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DOES SPACE MATTER? EMPIRICS ON GROWTH AND CONVERGENCE IN EU REGIONS†

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ABSTRACT

In this work we investigated the economic convergence process among extended EU regions using data on per-capita GDP for the period 1999-2006. In line with most of recent literature we used a spatial econometric framework to account for spatial heterogeneity and spatial interaction. After tests confirmed the hypothesis of spatial interaction (in the form of spatial spillovers) to be the more appropriate for our data, we introduced a gravity formulation to construct the elements of the contiguity matrix: this allows to relate the intensity of spillovers to some agglomeration measures. Results confirms that a convergence process exist even if spillovers play an important role explaining the biggest part of regional economic development. Moreover, in common with economic geography literature, we found that a trade-off between cooperation and competition characterizes relations between neighboring regions. If in fact on one side poor regions grow faster (according to catch-up hypothesis), on the other side non agglomerated areas show a lower capacity to absorb benefits of growth in neighboring areas.

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INTRODUCTION

The aim of this paper is to investigate the convergence process in European Union at regional level. Regions are in fact the main objective of European Cohesion Policy, both because they represent an intermediate political level between states and local administrations and because they're the main founds receivers. Moreover a convergence process is expected to take place in Europe since efforts have been done in order to remove barriers to national goods and services markets and labor and capital mobility should also have boosted the catching-up.So, classical regression tests are the natural starting point of such an analysis, even if standard β-convergence test has been criticized since it is not a sufficient evidence to allow global disparities reduction over time, that is the real focus of a cohesion-oriented policy; and that's why some others newer methodologies have been proposed (i.e. Quah, 1993). However authors are convinced that classical regression test has still some explaining power, even if some notations are needed. In particular, standard β-convergence test does not account for spatial matters, whose importance in regional growth process has been first underlined by Rey and Montouri (1999). Spatial econometric tools enable to consider spatial relations and/or spatial interactions in the standard convergence equation, so that to give a clearer estimation of the speed of the convergence process. We have found that a convergence process exist, as it was supposed to, and that is mainly characterized by spillover diffusion; then we tried to consider agglomeration factors in diffusion process. Emerging results, even without contributing to the debate on social disparities reduction, are much more interesting than the ones obtained with standard β-test, and some important implication may be extracted about the role played by geography in conditioning economic convergence dynamics. In the rest of the paper we first introduce an analysis of regional convergence and territorial cohesion in European Countries (paragraph 2). Then neo-classical convergence hypothesis, together with some results of previous studies in Europe at regional level (paragraph 3) are briefly shown. After a brief presentation of the data and of the spatial econometric tools used for empirical analysis (paragraph 4) we present our results (paragraph 5). In the final part we will try to extract some policy implications.

REGIONAL CONVERGENCE AND TERRITORIAL COHESION

The role and the importance of disequilibria among European regions are clearly stated in the EU Treaty where territorial cohesion is introduced along with economic and social cohesion (art.174). Furthermore, the Treaty clarifies that a "particular attention shall be paid to rural areas… and regions which suffer from severe and permanent natural or demographic

handicaps such as the northernmost regions with very low population density and island, cross-border and mountain regions" (art.174).

The emphasis on disparities is largely discussed in the sequence of reports on cohesion among regions and countries published by the EU Commission. Most of them are widely used as basis to cohesion policies. The latest evidence provides a contradictory picture of the phenomenon. On one side economic cohesion among countries has improved due to relevant performance of the so-called "cohesion countries" (countries with per capita GDP lower than 90% of European average) like Ireland and Spain that reached the top levels of European ranking. On the other side, cohesion among regions globally improved since eight regions over 78 overcome the 75% of per capita GDP (EU-27). Despite the low number of regions involved by a significant improvement, the fourth relation on social cohesion states that "The lagging regions in the EU-15, which were major recipients of support under cohesion policy during the period 2000--2006, showed a significant increase in GDP per head relative to the rest of the EU between 1995 and 2004. In 1995, 50 regions with a total of 71 million inhabitants had a GDP per head below 75% of the EU-15 average. In 2004, in nearly one in four of these regions home to almost 10 million, GDP per head had risen above the 75% threshold." Territorial cohesion exhibited an evidence of an increasing number of poles of development. Most of these poles are concentrated in large urban areas, in EU-15 regions as well as in the enlargement countries. A symmetric phenomenon of decreasing economic activities in rural areas emerged.

Until the nineties the core of the European growth was concentrated in the middle of EU-15 (Munich, Hamburg, Paris, London and Milan). Afterwards, the new comers of European economic growth emerged in Scandinavian countries, Spain and Ireland and in the capital towns of the enlargement countries. The polarisation of the economic development has largely been characterized by increasing diseconomies of agglomeration, due to increasing congestion costs and pressure on housing markets and network services, and subsequent suburbanisation. Despite an increasing optimistic view about economic convergence among EU regions, the analysis of EU policy-makers about territorial cohesion is focused on the potential problems arising from growth polarisation. Large capital towns (or better capital regions) often became strong economic growth attractors but, at the same time, increasing problems in surrounding regions and deprivation in rural areas offset the economies of agglomeration generated by increasing growth rates. Their core-peripheral dynamics is often characterized by relevant economic growth and loss of population at the core of capital region and less moderate economic growth and increasing population at the periphery of capital region (urban sprawling). In some countries economic growth is characterized by a bi-modal

(or tri-modal) distribution of regional growth rates with a leading town/region (usually the capital town region) and strong secondary poles (like Milan and Naples in Italy, Barcelona in Spain, Frankfurt and Munich), where economic growth is even higher than in the capital town. Usually, most of the economic growth is concentrated in the capital town region and less distributed in the rest of the country. Moreover, most of the economic potential is concentrated, according to EU analysis, in cross-border cooperation due to relaxation of constraints to economic exchanges from physical and administrative point of view. Cross-border areas are certainly in some cases consolidated areas of spillover effects in economic growth and in other cases, where the physical context is an obstacle, are marginal areas due to lack of infrastructure (i.e. mountain areas).

Territorial and economic differences in EU regions are also clearly due to different development patterns among European regions. Looking at the latest years (1995/2005), there have been at least three different situations:

in some regions high growth rates in per capita GDP have been obtained along with increase in productivity and in employment rates: ie. the case of Ireland;

in some other regions, relatively high growth rates in per capita GDP have been obtained along with increase in productivity and strong decline in employment rates;

in other regions, most of them in highly industrialised countries, lower (or negative) per capita GDP growth rate are accompanied by low productivity growth rate and by moderate employment rate growth.

The current economic crisis will certainly re-depict the current situation, since some of the new member states might be interested by structural crisis. Nevertheless, the underlying fundamentals of economic structure will strongly influence the recovering phase and the productivity patterns will be crucial.

The empirical evidence and most of the analysis of territorial cohesion are openly oriented to discuss how space may matters in the dynamics of convergence among European regions. Some very practical questions may arise. Are agglomerative factors crucial to explain increasing economic convergence? Is increasing economic convergence widely justified by current cohesion policies? Is there any additional room to stimulate spillover effects by supporting specific cooperation policies? Are spillover effects still relevant in a de-materialized economy in which geographical proximity may reduce its importance?

NEO-CLASSICAL CONVERGENCE HYPOTHESIS

Convergence, as well known, is the most important neoclassical growth model prediction (Solow, 1956): under simple hypothesis of perfect market competition, constant returns to scale production function and homogeneous agents, it is shown that all economies with similar characteristics follow a growth path toward a common and stable steady-state per-capita capital and income level. Barro and Sala-i-Martin (1991) suggested to test for that regressing annual average growth rate of per-capita income on a constant and initial income level: a negative and statistically significant coefficient can be taken as a convergence evidence, although it is not sufficient to allow disparities reduction over time (Barro & Sala-i-Martin, 1995) (Quah, 1993). The hypothesis has been tested in the absolute and conditional form: while the sooner applies to the case of similar structural characteristics between economies, the latter applies in the case economic structures differ.

Because of the lack of conditioning variables to be considered in standard regression at regional level, researchers interest focused on country level, while country dummy have been generally considered in regional analysis in order to catch some effects due to economic, social and cultural characteristics. Some studies on European regions have confirmed the role of country dummy in conditioning convergence process that, in any case, has been shown to exist (Brauningen & Niebuhr, 2005) (Fisher & Stirbock, 2004). Martin (1998) showed also that country dummy may have more explaining power than conditioning variables. Such studies, among the others, underlined that the assumption of homogeneous economic characteristics does not hold in general and neither in European case. Within such a framework, neo-classical analysis seems to be partial, and this leaves the field open to further studies investigating the nature of heterogeneity and the type of relations between regions. The first has been partly explored trough the use of panel data techniques. After a seminal work by Islam (1995) panel data approach has been used to investigate convergence at regional level: applying the within transformation to dependent and explanatory variables (as in the case of a Fixed Effects Estimator) enables to estimate the speed of convergence after regional specific effects have been detected. The main problem arising here is that economies are supposed to converge toward different steady states, and that's why convergence coefficient estimated with FE differs a lot from standard OLS coefficient obtained with cross-section approach. This has been found also at regional level in Europe by Tondl (1998). So, in the end, panel data techniques do not help better understanding convergence process, but clearly make regional heterogeneity to emerge, even if nothing can be said about the nature of heterogeneity.

The second has been explored trough the use of spatial econometric tools. Rey and Montouri (1999) firstly examined convergence matters under the spatial econometric point of view and some interesting results emerge when one or more terms of the standard convergence equation are supposed to follow a spatial autoregressive process. There are two ways that help to detect the role of space in regional convergence analysis: spatial relation and spatial interaction. A spatial relation emerge in the case that income distribution is not characterized by spatial randomness, and so the income level in one region is strictly related to income level in neighboring regions. In this case, part of regional heterogeneity could be explained by geographical location, since we can assume differences between two regions are lower when lower is the distance separating them. Spatial interaction refers to a case where effects of regional economic activity spill over the regional border affecting neighboring economies. As well as for intra-firms spillover diffusion (the case where benefits of an investment cannot be closed inside investor firm's walls but extend also to other firms nearly located), there's in fact no reason to suppose benefits in terms of growth are closed inside regional borders. Investigating the role of space in those two aspect will help reaching interesting insights on EU regional convergence debate.

DATA AND METHODOLOGY

The dataset is composed of 243 regions belonging to 24 member states (actually Romania and Bulgaria regions have been excluded): data on income are available starting from 1995 and ending on 2006. The measure unit is the per-capita Gross Domestic Product in Purchising Power Standard, at 1995 price level, so that to avoid possible biases coming from inflation or life-cost phenomena. Eurostat also provided European map at NUTSII administrative level, that has been used to extract information on geographical location of each region (those last were necessary to compute contiguity). In particular GISCO (the geographical information system of Eurostat) provides different kind of map containing information on regional location and, we attributed particular relevance to the map of regions as polygons defined by administrative boundaries and to the map of main cities (that is to say each region is geographically represented by its most important city).

In order to account for spatial relation and spatial interaction effects in convergence equation we used spatial econometric: this can be defined as a set of tools to deal with spatial effects in linear regression model. Spatial effects appear in linear regression model when one or more explicative variable, the dependent variable or the error term follow a spatial autoregressive (generally first order) process. This means that each observation is linked to neighboring

observations. In order to define neighboring a spatial weight matrix $\boldsymbol{W}$ is used, that is a squared positive matrix in which observations appears both in row and column and a non-zero element identifies contiguity between two observations. Generally self-contiguity is excluded so that each element in principal diagonal is zero, and the matrix is used in the row-standardized form. So, given a random vector $\boldsymbol{z}$, of dimension $\boldsymbol{n}$, its spatially lagged value $\boldsymbol{Wz}$, with $\boldsymbol{W}$ an $\boldsymbol{n} \cdot \boldsymbol{n}$ positive matrix, can be interpreted as the neighboring average of $\boldsymbol{z}$. This have some important implication in convergence analysis. Let's consider standard convergence equation in [1]

1 $$\left(\frac{1}{T}\right)\log\left(\frac{y_{t+T}}{y_t}\right) = \alpha + \beta\log(y_t) + \epsilon$$

and assume $\epsilon \sim \mathrm{iid}(0, \sigma_\epsilon^2)$. Here α and β can be estimated via OLS as long as errors are not correlated with explicative variables: what we expect is a negative and statistically significant coefficient.

The simplest way to account for spatial relation is to include in [1] a spatially lagged initial income level, so that the model became the one in [2]

2 $$\left(\frac{1}{T}\right)\log\left(\frac{y_{t+T}}{y_t}\right) = \alpha + \beta\log(y_t) + \gamma W\log(y_t) + \epsilon$$

Given convergence, if income would be randomly distributed across space we should note a $\boldsymbol{\beta}$ coefficient still significant but not the same for $\boldsymbol{\gamma}$. By contrast, a significant $\boldsymbol{\gamma}$ (expected negative), confirms the presence of geographical patterns of income and so growth rate is explained not only by initial income level but also by initial income level in surrounding areas. This formulation goes under the name of spatial cross-regressive model. Notice that, as long as error terms in [2] are still independent and identically distributed, coefficients can be estimated using OLS. At the same way spatial spillover effects can be estimated assuming that the dependent variable or the error term follow a spatial autoregressive process (Anselin 1988b). About first case, generally dependent variable is supposed to follow not a complete spatial autoregressive process but a mixed regressive autoregressive process, so that a spatially lagged dependent variable is added on the right-hand side of the standard regression model. The resulting model is commonly called Spatial Lag Model (hereafter SL), and in the case of the convergence equation it looks like in [3]:

3 $$\left(\frac{1}{T}\right)\log\left(\frac{y_{t+T}}{y_t}\right) = \rho W\left(\left(\frac{1}{T}\right)\log\left(\frac{y_{t+T}}{y_t}\right)\right)\alpha + \beta\log(y_t) + \gamma W\log(y_t) + \epsilon$$

with $\boldsymbol{\rho}$ the coefficient that measures the importance of spatial spillover effects. Notice that the presence of a spatially lagged dependent variable in right-hand side of [3] prevents the use of OLS as estimation method. Instead parameters may be estimated via Maximum Likelihood. Once we move the spatially lagged dependent variable in left-hand side we can reorganize everything to reach the reduced form of this model in [4]:

4 $$\left(\frac{1}{T}\right)\log\left(\frac{y_{t+T}}{y_t}\right) = (1-\rho W)^{-1}\alpha + (1-\rho W)^{-1}\beta\log(y_t) + (1-\rho W)^{-1}\epsilon$$

that is a non-linear model in α, ρ and β. In the second case described above, error terms are supposed to follow a spatial autoregressive process like in [5], so that an higher than expected growth rate in one region generates an higher than expected growth in neighboring regions.

5 $$\epsilon = \lambda W \epsilon + \mu$$

With $\boldsymbol{\mu} \sim \text{iid}(\mathbf{0}, \boldsymbol{\sigma}_{\boldsymbol{\mu}}^{\mathbf{2}})$: substituting [5] in [1] we have that

6 $$\left(\frac{1}{T}\right)\log\left(\frac{y_{t+T}}{y_t}\right) = \alpha + \beta\log(y_t) + (1-\lambda W)^{-1}\mu$$

and so, multiplying both sides of [6[by $(\mathbf{1}-\boldsymbol{\rho W})$ and reorganizing everything we get the so called Spatial Error Model (hereafter SE), that is the one in [7]

7 $$\left(\frac{1}{T}\right)\log\left(\frac{y_{t+T}}{y_t}\right) = \eta + \beta\log(y_t) + \lambda W\left(\left(\frac{1}{T}\right)\log\left(\frac{y_{t+T}}{y_t}\right)\right) + \delta W\log(y_t) + \mu$$

with $\boldsymbol{\eta} = (\mathbf{1}-\boldsymbol{\lambda W})^{-\mathbf{1}}\boldsymbol{\alpha}$ and a linear constraint on coefficients $\boldsymbol{\delta} = -\boldsymbol{\lambda\beta}$.

As well as for SL model also in SE model the lack of independence assumption made about the error term prevents the use of OLS, and Maximum Likelihood Method has to be used. Notice that in SE model both a spatially lagged growth rate and a spatially lagged initial income level are present, so that spatial relations and spatial interactions are considered together.

The last point of this section is devoted to a discussion on the correct choice of the contiguity matrix. As we said at the beginning of the section the where two different possibilities to obtain contiguity information: first one was obviously the use of a common boundary approach which allows to identify a set of regions as areas whom a region share a common administrative boundary with; the second was to use the main city geographical location to construct matrices based on k-nearest method (which identifies neighbors regions whose main city is one of the k nearest city to the base city, with k arbitrary chosen) and on a distance

method (which identifies neighbors regions whose main city is inside a certain great circle distance, with distance arbitrary chosen).

In both cases problems emerge. The decision to use the common boundary approach implies excluding some regions which are not considered given the fact that they're islands. This is a problem both because we leave some observations aside and because does not make sense assuming islands have no economic relations only because there's no geographical land sharing with other areas. On the other hand, both k-nearest and distance methods suffer of researcher's discretional level of the choice, relatively to the number of neighbors k in first case , and to the cutoff distance in the second case. In any case the choice of one against another is not neutral.

Discarding the common boundary approach for the reason above the choice between k-nearest and distance method has strong implications both for the theoretical connection network we have in mind and for the effects of the choice on the model specification. On one side in fact, the use of distance method implies regions like Brussels have 57 neighbors while Cyprus just 1; on the contrary the use of k-nearest method implies both Brussels and Cyprus benefit of spillovers using an identical connection structure, that is a very strong assumption. On the other side, the choice of the matrix is a fundamental step because tests for model specification, usually carried out in order to select the best spatial effects structure, are (may be) sensitive to the matrix choice[1]. And, last point, in the case one decide to use one of the two, how k (in the case of k-nearest) and distance (in the other case) should be fixed? Our opinion is that there's not an unique answer and it strongly depends from the case studied. However one can decide to chose a matrix and check consistency of the obtained results with the matrix choice, trying with several different matrix. The alternative way to be followed is to use some criteria to make a "correct" a priori choose, and it's what we have done.

EMPIRICAL RESULTS

In this section we provide empirical results of convergence analysis using spatial econometric approach. The starting point of such an analysis is a spatial autocorrelation test on residuals obtained from the OLS estimation of [1]. Results of OLS estimation in [1] are reported in table 1, followed by a series of test for spatial autocorrelation. Moran's I is computed according to Moran (1950) in order to explore the spatial distribution of error terms, while

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[1] See EMPIRICAL RESULTS

LM tests are used for model selection purpose, since a comparison of the two indicators (LM applied to spatial lag specification and to spatial error specification) is the best way to select the correct spatial interaction specification (Anselin and Rey (1991) constitute a non contradictable piece of literature in the field). The model with the highest value indicator should be chosen, and in the case both test are significant, common practice is to look at robust versions of both tests choosing the most significant (rarely both are strongly significant).

<<table 1 about here>>

Estimation results confirm the convergence hypothesis, given the significance of coefficient of initial income. The speed of convergence is then about 1.6% a year in common with standard empirical regional convergence literature. The remaining statistics confirm the goodness of fit of the model to our data. Spatial autocorrelation tests have been carried out with two type of matrices, one identifying neighbors the 4 nearest regions and the other identifying neighbors all region within a given distance (the distance is set in a way that no regions lack of neighbors). The choice was not arbitrary. For the k-nearest method we tested for spatial autocorrelation using all the matrices constructed with a k going from 1 to 30 and the Spatial lag specification seems to be the best choice for $k < 25$, while the Spatial Error specification should be used in case $k \geq 25$. We estimated all those models and the Spatial Lag with k=4 was the one achieving the higher likelihood. For the distance method we decided to start from the minimum distance allowing no islands and then we increased more and more the distance: tests confirmed that for the minimum distance Spatial lag is the correct specification, while increasing the distance moves results toward the Spatial Error specification. Again, estimating all models, the minimum distance matrix is the one that makes the model achieves the highest likelihood.

Finally we can conclude that the SL model is the best choice in both cases, given the higher value of the LM test (both in standard and robust version) for the Spatial Lag specification. Following the stepwise procedure described before for the matrix selection we should now estimate the Spatial Lag model with both matrices and the select the matrix that best fits the data according to Akaike Information Criterion (hereafter AIC) and the Log-Likelihood (hereafter LL) (Akaike, 1981). In fact it is exactly what we did are results are in table 2, but we would like to focus reader's attention to some particular aspects Of the LM test results before switching to spatial models estimates.

Notice that by construction (Anselin, 1988) the LM test is nothing but a test comparing residuals obtained estimating an unrestricted model (Spatial lag or Spatial Error) and a

restricted one (excluding the spatial specification). The higher is the value of the test the more is the variance that the spatial specification is able to observe. Following this argument the Lag specification best explains spatial structure of the data, and the higher value of the test in the case we use the distance matrix with respect to the k-nearest case implies that a distance matrix approach best corrects the model from errors due to misspecification of spatial structure. Unfortunately this contradicts results in table 2.

<<table 2 about here>>

Here the Lag and Error specifications have been estimated together in order to compare results. Moreover we estimated the common factor hypothesis which is nothing but a Lag specification where a lagged initial income was added with a constraint on the coefficient (see DATA AND METHODOLOGY). In the Lag specification, as well as in the Error one, the convergence coefficient is nearly constant, while the lagged growth rate representing the importance of spatial spillovers is higher in the models where we use the distance matrix.

Turning our attention to AIC and LL values, both values are in favor of the lag specification, as expected, but the Spatial Lag model estimated with the 4 nearest matrix is the best choice. Unfortunately the best choice suffer from a big problem: we cannot reject the null hypothesis of absence of spatial autocorrelation in residuals. It means that even after applying the lag specification to our data, residuals still remain autocorrelated. This is not such the case if we decide to use the distance method. Anyway, for the moment let us maintain both matrices as good and proceed with further result.

In the last column of table 2 , the two models ((a) with k-nearest matrix and (b) with distance matrix) are compared in the Spatial Cross Regressive specification: again according to AIC and LL model (b) is the best choice but her the convergence coefficient turns to be no more significant. This does not happen in model (a) where coefficients are all significant and of the expected sign.

Another interesting result can be extracted by estimates of Common factor hypothesis model: this last looks liken Error specification in [7] but is estimated as a Lag model with a lagged explicative variable with a constraint on its coefficient. If the Error specification is the correct one there would be not so much difference between the Error model and the Common Factor Hypothesis (CFH) model, except for the case that the CFH provides a direct estimate of the parameter under restriction. Once we know the Lag specification is the preferred, we expect the restriction to be not significant: but this again happens only in model (a) not in model (b),

where the lagged initial income (as far as in the Spatial Cross Regressive model) took the place of the initial income itself.

Combining together these two evidences (error autocorrelation and substitution between initial income and it’s lagged value) of model (b) with respect to model (a) allows to conclude in favor of some kind of misspecification present in model (b) even if it is the one best fitting the data. However, the most important general conclusion is that spatial relations characterize regional economic development process, but spatial interactions play a more important role. This, in turn, means that spatial spillovers are a key factor in regional growth, explaining more than what convergence theory alone does.

Now, given this strong evidence that regional growth is characterized by spillover diffusion, accounting for contiguity in W matrix simply with 1 or 0 may appear as a simplification, as long as it is the empirical counterpart of the assumption that spillover diffusion process is the same in all areas. On the contrary, diffusion is supposed to be easier in agglomerated areas and faster if regions are separated by small distances. This assumption has an economic meaning as long as it is true that the richer is your neighbor the more you can benefit from the neighboring relation and the lower is the distance separating two regions the easier will be to maintain the economic relation. That's why a gravity formulation for the element of W matrix should represent a better specification. In particular, we supposed spillover diffusion depends positively on the size cross-product and negatively on distance: size can reflect economic agglomeration (in this case we used GDP), social agglomeration (in this case we used the population) or the stock of physical infrastructure (measured as the kilometers of motorways or of other roads). Coming out matrices are reported in table 3 together with the name identifying the model.

Applying these matrices to spatial lag model we obtained different estimated values of parameters, but in all cases slopes were of the expected sign and significant. Model have been estimated applying the gravity structure both to the k-nearest contiguity and to the distance contiguity matrices. Results are respectively in tables 4 and 5. Given consistency of all models we selected the most efficient using again AIC and LL. In each of the two cases rescaling the element of the W matrix by the distance separating neighboring regions allows to have a better specification of the model. Adding information on agglomeration (economic, social or infrastructure) is helpful in the case of the k-nearest matrix, while it is not in the case of the distance matrix. And in particular in table 4 the $\left(\frac{gdp_i gdp_j}{d_{ij}}\right)$ hypothesis find empirical validation reflecting the importance of economic interaction between neighboring regions. At the same way the stock of physical infrastructure is important but only when measured with

the kilometers of road excluding motorways. This result should be not misleading because it does not mean that motorways are not important but more simply that kilometers of standard roads are a better proxy of the general level of infrastructure. Combining those two result together in a specification that accounts for both (i.e. the $\left(\frac{gdp_i gdp_j road_i road_j}{d_{ij}}\right)$) gives the best result. On the other hand nothing happens in table 5 where the best specification is obtained simply scaling the W matrix elements by distance or squared distance. This is because the distance matrix already reflects the agglomeration structure given that periphery regions are least connected.

Unfortunately conclusions following results in table 4 cannot be considered completely consistent because of the constant presence of spatial autocorrelation of residuals in all models, again moving preference toward the distance method matrix. Moreover notice that the likelihood achieved by the best model estimated with distance method is higher than the best one estimated with k-nearest method, finally concluding in favor of the distance method.

Finally it’s worthwhile to underline the difference between the spatial spillover coefficients obtained with the two specification (table 6). In the distance method case this is much more higher than in the k-nearest case, meaning that if we have in mind an Europe with regions in the core that are most connected and regions in periphery least connected, the “spillover effect”, that we have proved to be a determinant of regional growth contributing to the diffusion of each other benefits between neighboring regions, is more important that in the case we assume each region, wherever it is located, has the same number of connection with neighbors (in this way not differentiating between core and periphery). This last case appears too much restrictive if we keep into account the relation, even if weak, between the number of neighbors of each region and its income level. This is in figure 6 for the distance method (k-nearest method would appear as an horizontal line).

CONCLUDING REMARKS

In this work we have examined convergence in EU regions starting from classical regression framework and also using spatial econometric tools. The linear regression approach to convergence has been fully criticized both under the theoretical and empirical point of view: theoretically because it is derived by neoclassical growth model, whose assumption (in particular the CRS production function and the uniqueness and stability of the steady state) seem to be quite unrealistic and simplistic; empirically because standard convergence evidence is not sufficient to allow disparities reduction over time. And that's why some others more recent approaches emerged focusing on the long-run tendency of income distribution (Quah, 1993b). Our opinion is that the econometric approach has still some explaining power: accounting for spillover diffusion in regional growth gives a clearer evidence of income convergence and results are also coherent with many statements of New Economic Geography (Ottaviano & Thisse, 2004). We have found evidence of convergence in EU regions during the period 1995-2004 and the speed of this process has been estimated around 1.6% a year. Since errors were spatially autocorrelated, some kind of spatial process should have been considered, and the spatial lag model, accounting for benefits in term of growth one region receives from neighbors, resulted the best choice. Those relations have been considered using two kinds of contiguity matrix, both made by elements 0 characterizing non-contiguity and 1 characterizing contiguity: first one is constructed considering neighbors all regions situated within a defined cut-off distance (then such a distance is computed in a way that no region have been excluded), and second one is constructed considering neighbors the 4 nearest regions. Results made using the two matrices differ and residual autocorrelation tests together with evidences from several other estimates lead to conclude that a sort of misspecification applies to the case of the second model.

Moreover, since spillovers emerged as the key element of regional growth, a binary choice for the contiguity matrix may be not a good description of the spillover diffusion phenomena, while a gravity structure (Newton, 1687) (Zipf, 1946) (Sen & Smith, 1995), relating the intensity of interaction to variables that are proxy of economic and social agglomeration and of the transportation infrastructure level, should provide, at least theoretical, a better specification, improving model’s goodness of fit. This in fact can be seen applying the gravity structures to the matrix constructed with k-nearest method but not in the other case, in which the best fit is obtained simply rescaling contiguity matrix elements by squared distance separating regions. In this last case the spillover coefficient is higher than in the k-nearest case, meaning that the assumption that all regions have the same number of relations

underestimates the spillover effect. This in turn implies that the higher the number of interaction the easier it will be to catch growth benefits spill over neighbor's borders.

So we can conclude that a convergence process exist but regional growth is mainly a spatial matter rather than a simple capital accumulation story. Agglomeration and economic interaction are key factors and their important presence positively affects one regions growth. However, even if poor regions grow faster, poor regions located near developed areas have more growth opportunity. Policy makers should account for than when planning intervention in least developed areas, given that these last are located in European periphery and that developed regions tend to be well connected: both facts, when combined with our evidence, allow to define the development process as a process whose benefits are not equally distributed across regions but are concentrated in some already developed and well interconnected areas.

Table 1: Convergence equation estimates

OLS Estimates		
C	0.202349 (11.896) ***	
LN GDP95	-0.016663 (-9.347) ***	
Adj R-Squared	0.263	
F(1,241)	87.36 ***	
Log-Likelihood	747.2297	
Akaike Information Criterion	-1488.459	

Spatial Autocorrelation Diagnostic		
	distance method	k-nearest method
Moran I on residuals	0.1703474273	0.317182278
LM-Lag	112.2952 ***	75.5784 ***
LM-Err	104.4178 ***	55.5196 ***
Robust LM-Lag	19.2903 ***	21.6272 ***
Robust LM-Err	11.4129 ***	1.5684

Table 2: Spatial models estimates

Maximum Likelihhod / OLS Estimates

	Spatial lag		Spatial Error		Common Factor Hypothesis		Spatial Cross Regressive	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
C	0.0894872	0.0954011	0.1354334	0.1200475	0.1221904	0.1287559	0.306825	0.249296
	(4.8866) ***	(5.5353) ***	(6.0092)	(5.3153) ***	(3.3009) ***	(5.6118) ***	(10.882) ***	(13.163) ***
LN GDP95	-0.008412	-0.0080296	-0.0094672	-0.0080481	-0.0064576	-0.0026133	-0.006752	-0.004549
	(-4.8276) ***	(-4.8054) ***	(-4.0353)	(-3.3958) ***	(-2.5534) *	(-0.9908)	(-2.436) ***	(-1.503)
LAGGED LN GDP95	-	-			-0.0051582	-0.008672	-0.020832	-0.017008
	-	-			(-1.0655)	(-2.6539) ***	(-4.549) ***	(-4.842) ***
LAGGED GROWTH RATE	0.79477	0.5668	0.84916	0.59461	0.74665	0.51689	-	-
	(10.57) ***	(9.5888) ***	(12.447) ***	(9.9838) ***	(7.9694) ***	(7.859) ***	-	-
Likelihood Ratio	54.032 ***	65.784 ***	45.215***	51.94 ***	35.153 ***	50.401 ***	-	-
Wald test / F Statistic	111.72 ***	91.945 ***	154.93 ***	99.676 ***	63.511 ***	61.763 ***	57.6 ***	59.47 ***
Log-Likelihood	774.2455	780.1217	769.8374	773.1996	774.856	783.7555	757.2792	758.5551
Akaike information Criterion	-1540.5	-1552.2	-1531.7	-1538.4	-1539.7	-1557.5	-1506.558	-1509.11
LM test on residual autocorrelation	0.11062	4.914 ***	-	-	0.2105	0.026302	-	-

model (a) estimated with distance method matrix and model (b) with k-nearest method matrix

Table 3: Gravity structures for contiguity matrix elements

W	w_{ij}	R+R/D	$(other_i + other_j)/d_{ij}$	YYMM/D	$(gdp_i \cdot gdp_j)(mt_i \cdot mt_j)/d_{ij}$
W/D	w_{ij}/d_{ij}	Y2Y2/D	$gdp_i^2 \cdot gdp_j^2/d_{ij}$	YYRR/D	$(gdp_i \cdot gdp_j)(road_i \cdot road_j)/d_{ij}$
W/D2	w_{ij}/d_{ij}^2	P2P2/D	$pop_i^2 \cdot pop_j^2/d_{ij}$	PPMM/D	$(pop_i \cdot pop_j)(mt_i \cdot mt_j)/d_{ij}$
YY/D	$gdp_i \cdot gdp_j/d_{ij}$	M2M2/D	$mt_i^2 \cdot mt_j^2/d_{ij}$	PPRR/D	$(pop_i \cdot pop_j)(road_i \cdot road_j)/d_{ij}$
PP/D	$pop_i \cdot pop_j/d_{ij}$	R2R2/D	$road_i^2 \cdot road_j^2/d_{ij}$	YY+PP/D	$(gdp_i \cdot gdp_j) + (pop_i \cdot pop_j)/d_{ij}$
MM/D	$mot_i \cdot mot_j/d_{ij}$	Y2+Y2/D	$(gdp_i^2 + gdp_j^2)/d_{ij}$	YY+MM/D	$(gdp_i \cdot gdp_j) + (mt_i \cdot mt_j)/d_{ij}$
RR/D	$road_i \cdot road_j/d_{ij}$	P2+P2/D	$(pop_i^2 + pop_j^2)/d_{ij}$	YY+RR/D	$(gdp_i \cdot gdp_j) + (road_i \cdot road_j)/d_{ij}$
Y+Y/D	$(gdp_i + gdp_j)/d_{ij}$	M2+M2/D	$(mt_i^2 + mt_j^2)/d_{ij}$	PP+MM/D	$(pop_i \cdot pop_j) + (mt_i \cdot mt_j)/d_{ij}$
P+P/D	$(pop_i + pop_j)/d_{ij}$	O2+O2/D	$(other_i^2 + other_j^2)/d_{ij}$	PP+RR/D	$(pop_i \cdot pop_j) + (road_i \cdot road_j)/d_{ij}$
M+M/D	$(mot_i + mot_j/d_{ij})$	YYPP/D	$(gdp_i \cdot gdp_j)(pop_i \cdot pop_j)/d_{ij}$		

Table 4: Gravity Approach in Spatial Lag model – k-nearest contiguity

Maximum Likelihood Estimates k-nearest Method Contiguity Matrix								
	COEFFICIENTS							
MODEL	*CONST* (z-stat)	*INIT INC* (z-stat)	*LAG GR RATE* (z-stat)	*LR TEST* (p-value)	*WALD STATISTIC* (p-value)	*LL*	*AIC*	*LM* (p-value)
W	0.0954011	-0.0080296	0.5668	65.784	91.945	780.1217	-1552.2	4.914
	(5.5353)	(-4.8054)	(9.5888)	(0.000)	(0.000)			(0.026)
W/D	0.0946538	-0.007937	0.56411	70.533	98.084	782.496	-1557	6.8557
	(5.6116)	(-4.8415)	(9.9037)	(0.000)	(0.000)			(0.009)
W/D2	0.0988115	-0.0082455	0.53683	70.504	94.678	782.4818	-1557	10.572
	(5.9229)	(-5.0695)	(9.7303)	(0.000)	(0.000)			(0.001)
YY/D	0.094756	-0.0079455	0.56351	70.677	97.796	782.5682	-1557.1	6.9245
	(5.6197)	(-4.8485)	(9.8892)	(0.000)	(0.000)			(0.008)
PP/D	0.0949681	-0.0079644	0.56257	70.154	97.156	782.3069	-1556.6	6.9969
	(5.6218)	(-4.8514)	(9.8568)	(0.000)	(0.000)			(0.008)
MM/D	0.106059	-0.0089145	0.51534	61.624	74.087	778.0416	-1548.1	11.296
	(6.0804)	(-5.2721)	(8.6074)	(0.000)	(0.000)			(0.000)
RR/D	0.0938895	-0.0078767	0.56763	70.803	100.02	782.6314	-1557.3	5.7565
	(5.5703)	(-4.8074)	(10.001)	(0.000)	(0.000)			(0.016)
Y+Y/D	0.094694	-0.0079403	0.56386	70.613	97.967	782.5363	-1557.1	6.8871
	(5.6152)	(-4.8446)	(9.8978)	(0.000)	(0.000)			(0.008)
P+P/D	0.0947889	-0.0079487	0.56342	70.362	97.659	782.4106	-1556.8	6.9181
	(5.6158)	(-4.8456)	(9.8822)	(0.000)	(0.000)			(0.008)
M+M/D	0.1005128	-0.0084592	0.54366	65.565	86.911	780.012	-1552	7.8273
	(5.8407)	(-5.0655)	(9.3226)	(0.000)	(0.000)			(0.005)
R+R/D	0.0942798	-0.0079081	0.56597	70.665	98.989	782.5621	-1557.1	6.2862
	(5.5901)	(-4.8244)	(9.9493)	(0.000)	(0.000)			(0.012)
Y2Y2/D	0.0949173	-0.007959	0.56265	70.78	97.379	782.62	-1557.2	7.01
	(5.6306)	(-4.85799	(9.8681)	(0.000)	(0.000)			(0.008)
P2P2/D	0.0954227	-0.008003	0.56025	69.633	95.886	782.0462	-1556.1	7.2122
	(5.6380)	(-4.8661)	(9.7921)	(0.000)	(0.000)			(0.007)
M2M2/D	0.1156258	-0.0097102	0.46919	54.491	57.454	774.4752	-1541	15.666
	(6.4844)	(-5.6226)	(7.5798)	(0.000)	(0.000)			(0.000)
R2R2/D	0.094483	-0.0079327	0.56541	69.841	98.85	782.1502	-1556.3	5.2379
	(5.5845)	(-4.8238)	(9.9423)	(0.000)	(0.000)			(0.022)
Y2+Y2/D	0.0947426	-0.0079444	0.56359	70.69	97.841	782.5748	-1557.1	6.9205
	(5.6193)	(-4.8482)	(9.8914)	(0.000)	(0.000)			(0.008)
P2+P2/D	0.0949531	-0.0079625	0.56252	70.152	97.13	782.3057	-1556.6	7.0028
	(5.6213)	(-4.8505)	(9.8554)	(0.000)	(0.000)			(0.008)
M2+M2/D	0.1073868	-0.0090621	0.5177	60.004	74.9	777.2315	-1546.5	9.165
	(6.1055)	(-5.3170)	(8.6545)	(0.000)	(0.000)			(0.002)

R2+R2/D	0.0945541	-0.0079352	0.56523	70.237	98.465	782.3481	-1556.7	6.0125
	(5.595)	(-4.8316)	(9.923)	(0.000)	(0.000)			(0.014)
YYPP/D	0.0950963	-0.0079751	0.56183	70.293	96.79	782.3762	-1556.8	7.0628
	(5.6311)	(-4.8594)	(-4.8594)	(0.000)	(0.000)			(0.008)
YYMM/D	0.1061227	-0.0089179	0.5145	61.797	73.764	778.128	-1548.3	11.423
	(6.0879)	(-5.2774)	(8.5886)	(0.000)	(0.000)			(0.000)
YYRR/D	0.0938881	-0.0078766	0.56751	71.032	99.962	782.7458	-1557.5	5.7638
	(5.5738)	(-4.8103)	(9.9981)	(0.000)	(0.000)			(0.016)
PPMM/D	0.1067641	-0.0089732	0.51173	60.955	72.635	777.7071	-1547.4	11.792
	(6.1069)	(-5.2951)	(8.5226)	(0.000)	(0.000)			(0.000)
PPRR/D	0.0942688	-0.0079094	0.56577	70.323	98.989	782.3914	-1556.8	5.9036
	(5.5835)	(5.5835)	(9.9493)	(0.000)	(0.000)			(0.015)
YY+PP/D	0.0948339	-0.0079525	0.56314	70.445	97.522	782.4522	-1556.9	6.9513
	(5.6197)	(-4.8489)	(9.8753)	(0.000)	(0.000)			(0.008)
YY+MM/D	0.1005786	-0.008465	0.5434	65.629	86.804	780.0443	-1552.1	7.8169
	(5.8464)	(-5.0704)	(9.3169)	(0.000)	(0.000)			(0.005)
YY+RR/D	0.0942767	-0.0079077	0.56591	70.773	98.965	782.6162	-1557.2	6.2879
	(5.5917)	(-4.8257)	(9.9481)	(0.000)	(0.000)			(0.012)
PP+MM/D	0.1009168	-0.0084935	779.7916	65.124	85.924	779.7916	-1551.6	8.088
	(5.8545)	(-5.0781)	(9.2695)	(0.000)	(0.000)			(0.004)
PP+RR/D	0.0944237	-0.0079204	0.56523	70.456	98.547	782.458	-1556.9	6.3531
	(5.5946)	(-4.8286)	(9.9271)	(0.000)	(0.000)			(0.011)

Table 5: Gravity Approach in Spatial Lag model – distance contiguity

Maximum Likelihood Estimates Distance Method Contiguity Matrix

MODEL	*COEFFICIENTS* *CONST* (z-stat)	*INIT INC* (z-stat)	*LAG GR RATE* (z-stat)	*LR TEST* (p-value)	*WALD STATISTIC* (p-value)	*LL*	*AIC*	*LM* (p-value)
W	0.08951	-0.0084138	0.79466	54.027	111.65	774.2432	-1540.5	0.10967
	(4.8871)	(-4.8281)	(10.566)	(0.000)	(0.000)			(0.740)
W/D	0.0759473	-0.0071109	0.81676	71.954	174.43	783.2067	-1558.4	0.67459
	(4.4035)	(-4.2652)	(13.207)	(0.000)	(0.000)			(0.411)
W/D2	0.0766542	-0.0068575	0.74271	82.498	146.87	788.4785	-1569	1.7029
	(4.5072)	(-4.1901)	(12.119)	(0.000)	(0.000)			(0.192)
YY/D	0.104089	-0.009733	0.75426	43.424	71.508	768.942	-1529.9	2.7744
	(5.4713)	(-5.4650)	(8.4563)	(0.000)	(0.000)			(0.096)
PP/D	0.1021562	-0.0095356	0.75226	44.454	71.663	769.4566	-1530.9	2.6093
	(5.3356)	(-5.3283)	(8.4654)	(0.000)	(0.000)			(0.106)
MM/D	0.1064515	-0.0097827	0.71729	42.661	52.202	768.5602	-1529.1	3.9287
	(5.6963)	(-5.6233)	(7.2251)	(0.000)	(0.000)			(0.047)
RR/D	0.1019963	-0.0095095	0.74844	43.531	69.976	768.995	-1530	2.1989
	(5.2803)	(-5.2785)	(8.3652)	(0.000)	(0.000)			(0.138)
Y+Y/D	0.101034	-0.0094673	0.76524	45.501	79.188	769.98	-1532	2.0109
	(5.3549)	(-5.3397)	(8.8988)	(0.000)	(0.000)			(0.156)
P+P/D	0.0994319	-0.0093018	0.76317	46.339	78.982	770.3991	-1532.8	1.9093
	(5.2401)	(-5.2242)	(8.8872)	(0.000)	(0.000)			(0.167)
M+M/D	0.1022429	-0.0094556	0.74038	45.562	45.562	770.0108	-1532	3.1187
	(5.5097)	(-5.4482)	(7.8754)	(0.000)	(0.000)			(0.077)
R+R/D	0.0992292	-0.0092758	0.76067	45.611	77.614	770.0354	-1532.1	1.6095
	(5.1920)	(-5.1814)	(8.8099)	(0.000)	(0.000)			(0.204)
Y2Y2/D	0.1050435	-0.0098317	0.75663	43.367	71.993	768.9133	-1529.8	2.9071
	(5.5625)	(-5.5516)	(8.4848)	(0.000)	(0.000)			(0.088)
P2P2/D	0.1010407	-0.0094242	0.75309	45.454	72.401	769.9568	-1531.9	2.6074
	(5.2848)	(-5.2724)	(8.5089)	(0.000)	(0.000)			(0.106)
M2M2/D	0.1103564	-0.010007	0.6811	41.455	43.392	767.9571	-1527.9	4.0866
	(5.9746)	(-5.8158)	(6.5872)	(0.000)	(0.000)			(0.043)
R2R2/D	0.1014156	-0.0094034	0.73695	43.321	65.479	768.89	-1529.8	1.7882
	(5.1986)	(-5.1864)	(8.0919)	(0.000)	(0.000)			(0.181)
Y2+Y2/D	0.1019143	-0.0095585	0.76723	45.452	79.649	769.9557	-1531.9	2.1419
	(5.4347)	(-5.4165)	(8.9246)	(0.000)	(0.000)			(0.143)
P2+P2/D	0.0985442	-0.0092122	0.76363	47.158	79.417	770.8088	-1533.6	1.935
	(5.1974)	(-5.1780)	(8.9116)	(0.000)	(0.000)			(0.164)
M2+M2/D	0.1046857	-0.0095832	0.71625	45.193	53.4	769.826	-1531.7	3.2423
	(5.6977)	(-5.5823)	(7.3075)	(0.000)	(0.000)			(0.072)

R2+R2/D	0.0987387 (5.1210)	-0.0091897 (-5.1045)	0.75179 (8.5596)	45.433 (0.000)	73.267 (0.000)	769.9462	-1531.9	1.3744 (0.241)
YYPP/D	0.1035781 (5.4972	-0.0096966 (-5.4847)	0.76039 (8.5996)	44.61 (0.000)	73.953 (0.000)	769.5345	-1531.1	3.1473 (0.076)
YYMM/D	0.1092286 (5.9041)	-0.0100515 (-5.8166)	0.71728 (7.2117)	41.792 (0.000)	52.008 (0.000)	768.1258	-1528.3	4.1645 (0.041)
YYRR/D	0.102986 (5.4235)	-0.0096424 (-5.4231)	0.76047 (8.571)	43.936 (0.000)	73.462 (0.000)	769.198	-1530.4	2.925 (0.087)
PPMM/D	0.1049633 (5.6173)	-0.0096214 (-5.5324)	0.7154 (7.2272)	43.823 (0.000)	52.232 (0.000)	769.141	-1530.3	4.2214 (0.039)
PPRR/D	0.1000289 (5.1863)	-0.0093005 (-5.1707)	0.74698 (8.3773)	45.418 (0.000)	70.179 (0.000)	769.9388	-1531.9	2.042 (0.153)
YY+PP/D	0.1031832 (5.4807)	-0.0096621 (-5.4673)	0.76173 (8.6536)	44.854 (0.000)	74.885 (0.000)	769.6569	-1531.3	3.0363 (0.081)
YY+MM/D	0.1085853 (5.8739)	-0.0100016 (-5.7893)	0.72081 (7.301)	42.234 (0.000)	53.305 (0.000)	768.3469	-1528.7	4.0761 (0.043)
YY+RR/D	0.1025912 (5.4080)	-0.0096079 (-5.4065)	0.76186 (8.6267)	44.197 (0.000)	74.42 (0.000)	769.3282	-1530.7	2.8125 (0.093)
PP+MM/D	0.1045605 (5.5995)	-0.0095908 (-5.5163)	0.71782 (7.2854)	44.091 (0.000)	53.077 (0.000)	769.2751	-1530.6	4.1195 (0.042)
PP+RR/D	0.0998215 (5.1797)	-0.0092837 (-5.1637)	0.74808 (8.4124)	45.565 (0.000)	70.768 (0.000)	770.0123	-1532	1.9988 (0.157)

Table 6: coefficients in the two best models

Method	Matrix	Spillover Coefficient	Log-Likelihood
K-nearest	$gdp_i gdp_j road_i road_j / d_{ij}$	0.56751	782.7458
Distance	w_{ij}/d_{ij}^2	0.74271	788.4785

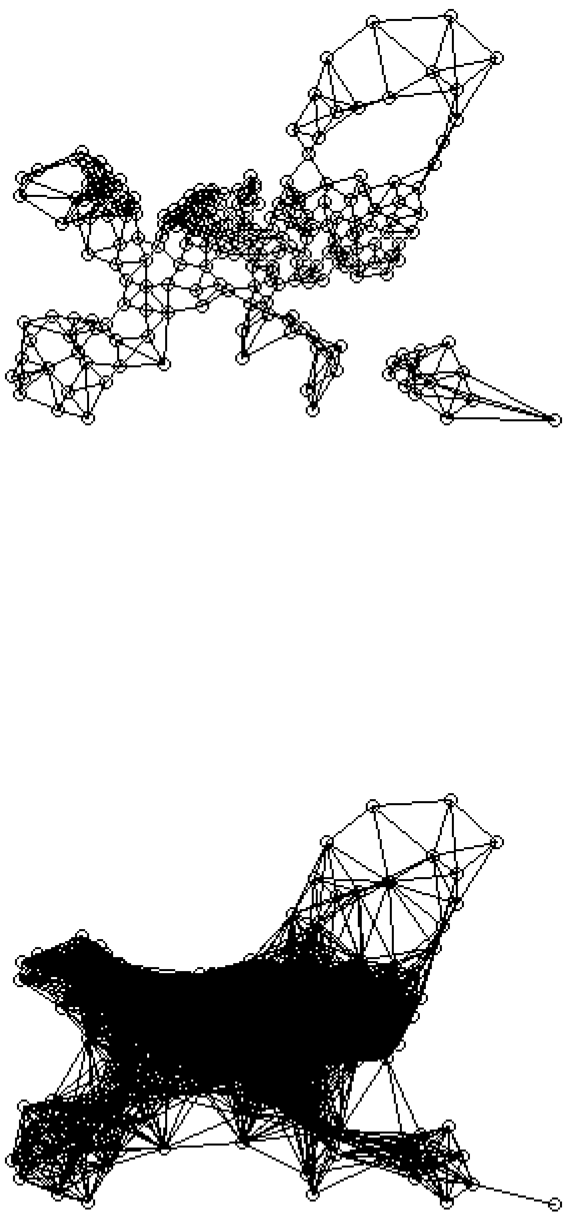

Figure 1: Connections with k-nearest method (upper) and distance method (lower)

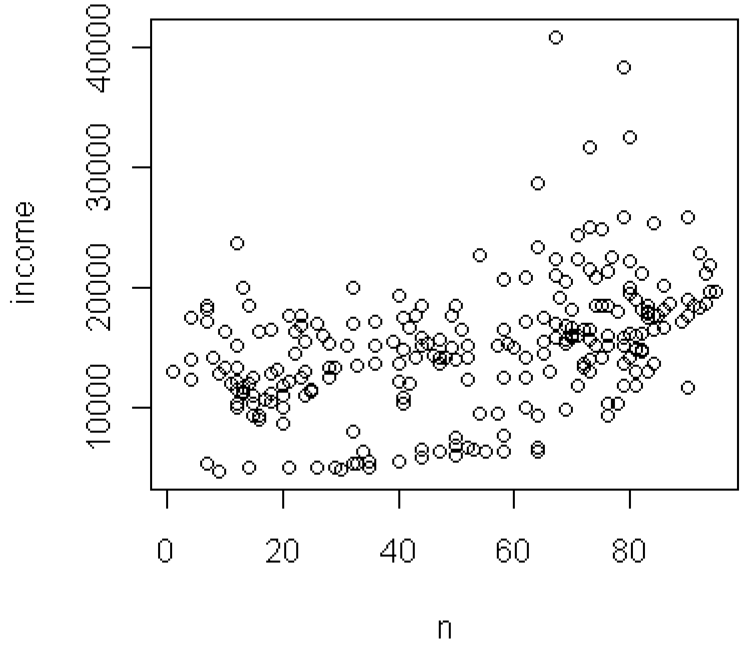

Figure 2: correlation between income and number of connections

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