economic Literature*, **XXXVII**, 1120-49.

Rappaport, J. (1999) *Local Growth Empirics*, CID Working paper 23, Center for International Development at Harvard University, Cambridge, M.A.

Rey, S.J. and B.D. Montuori (1999) US regional income convergence: a spatial economic perspective. *Regional Studies*, 33:143-156.

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

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

Temple J (1999) The new growth evidence. *Journal of Economic Literature* 37: 112–156.

Table 1: Variables Included in Sequence of General Unrestricted Models

No	GUM	Variable Name	Description
Core Included in General Unrestricted Models			
	All	Constant	
1	All	Ln Population	Natural log of population in 1979
2	All	Population density	Density of population in FUR in 1979
3	All	Industrial Emp. 1975	% of labour force in industry in surrounding NUTS 2 region 1975
4	All	Coalfield: core	A dummy=1 if the core of the FUR is located within a coalfield
5	All	Coalfield: hinterland	A dummy=1 if the hinterland of the FUR is located in a coalfield
6	All	Port size 1969*	Volume of port trade in 1969 in tons
7	All	Agric Emp.1975*	% of labour force in agriculture in surrounding NUTS 2 region 1975
8	All	Unemployment 1977/81*	Mean FUR unemployment rate 1977 to 1981
9	1,2a,3 & 4	Nat Ex-FUR GDP Growth '79-'93	Annualised rate of growth of GDP p.c. in the territory of each country outside major FURs between 1978/80 and 1992/94
10	All	Policy Incentive*	Ratio of FUR population to that of the largest governmental unit associated with the FUR (1981): see below for details.
11	All	University Staff emp. ratio 1977/78/79*	Ratio of university staff 1977-78 to total FUR employment 1979
12	All	University Students emp. ratio 1977/78/79*	Ratio of university students 1977-78 to total FUR employment 1979
13	All	R&D Facilities per million population*	R&D laboratories of Fortune top 500 companies per million population 1980
14	All	R&D Facilities per million employed*	R&D laboratories of Fortune top 500 companies per million employees 1980
Country Dummies Included in Second General Unrestricted Models			
15	2	United Kingdom	Dummy=1 for all FURs in United Kingdom: otherwise=0
16	2	France	Dummy=1 for all FURs in France: otherwise=0
17	2	Spain	Dummy=1 for all FURs in Spain: otherwise=0
18	2	Benelux	Dummy=1 for all FURs in Belgium & Netherlands: otherwise=0
19	2	Germany & Denmark	Dummy=1 for all FURs in Germany & Denmark: otherwise=0
20	2	Italy & Greece	Dummy=1 for all FURs in Italy & Greece: otherwise=0
21	2	North Italy	Dummy=1 for all FURs in north of Rome: otherwise=0
Climate Variables Included in Third and Fourth General Unrestricted Models			
22	3, 4	Frost frequency*	Ratio of frequency of days with frost between FUR and national average (1970s and 1980s)
23	3, 4	Wet days*	Ratio of wet day frequency between FUR and national average (1970s and 1980s)
24	3, 4	Maximum temperature*	Ratio of maximum temperature between FUR and national average (1970s and 1980s)

Table 1 continued

		Spatial Adjustment Variables Included in Fourth General Unrestricted Model	
25	4	Integration Gain*	Change in economic potential for FUR resulting from pre-Treaty of Rome EEC to post enlargement EU with reduced transport costs
26	4	Peripherality dummy	Dummy=1 if FUR more than 10 hours time distance from Brussels
27	4	University Student density employment	Sum of university students per 1000 employees in all FURs within 150 minutes travel time discounted by distance with 600 time penalty added for national borders
28	4	University Staff density employment	Sum of university staff per 1000 employees in all FURs within 150 minutes travel time discounted by distance with 600 time penalty added for national borders
29	4	R&D Facilities density employment	Sum of R&D Facilities per million employees in all FURs within 150 minutes travel time discounted by distance with 600 time penalty for national borders
30	4	R&D Facilities density population	Sum of R&D Facilities per million population in all FURs within 150 minutes travel time discounted by distance with 600 time penalty for national borders
31	4	Unemployment 1977/81 density	Sum of differences between the unemployment rate (average between 1977 and 1981) of a FUR and the rates in neighbouring FURs (60min) discounted by distance by the distance

* Variables tried as a quadratic for reasons explained in the text. Never entered as squared value alone.

Table 2a: Dependent Variable Annualised Rate of Growth of GDP p.c. Mean 1978/80 to mean 1992/4: 'Artisanal' Results

	Model 1	**Model 2**
R^2	0.7413	0.7555
Adjusted R^2	0.6986	0.7095
AIC	-11.026	-11.044
LIK	685.071	688.488
Observations	121	121
Constant	-0.0234	-0.026257
s.e.	0.00925	0.009192
Nat Non-FUR GDP Growth '79-'93	0.89487	0.902537
s.e.	0.09931	0.097571
Coalfield: core	-0.00516	-0.005213
s.e.	0.00128	0.001287
Coalfield: hint'land	-0.00346	-0.003176
s.e.	0.00155	0.001526
Port size 1969	-0.00100	-0.000922
s.e.	0.00038	0.000379
Port size 1969 squared	0.0000481	0.0000450*
s.e.	0.0000240	0.0000237
Agric Emp.1975	0.000389	0.004838
s.e.	0.000155	0.000159
Agric Emp.1975 squared	-0.0000113	-0.000012
s.e.	0.0000040	0.000004
Unemployment 1977/81	-0.00033	-0.000310
s.e.	0.00014	0.000136
Ln Population 1981	0.00165	0.001611
s.e.	0.00057	0.000557
Population Density 1981	-0.0000014	-0.0000013
s.e.	0.0000006	0.0000006
Integration Gain	0.00460	0.005162
s.e.	0.00144	0.001430
University Student emp. ratio 1977/78/79	0.0000368	0.000031
s.e.	0.0000101	0.000011
R&D Facilities pop. per million	0.000896	0.000845
s.e.	0.000275	0.000275
Policy incentive	0.00266	0.008562[a]
s.e.	0.00108	0.003455
Policy incentive squared		-0.002647* [a]
s.e.		0.001554
R&D Facilities density population	0.19680	0.262331
s.e.	0.08742	0.094307
Peripherality Dummy	0.00593	0.005411
s.e.	0.00131	0.001318
University Student density employment	-0.00894	-0.010527
s.e.	0.00381	0.003797
Unemployment 1977/81 density		-0.134403*
s.e.		0.069318

Italics indicate not significant at 10%: all variables significant at 5% except where indicated with an asterisk.
[a]Significant at 10% only but F test indicates they should not be excluded as a pair at 5% level

Table 3a: Dependent Variable Annualised Rate of Growth of GDP p.c. Mean 1978/80 to mean 1992/4: Finding Core Variables – including Non-FUR Growth: PcGets

Model	1a	1b	2a	2b
R^2	0.6712	0.6785	0.6897	0.6193
Adjusted R^2	0.6347	0.6372	0.6520	0.5731
AIC	-10.8690	-10.8686	-10.9102	-10.7058
LIK	670.57	671.55	674.06	661.70
Constant	-0.03099	-0.03200	-0.03233	-0.02745
s.e.	0.00937	0.00937	0.00927	0.0092
Coalfield: core	-0.00632	-0.00621	-0.00578	-0.00579
s.e.	0.00120	0.00120	0.00118	0.00130
Coalfield: hint'land	-0.00437	-0.00418	-0.00372	
s.e.	0.00160	0.00160	0.00161	
Port size 1969	-0.00145	-0.00147	-0.00116	-0.00057
s.e.	0.00040	0.00040	0.00039	0.00020
Port size 1969 squared	0.00007	0.00008	0.00006	
s.e.	0.00003	0.00003	0.00002	
Agric Emp.1975	0.00047	0.00051	0.00044	0.00094
s.e.	0.00016	0.00016	0.00015	0.00018
Agric Emp.1975 squared	-0.000013	-0.000013	-0.000014	-0.000023
s.e.	0.000004	0.000004	0.000002	0.000005
Nat Non-FUR GDP Growth '79-'93	0.95219	0.94416	1.16248	
s.e.	0.10255	0.10238	0.11628	
Ln Population 1981	0.00211	0.00212	0.00154	0.00234
s.e.	0.00060	0.00060	0.00058	0.00063
Population Density 1981	-0.0000016	-0.0000015		
s.e.	0.0000007	0.0000007		
Unemployment 1977/81			-0.00047	-0.00049
s.e.			0.00015	0.00017
University Student emp. ratio 1977/78/79	0.000036	0.000031	0.000036	0.000035
s.e.	0.000007	0.000012	0.000014	0.000013
R&D Facilities pop. per million	0.00078	0.00081		
s.e.	0.00029	0.00029		
Policy incentive	0.00330	0.00750	0.00720	0.01017[a]
s.e.	0.00108	0.00335	0.00342	0.00397
Policy incentive squared		*-0.00209*	*-0.00192*	-0.00311*[a]
s.e.		*0.00158*	*0.00160*	0.00181
Germany & Denmark			-0.00536	-0.00340
s.e.			0.00128	0.00140
France				-0.01210
s.e.				0.00149
Italy & Greece				-0.00338
s.e.				0.00169
Spain				-0.00413
s.e.				0.00185

Italics indicate not significant at 10%: all variables significant at 5% except where indicated with an asterisk.
[a]Significant at 10% only but F test indicates they should not be excluded as a pair at 5% level

Table 4a: Dependent Variable Annualised Rate of Growth of GDP p.c. Mean 1978/80 to mean 1992/4: Finding Specific Models – including spatial variables: PcGets

Model	3a	3b	4a	4b
R^2	0.6789	0.6781	0.7646	0.7719
Adjusted R^2	0.6399	0.6390	0.7175	0.7235
AIC	-10.7447	-10.8736	-11.0706	-10.8792
LIK	672.00	671.86	690.77	692.68
Constant	-0.02507	-0.02051	-0.03720	-0.03772
s.e.	0.00934	0.00986	0.01024	0.01004
Coalfield: core	-0.00665	-0.00663	-0.00489	-0.00524
s.e.	0.00118	0.00118	0.00128	0.00128
Coalfield: hint'land	-0.00451	-0.00447	-0.00331	-0.00327
s.e.	0.00159	0.00159	0.00151	0.00150
Port size '69	-0.00143	-0.00143	-0.00104	-0.00096
s.e.	0.00040	0.00040	0.00037	0.00037
Port size '69 squared	0.00007	0.000074	0.000051	0.000047
s.e.	0.00002	0.000025	0.000023	0.000023
Agric Emp.'75	0.00062	0.00062	0.00034	0.00038
s.e.	0.00015	0.00015	0.00016	0.00016
Agric Emp.'75 squared	-0.000015	-0.000015	-0.0000093	-0.000010
s.e.	0.000004	0.000004	0.0000041	0.000004
Nat Non-FUR GDP Growth '79-'93	0.92382	0.92452	0.84862	0.85222
s.e.	0.10106	0.10120	0.09823	0.09720
Ln Population 1981	0.00195	0.00196	0.00149	0.00146
s.e.	0.00059	0.00059	0.00055	0.00055
Population Density 1981			-0.0000014	-0.0000013
s.e.			0.0000006	0.0000006
Unemployment 1977/81			-0.00040	-0.00035
s.e.			0.00014	0.00014
University Student emp. ratio 1977/78/79	0.00003	0.0000283	0.0000270	0.0000259
s.e.	0.00001	0.0000114	0.0000110	0.0000104
R&D Facilities pop. per million	0.00095	0.00095	0.00086	0.00079
s.e.	0.00029	0.00029	0.00027	0.00027
Policy incentive	0.00871	0.00870	0.00666*	0.00770[a]
s.e.	0.00334	0.00335	0.00342	0.00343
Policy incentive squared	-0.00269*	-0.00269*	*-0.00219*	*-0.00253*[a]
s.e.	0.00158	0.00158	*0.00153*	*0.00153*
Maximum temperature		-0.00943		
s.e.		0.00397		
Maximum temperature squared	-0.00467			
s.e.	0.00192			
Wet days			0.03992	0.03834
s.e.			0.01463	0.01450
Wet days squared			-0.02029	-0.01928
s.e.			0.00731	0.00725
Integration gain			0.00408	0.00435
s.e.			0.00150	0.00149
Peripherality dummy			0.00647	0.00632
s.e.			0.00134	0.00133
Unemployment 1977/81 density				-0.12129*
s.e.				0.06806
University Student density employment			-0.00992	-0.01097
s.e.			0.00370	0.00371
R&D Facilities density population			0.18092	0.25088
s.e.			0.08620	0.09388

Italics indicate not significant at 10%: all variables significant at 5% except where indicated with an asterisk.
[a]Significant at 10% only but F test indicates they should not be excluded as a pair at 5% level

Table 2b: Regression diagnostics for spatial dependence: 'Artisanal Models'

REGRESSION DIAGNOSTICS (SpaceStat)	**Models**	**1**		**2**		
MULTICOLLINEARITY CONDITION NUMBER	98.92			100.87		
TEST ON NORMALITY OF ERRORS	DF	Value	Prob	DF	Value	Prob
TEST=Jarque-Bera	2	0.3814	0.8264	2	1.2374	0.5386
DIAGNOSTICS FOR HETEROSKEDASTICITY						
RANDOM COEFFICIENTS	DF	Value	Prob	DF	Value	Prob
TEST=Breusch-Pagan	17	19.9917	0.2747	19	20.8169	0.3470
DIAGNOSTICS FOR SPATIAL DEPENDENCE						
FOR WEIGHT MATRIX (row-standardized)	Inverse of time-distance with infinite national border effect					
TEST	MI/DF	Value	Prob	MI/DF	Value	Prob
Moran's I (error)	-0.05797	-0.3996	0.6895	-0.04784	-0.1457	0.8842
Lagrange Multiplier (error)	1	1.6403	0.2003	1	1.1171	0.2905
Lagrange Multiplier (lag)	1	1.0696	0.3010	1	1.4510	0.2284
FOR WEIGHT MATRIX (row-standardized)	Inverse of time-distance squared with infinite national border effect					
Moran's I (error)	-0.06968	-0.2986	0.7653	-0.06140	-0.1916	0.8480
Lagrange Multiplier (error)	1	1.0860	0.2974	1	0.8432	0.3585
Lagrange Multiplier (lag)	1	1.4589	0.2271	1	1.9795	0.1594
FOR WEIGHT MATRIX (row-standardized)	Inverse of time-distance with 600 minute national border effect					
Moran's I (error)	-0.01668	0.6336	0.5263	-0.01504	0.6940	0.4877
Lagrange Multiplier (error)	1	0.4839	0.4867	1	0.3938	0.5303
Lagrange Multiplier (lag)	1	0.5667	0.4516	1	0.9660	0.3257
FOR WEIGHT MATRIX (row-standardized)	Inverse of time-distance squared with 600 minute national border effect					
Moran's I (error)	-0.03840	-0.1358	0.8919	-0.03589	-0.1484	0.8820
Lagrange Multiplier (error)	1	0.4452	0.5046	1	0.3888	0.5329
Lagrange Multiplier (lag)	1	1.1855	0.2762	1	1.5291	0.2162
FOR WEIGHT MATRIX (row-standardized)	Inverse of time-distance with zero national border effect					
Moran's I (error)	-0.01672	0.3679	0.7129	-0.01538	0.4386	0.6610
Lagrange Multiplier (error)	1	0.7609	0.3830	1	0.6440	0.4223
Lagrange Multiplier (lag)	1	0.0702	0.7911	1	0.4333	0.5104
FOR WEIGHT MATRIX (row-standardized)	Inverse of time-distance squared with zero national border effect					
Moran's I (error)	-0.02915	0.1787	0.8582	-0.02911	0.1375	0.8906
Lagrange Multiplier (error)	1	0.3506	0.5538	1	0.3498	0.5542
Lagrange Multiplier (lag)	1	0.0494	0.8240	1	0.1902	0.6627

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

Table 3b: Regression diagnostics for spatial dependence: Finding Core Variables – including Non-FUR Growth: PcGets

REGRESSION DIAGNOSTICS (SpaceStat)	**Models**	**1a**			**1b**			**2a**			**2b**	
MULTICOLLINEARITY CONDITION NUMBER	78.77			80.62			82.53			79.76		
TEST ON NORMALITY OF ERRORS	DF	Value	Prob	DF	Value	Prob	DF	Value	Prob	DF	Value	Prob
TEST=Jarque-Bera	2	2.0205	0.3641	2	3.3273	0.1894	2	0.5832	0.7471	2	*4.8275*	*0.0895*
DIAGNOSTICS FOR HETEROSKEDASTICITY												
RANDOM COEFFICIENTS	DF	Value	Prob	DF	Value	Prob	DF	Value	Prob	DF	Value	Prob
TEST=Breusch-Pagan	12	17.3352	0.1374	13	19.3825	0.1117	13	17.2585	0.1878	13	**22.9188**	**0.0427**
DIAGNOSTICS FOR SPATIAL DEPENDENCE												
FOR WEIGHT MATRIX (row-standardized)	Inverse of time-distance with infinite national border effect											
TEST	MI/DF	Value	Prob	MI/DF	Value	Prob	MI/DF	Value	Prob	MI/DF	Value	Prob
Moran's I (error)	0.0404	*1.7904*	*0.0734*	0.04344	*1.8729*	*0.0611*	-0.00051	0.9328	0.3509	0.03703	**2.3959**	**0.0166**
Lagrange Multiplier (error)	1	0.7982	0.3716	1	0.9212	0.3372	1	0.00013	0.9910	1	0.6693	0.4133
Lagrange Multiplier (lag)	1	**7.0480**	**0.0079**	1	**6.6183**	**0.0101**	1	2.0401	0.1532	1	**9.0238**	**0.0027**
FOR WEIGHT MATRIX (row-standardized)	Inverse of time-distance squared with infinite national border effect											
Moran's I (error)	0.05348	1.3687	0.1711	0.05593	1.4068	0.1595	0.0353	1.2243	0.2208	0.0602	1.8836	*0.0596*
Lagrange Multiplier (error)	1	0.6397	0.4238	1	0.6996	0.4029	1	0.2793	0.5972	1	0.8108	0.3679
Lagrange Multiplier (lag)	1	**7.3863**	**0.0066**	1	**7.1177**	**0.0076**	1	**4.1352**	**0.0420**	1	**7.4412**	**0.0064**
FOR WEIGHT MATRIX (row-standardized)	Inverse of time-distance with 600 minute national border effect											
Moran's I (error)	0.03000	**2.8340**	**0.0046**	0.0303	**2.8693**	**0.0041**	0.0106	1.9680	**0.0491**	-0.00375	1.5111	0.1308
Lagrange Multiplier (error)	1	1.5625	0.2113	1	1.5984	0.2061	1	0.1962	0.6578	1	0.0244	0.8758
Lagrange Multiplier (lag)	1	6.0683	**0.0138**	1	**5.8394**	**0.0157**	1	1.9789	0.1595	1	**4.2374**	**0.0395**
FOR WEIGHT MATRIX (row-standardized)	Inverse of time-distance squared with 600 minute national border effect											
Moran's I (error)	0.06565	*1.7792*	*0.0752*	0.06620	*1.7888*	*0.0736*	0.0486	1.6014	0.1093	0.0169	1.2432	0.2138
Lagrange Multiplier (error)	1	1.3012	0.2540	1	1.3233	0.2500	1	0.7120	0.3988	1	0.0864	0.7688
Lagrange Multiplier (lag)	1	**7.5294**	**0.0061**	1	**7.1366**	**0.0076**	1	**4.1707**	**0.0411**	1	4.6681	**0.0307**
FOR WEIGHT MATRIX (row-standardized)	Inverse of time-distance with zero national border effect											
Moran's I (error)	0.0145	2.3944	**0.0166**	0.0143	**2.3972**	**0.0165**	0.0024	1.6411	0.1008	-0.00758	1.1601	0.2460
Lagrange Multiplier (error)	1	0.5733	0.4489	1	0.5553	0.4561	1	0.0162	0.8988	1	0.1563	0.6926
Lagrange Multiplier (lag)	1	*2.7475*	*0.0974*	1	2.4908	0.1145	1	0.9117	0.3397	1	2.5622	0.1094
FOR WEIGHT MATRIX (row-standardized)	Inverse of time-distance squared with zero national border effect											
Moran's I (error)	0.0612	*1.8831*	*0.0597*	0.0573	*1.7963*	*0.0724*	0.0388	1.5205	0.1284	-0.01480	0.5336	0.5936
Lagrange Multiplier (error)	1	1.5445	0.2139	1	1.3549	0.2444	1	0.6212	0.4306	1	0.0903	0.7637
Lagrange Multiplier (lag)	1	*3.3245*	*0.0683*	1	*2.8781*	*0.0898*	1	1.7275	0.1887	1	1.8729	0.1711

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

Table 4b: Regression diagnostics for spatial dependence: Finding Specific Models – including spatial variables: PcGets

REGRESSION DIAGNOSTICS (SpaceStat)	**Models**	**3a**		**3b**			**4a**			**4b**		
MULTICOLLINEARITY CONDITION NUMBER	82.89			84.99			170.27			170.52		
TEST ON NORMALITY OF ERRORS	DF	Value	Prob	DF	Value	Prob	DF	Value	Prob	DF	Value	Prob
TEST=Jarque-Bera	2	0.7819	0.6764	2	0.8204	0.6635	2	2.6862	0.2610	2	3.1805	0.2039
DIAGNOSTICS FOR HETEROSKEDASTICITY												
RANDOM COEFFICIENTS	DF	Value	Prob	DF	Value	Prob	DF	Value	Prob	DF	Value	Prob
TEST=Breusch-Pagan	13	*20.0332*	*0.0944*	13	19.7273	0.1022	20	*28.8825*	*0.0901*	21	28.6001	0.1239
DIAGNOSTICS FOR SPATIAL DEPENDENCE												
FOR WEIGHT MATRIX (row-standardized)	Inverse of time-distance with infinite national border effect											
TEST	MI/DF	Value	Prob	MI/DF	Value	Prob	MI/DF	Value	Prob	MI/DF	Value	Prob
Moran's I (error)	0.0009	0.8554	0.3923	0.00034	0.8409	0.4004	-0.06077	-0.3790	0.7047	-0.05938	-0.3514	0.7253
Lagrange Multiplier (error)	1	0.0004	0.9839	1	0.0001	0.9941	1	1.8028	0.1794	1	1.7209	0.1896
Lagrange Multiplier (lag)	1	*3.4779*	*0.0622*	1	*3.3025*	*0.0692*	1	1.1523	0.2831	1	1.5775	0.2091
FOR WEIGHT MATRIX (row-standardized)	Inverse of time-distance squared with infinite national border effect											
Moran's I (error)	-0.0003	0.5994	0.5489	-0.000678	0.5908	0.5547	-0.07938	-0.3516	0.7252	-0.08193	-0.4126	0.6799
Lagrange Multiplier (error)	1	0.0000	0.9969	1	0.0001	0.9919	1	1.4097	0.2351	1	1.5016	0.2204
Lagrange Multiplier (lag)	1	**4.1455**	**0.0417**	1	**4. 2780**	**0.0448**	1	1.1355	0.2866	1	1.6855	0.1942
FOR WEIGHT MATRIX (row-standardized)	Inverse of time-distance with 600 minute national border effect											
Moran's I (error)	0.0036	1.4127	0.1578	0.00325	1.3942	0.1635	-0.02087	0.4745	0.6351	-0.02051	0.4639	0.6427
Lagrange Multiplier (error)	1	0.0226	0.8804	1	0.0184	0.8921	1	0.7580	0.3840	1	0.7321	0.3922
Lagrange Multiplier (lag)	1	2.4557	0.1171	1	2.2956	0.1297	1	0.5202	0.4708	1	1.1201	0.2899
FOR WEIGHT MATRIX (row-standardized)	Inverse of time-distance squared with 600 minute national border effect											
Moran's I (error)	0.0073	0.7723	0.4399	0.00717	0.7675	0.4428	-0.0568	-0.1169	0.9070	-0.05842	-0.1759	0.8604
Lagrange Multiplier (error)	1	0.0162	0.8986	1	0.01553	0.9008	1	0.9744	0.3236	1	1.0305	0.3100
Lagrange Multiplier (lag)	1	*3.6785*	*0.0551*	1	*3.5446*	*0.0597*	1	0.7455	0.3879	1	1.2755	0.2587
FOR WEIGHT MATRIX (row-standardized)	Inverse of time-distance with zero national border effect											
Moran's I (error)	-0.0075	0.7255	0.4681	-0.00789	0.6955	0.4867	-0.01663	0.4849	0.6278	-0.0159	0.5131	0.6079
Lagrange Multiplier (error)	1	0.1540	0.6948	1	0.1694	0.6807	1	0.7528	0.3856	1	0.6882	0.4068
Lagrange Multiplier (lag)	1	0.7989	0.3714	1	0.7157	0.3976	1	0.0646	0.7993	1	0.5508	0.4580
FOR WEIGHT MATRIX (row-standardized)	Inverse of time-distance squared with zero national border effect											
Moran's I (error)	-0.0130	0.3251	0.7451	-0.01343	0.3138	0.7537	-0.03323	0.1825	0.8552	-0.03337	0.1464	0.8836
Lagrange Multiplier (error)	1	0.0700	0.7914	1	0.0744	0.7850	1	0.4557	0.4996	1	0.4596	0.4978
Lagrange Multiplier (lag)	1	0.6212	0.4306	1	0.5785	0.4469	1	0.00002	0.9961	1	0.1367	0.7116

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

Appendix 1: Variable Definitions and data

Appendix Table 1: The dependent variable was in all cases the annualised rate of FUR growth in estimated GDP p.c. converted at OECD PPS. Growth measured between means of 1978/80 and 1992/94 and estimated from Eurostat NUTS 3 and national data as described in text

	Variable Name	Description
1	Ln Population	Natural log of population in 1979
2	Population density	Density of population in FUR in 1979
3	Coalfield: core	A dummy=1 if the core of the FUR is located within a coalfield
4	Coalfield: hinterland	A dummy=1 if the hinterland of the FUR is located in a coalfield
6	Port size '69	Volume of port trade in 1969 in tons
7	Agric Emp.'75	Percentage of labour force in agriculture in surrounding Level 2 region in 1975
8	Nat Ex-FUR GDP Grow '79-'93	Annualised rate of growth of GDP p.c. in the territory of each country outside major FURs between 1978/80 and 1992/94
9	Policy Incentive	Ratio of FUR population to the that of the largest governmental unit associated with the FUR (1981): see below for details.
10	Integration Gain	Change in economic potential for FUR resulting from movement from individual nation-states to post enlargement EU with reduced transport costs
11	University Students ratio 1977/78/79	Ratio between university and higher education students (1977-1978) and total employment (1979)
12	University Student density in neighbouring FURs within 150 minutes	Sum of university and higher education students per 1000 employees in all FURs within 150 minutes travel time with 600 time penalty added for national borders
13	R&D Facilities per million population	R&D laboratories of Fortune top 300 companies per million employees (1980)
14	R&D Facilities per million in FURs within 150 minutes+600 min border cost	Sum of R&D Facilities per million employees in all FURs within 150 minutes travel time with 600 time penalty for national borders
15	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
16	Dummy for peripheral FURs 600 mins or more travel time from Brussels	Dummy variable = 0 if FUR is less than 600 minutes travel time (allowing for sea crossings) from Brussels: =1 for all other FURs

To estimate the **Policy Incentive** 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 NUTS 1 Land 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 abolition of London-wide government in the middle of the period. In 1985, 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 some of 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.

Sources for other data

Variable number	
1	National Censuses of population or – where unavailable – national registration data
2	Area from administrative maps
3	*Oxford Regional Economic Atlas*, Oxford: OUP, 1971
4	*Oxford Regional Economic Atlas*, Oxford: OUP, 1971
5	Hanbusch der Europaischen Seehafen Band II, III, IV, V, VI, VII, VIII, IX & X Hamburg: Verlag Weltarchiv, various dates from 1968
6	Eurostat
7	Estimated from Eurostat data
8	See above for details.
9	Estimated from Clark *et al* 1969 and Keeble *et al* 1988
10	University Students taken from *The International Association of Universities*, *International Handbook of Universities*, 1978, (seventh edition), London: The Macmillan Press; *Association of Commonwealth Universities, Commonwealth University Yearbook 1979*, 1978, (fifty-fifth edition) London: The Association of Commonwealth Universities; and *The World of Learning 1978-1979*, 1978, (twenty-ninth edition), London: Europa Publications: total employment estimated from Eurostat data
11	University Student density as per variable11: time-distances here and elsewhere from standard road freight software
12	R&D laboratories of Fortune top 500 companies as reported in *Directory of European Research*, London: Longman, 1982
13	R&D Facilities as per 13: time-distances as per 12
14	Unemployment rates estimated for FURs from Eurostat NUT 3 data
15	Time-distances from standard road freight software: Microsoft

Appendix 2: FUR and NUTS GDP data

FUR	NUTS Level 3	% Difference FUR:NUTS Growth rate 1978/80 to 1992/94	Mean GDP p.c. 1992-94.
Antwerpen	Antwerpen (Arrondissement)	2.02	-14.26
Bruxelles-Brussel	Reg.Bruxelles-Cap./Brussels Hfdst.Gew.	-4.12	-59.64
Charleroi	Charleroi	-0.17	-8.60
Liege	Liege (Arrondissement)	6.47	-0.43
Aarhus	Aarhus Amt	0.62	0.01
Koebenhavns	Koebenhavns Amt	-2.27	-7.82
Aachen	Aachen, Landkr.	13.39	22.27
Augsburg	Augsburg, Krfr.St.	-4.51	-42.99
Bielefeld	Lippe	0.05	16.26
Bochum	Recklinghausen	8.11	17.50
Bonn	Rhein-Sieg-Kreis	-1.05	21.75
Braunschweig	Braunschweig, Krfr.St.	-3.70	-26.89
Bremen	Bremen, Krfr.St.	0.80	-36.05
Dortmund	Dortmund, Krfr.St.	2.32	-11.76
Duesseldorf	Duesseldorf, Krfr.St.	-0.23	-51.05
Duisburg	Duisburg, Krfr.St.	3.68	-12.00
Essen	Essen, Krfr.St.	-3.76	-13.94
Frankfurt	Frankfurt am Main, Krfr.St.	-0.08	-89.61
Hamburg	Hamburg	0.83	-27.67
Hannover	Hannover, Landkr.	-3.49	38.82
Karlsruhe	Karlsruhe, Landkr.	0.46	21.95
Kassel	Kassel, Landkr.	-12.13	19.47
Koeln	Koeln, Krfr.St.	-0.32	-25.64
Krefeld	Viersen	-16.69	12.38
Manheim	Rhein-Neckar-Kreis	-9.62	30.27
Moenchengladbach	Moenchengladbach, Krfr.St.	-1.12	-13.67
Muenchen	Muenchen, Krfr.St.	0.60	-38.84
Muenster	Steinfurt	2.08	11.20
Nuernberg	Nuernberg, Krfr.St.	-2.73	-47.74
Saarbruecken	Saarbruecken, Stadtverband	3.10	-33.11
Stuttgart	Stuttgart, Stadtkr.	-0.57	-60.71
Wiesbaden	Wiesbaden, Krfr.St.	-22.16	-58.16
Wuppertal	Wuppertal, Krfr.St.	-1.79	-4.24
Athens	Attiki	-0.81	0.07
Saloniki	Thessaloniki	-0.15	-0.04
Alicante	Alicante	0.00	0.00
Barcelona	Barcelona	0.05	0.31
Bilbao	Vizcaya	-0.87	0.19
Cordoba	Cordoba	0.00	0.00
Gijon/Aviles	Asturias	0.00	0.00
Granada	Granada	-0.02	0.34
La Coruna	La Coruna	0.00	0.00
Madrid	Madrid	-0.16	-0.58
Malaga	Malaga	0.02	-0.01
Murcia	Murcia	0.00	0.00
Palma De Mallorca	Baleares	0.00	0.00
Sevilla	Sevilla	-0.43	-0.14
Valencia	Valencia	-0.16	0.19
Valladolid	Valladolid	0.01	-0.01
Vigo	Pontevedra	0.00	0.00
Zaragoza	Zaragoza	-2.31	0.53
Bordeaux	Gironde	0.03	-0.02
Clermont-Ferrand	Puy-de-Dome	0.00	0.00
Dijon	Cote-d'Or	0.00	0.00
Grenoble	Isere	-0.02	-0.01

Le Havre	Seine-Maritime	0.00	0.00
Lille	Nord	0.00	0.00
Lyon	Rhone	-0.45	-5.67
Marseille	Bouches-du-Rhone	0.00	0.00
Montpellier	Herault	0.00	0.00
Mulhouse	Haut-Rhin	0.00	0.00
Nancy	Meurthe-et-Moselle	0.00	0.00
Nantes	Loire-Atlantique	0.81	-6.96
Nice	Alpes-Maritimes	0.00	0.00
Orleans	Loiret	0.37	-0.39
Paris	Paris	-6.12	-78.87
Rennes	Ille-et-Vilaine	0.00	0.00
Rouen	Seine-Maritime	2.19	-6.17
St. Etienne	Loire	3.16	-1.60
Strasbourg	Bas-Rhin	0.00	0.00
Toulon	Var	0.00	0.00
Toulouse	Haute-Garonne	0.00	0.00
Valenciennes	Nord	0.00	0.00
Dublin	East	-7.12	5.94
Bari	Bari	11.43	6.03
Bologna	Bologna	-3.26	-3.72
Brescia	Brescia	4.16	-3.24
Cagliari	Cagliari	5.05	4.21
Catania	Catania	22.76	14.88
Firenze	Firenze(94)	15.27	10.52
Genova	Genova	5.58	6.46
Messina	Messina	12.86	10.51
Milano	Milano(94)	5.03	9.40
Napoli	Napoli	3.90	5.53
Padova	Padova	3.13	-0.34
Palermo	Palermo	12.41	10.30
Roma	Roma	1.36	-0.59
Taranto	Taranto	10.01	7.14
Torino	Torino	-8.16	-2.33
Venezia	Venezia	-3.26	-0.50
Verona	Verona	2.00	0.41
Amsterdam	Groot-Amsterdam	-7.30	-26.55
Rotterdam	Groot-Rijnmond	3.48	-5.48
's-Gravenhage	Agglom.'s-Gravenhage	6.74	-7.40
Utrecht	Utrecht	-0.75	-2.66
Lisboa	Lisboa E Vale Do Tejo	2.88	-5.24
Porto	Norte	9.23	9.78
Belfast	Northern Ireland	0.00	0.00
Birmingham	West Midlands (County)	1.53	-2.93
Brighton	East Sussex	4.68	7.22
Bristol	Avon	-0.99	-2.12
Cardiff	South Glamorgan	-9.49	-20.80
Coventry	West Midlands (County)	5.60	0.61
Derby	Derbyshire	-0.08	-0.18
Edinburgh	Lothian	-0.42	-0.73
Glasgow	Strathclyde	-0.35	-0.04
Hull	Humberside	0.00	0.00
Leeds	West Yorkshire	0.87	0.68
Leicester	Leicestershire	0.00	0.00
Liverpool	Merseyside	0.59	0.58
London	Greater London	1.08	-9.42
Manchester	Greater Manchester	1.42	1.20
Newcastle	Tyne and Wear	-1.83	-6.55
Nottingham	Nottinghamshire	0.05	-0.74
Plymouth	Devon	-2.66	-6.28
Portsmouth	Hampshire	0.00	0.00
Sheffield	South Yorkshire	1.98	0.90

Southampton	Hampshire	0.00	0.00
Stoke	Staffordshire	1.94	3.70
Sunderland	Tyne and Wear	-1.44	-4.95
Teesside	Cleveland	5.59	1.53

The table above shows for each FUR the corresponding NUTS Level 3 region in which the largest proportion of its population resided in 1981. The last two columns show respectively the percentage difference in calculated growth rates for the estimated FUR and corresponding NUTS regions' GDP p.c. between the mean of 1978/1980 and the mean of 1992/1994; and the percentage difference between the two GDP p.c. values for the mean of 1992/94. Other representations are, of course, possible. For example, here we are comparing just FUR and NUTS 3 data. But one could take different NUTS level regions e.g. the most commonly used - NUTS 2 regions – or vary the NUTS Level used according to the size of the city for different FURs and the results would be somewhat different. As can be seen growth rates using the basis of comparison illustrated here vary by up to 23% while estimated GDP per capita varies up to 79%