Spatial Externalities and Empirical Analysis: The case of Italy*

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Abstract

In the last ten years the space issue, i.e. the study of the role played by space in economic phenomena, has attracted a lot of interest from many economic fields. The combination of increasing returns, market imperfections, and trade costs creates new forces that, together with factor endowments, determine the distribution of economic activities. Despite their theoretical relevance, there is still little evidence, especially at large scale level, on the effective contribution of these externalities to agents' location decisions. The aim of this work is to estimate a model of economic geography, using a space-time panel data on Italian provinces, in order to both test the empirical relevance of this theory, and try to give a measure of the geographic extent of spatial externalities. Particular attention has been devoted to address rigorously those endogeneity issues that naturally arises when dealing with both structural models and spatial data. Our results are consistent with the hypothesis that product-market linkages, coming from increasing returns and trade costs, actually influence the geographic concentration of economic activities and that their spread over space is, contrary to previous findings, not negligible.

Keywords: Economic Geography, Spatial Externalities, Market Potential.

JEL Codes: F12, R12, R32.

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1 Introduction

Economic activities are certainly not equally distributed across space. However, despite some interesting early contributions made by Hirschman, Perroux or Myrdal, this issue remained largely unaddressed by mainstream economic theory for a long while. As argued by Krugman [1995], this is probably because economists lacked a model embracing both increasing returns and imperfect competition in a general equilibrium setting. Indeed, as shown by Fujita and Thisse [2001] in a very general setting, the price-taking hypothesis is incompatible with the existence of a non-autarchic competitive equilibrium in space unless one relies on factor endowments differences.

The relatively recent new economic geography literature (NEG) has finally provided a collection of general equilibrium models explicitly dealing with space, and capable to account for many salient features of the economic landscape.[1] Agents choose their location on the basis of market-price incentives. Then, the combination of increasing returns at firm level with market power (usually in the form of monopolistic competition) and transportation costs, give rise to an endogenous agglomeration, provided that centripetal forces are sufficiently strong. This process is best analyzed is terms of spatial *pecuniary* externalities. When some workers\firms choose to migrate\delocate, they are likely to affect prices prevailing in both the labor and product market in the two locations. Thus, the location choice of some agents has an impact trough prices (so the pecuniary nature) on other agents creating an externality. Moreover, as Fujita and Thisse [2001] observed, such pecuniary externalities are especially relevant in the context of imperfectly competitive markets because prices do not reflect the social values of individual decisions. At this point increasing returns operates: if they are sufficiently strong to overcome competition for markets and factors, agents will find it convenient to agglomerate.

As Krugman [1995] pointed out, there is a strong connection between the NEG and some older fields in economics. To a large extent, what have been actually done is in fact rediscovering concepts and ideas that did not receive much attention by mainstream economic theory because of their lack of a rigorous formal counterpart.[2] Within this group of overlooked contributions, and of particular interest for the present work, is the literature on *market potential* started with Harris (1954). This literature argued that firms' desirability for a location as a production site depends on its access to markets, and that the quality of this access may be described by an index of market potential which is a weighted sum of the purchasing power of all other locations, with weights depending inversely on distance. Although this approach has proved to be empirically quite powerful in analyzing the location of industry, it totally lacked any microeconomic foundation. At that time there were in fact no rigorous explanations of why a correlation between market access and firms' location should exists. However, Krugman [1992], Fujita and Krugman [1995], and Fujita,

[1]See Fujita and Thisse [1996], Ottaviano and Puga [1998], and Fujita, Krugman and Venables [1999] for a review of the literature.

[2]Examples are Lörsh (1940) and Christaller (1933) *central place theory*, Rosenstein-Rodan (1943) *big push*, Perroux (1955) *growth poles*, Myrdal (1957) *circular and cumulative causation*, and Hirschman (1958) *backward and forward linkages.*

Krugman and Venables [1999] show that market potential functions can be obtained from formal spatial general-equilibrium models, thus providing the theoretical background for the use of such approach to study the distribution pattern of economic activities.

The main objective of this work is to estimate a market potential function, derived from a formal NEG model, using data for Italian provinces. The particular framework used is a multi-location extention of the original Helpman [1998] two-location model, originally introduced by Hanson [1998]. The model of Helpman [1998] is actually a variant of the well-known Krugman [1991] and Krugman [1992] core-periphery models. However, from an empirical point of view, it is preferable to Krugman's models because of the less extreme nature of its equilibria,[3] and we will use it in order to:

1. Obtain estimates of structural parameters to infer about the consistency of Helpman's model with reality.

2. Evaluate our theory-based market potential function in the light of the empirical literature on market potential, in order to investigate the specific contribution of the model in understanding firms' location.

3. Give an idea of the extent of spatial externalities by measuring how far in space a shock in one location affect the others.

There is a growing empirical literature on the location of economic activities, especially at low-scale geographical level. There are, however, different line of research, each relying on a different agglomeration mechanism.[4] First, agents may be drawn to regions with pleasant weather or other exogenous amenities.[5] Roback [1982], Beeson and Eberts [1989], and Gyourko and Tracy [1991] estimate the economic value of such amenities. Second, human capital accumulation by one individual may raise the productivity of her neighbors, making agglomerated regions attractive places to work.[6] Rauch [1993], Glaeser and Mare [1994], and Peri [1998] find that wages are higher in cities with higher average education levels. Furthermore, technological spillovers, like Marshall or Jacobs externalities, may also contribute to geographic concentration.[7]

By contrast, here we stress on increasing returns and market interactions, as opposed to factor endowments (exogenous amenities), and technological externalities (human capital and technological spillovers) taking the NEG literature, and in particular Helpman [1998] model, as the theoretical basis of our investigations. Combes and Lafourcade [2001], Head and Mayer [2002], and Teixeira [2003] represent other

[3] In Krugman [1991] and Krugman [1992], when agglomeration occurs economic activities fully concentrate in very few locations (in many cases just one) leaving most of the economic space completely empty. Actually, we do not observe such tremendous concentrations in real world. By contrast, Helpman's model generates weaker agglomeration patterns that are more consistent with spatial distribution of economic activities.

[4] See Hanson [2000] for a survey of the literature on agglomeration economies.

[5] See for example Rosen [1979], and Roback [1982]

[6] This idea is related to Lucas [1988], and Black and Henderson [1999].

[7] See for example Glaeser et al. [1992], Jaffe, Trajtenberg, and Henderson [1993], Henderson, Kuncoro, and Turner [1995], and Ciccone and Hall [1996].

examples of this approach. However, the closest reference with the present analysis is certainly that of Hanson [1998], to which we will extensively refer throughout the rest of the paper. An important contribution of our work is the implementation of a rigorous estimation methodology, derived from Spatial Econometrics and Dynamic Panel Data techniques, that tries to addresses those endogeneity issues that naturally arises when dealing with a structural spatial equilibrium models. Indeed, both the problem of simultaneity among variables and the spatial nature of the data make standard estimation techniques, applied on a cross-section of spatial data, inadequate[8]. We will argue that a possible solution to this endogeneity trap consists in exploiting the information coming from the time dimension, thus using a space-time panel data approach.

The rest of the paper is organized as follows. Section 2 describes the theoretical model: a multi-location version of Helpman [1998]. In Section 3 we give some insight on the mechanics of the model, and we derive the equation we will subsequently estimate. Section 4 deals with data issues, while in Section 5 we discuss econometric concerns. Detailed estimation results are presented in section 6. Finally, in section 7 we draw our conclusions and suggest directions for further research.

2 The Model

Imagine an economy consisting of Φ locations, two sectors (the manufacturing sector M and the housing sector H), and one production factor (labor). The M-sector produces a continuum of varieties of a horizontally differentiated product under increasing returns to scale, using labor as the only input. Each variety of this differentiated good can be traded among locations incurring in iceberg-type transportation costs $v_{i,k}$.[9] Referring to two generic locations as i and k ($i,k = 1,2,...,\Phi$), we thus have that for each unit of good shipped from i to k, just a fraction $v_{i,k} = f(d_{i,k})$ of it, where $d_{i,k}$ is distance between the two locations and $f()$ is a decreasing function, arrives at destination. The generic quantity $v_{i,k}$ is therefore an inverse measure of transportation costs and, indicating with $p_{m,i}$ the mill price of a variety produced in location i, the corresponding delivered price paid by a consumer living in k would be $p^*_{m,i} = p_{m,i}/v_{i,k}$. The H-sector provides instead a homogeneous good, housing, that cannot be traded and whose amount in each location (H_i) is supposed to be exogenously fixed. Its price $P_{H,i}$ can therefore differ from one place to another and is determined by the equilibrium between local supply and demand.

Labor is supposed to be freely mobile, and its (exogenous) total amount in the economy is equal to L. The equilibrium spatial distribution of our workers-consumers is thus determined by both wages (w_i), and prices prevailing in each location. We will denote L_i, with $\sum_{i=1}^{\Phi} L_i = L$, as labor in location i, and $\lambda_i = L_i/L$

[8]See Anselin [1988] for details.

[9]The term transportation costs does not simply refers to shipment costs but in general to all costs and impediments of doing business in different markets, like information costs, language differences, etc.

as the corresponding regional share of total workers. Preferences and technology are not region-specific. Therefore, it is notationally convenient to describe them without explicitly referring to any particular location.

Preferences are described by the standard Cobb-Douglas utility function with CES type sub-utility for the differentiated product, i.e.:

$$U = (C_M)^{\mu} (C_H)^{1-\mu} \qquad 0 < \mu < 1 \tag{1}$$

where C_M stands for an index of the consumption of the M-sector varieties, while C_H is housing consumption. We assume that the modern sector provides a continuum of varieties of (endogenous) size N, the consumption index C_M is thus given by[10]:

$$C_M = \left[\int_0^N c_m(j)^{\rho} dj \right]^{1/\rho} \qquad 0 < \rho < 1 \tag{2}$$

where $c_m(j)$ represents the consumption of variety $j \in [0, N]$. Hence, each consumer has a love for variety and the parameter $\sigma \equiv 1/(1-\rho)$, varying from 1 to ∞, represents the (constant) elasticity of substitution between any two varieties. The bigger is σ the more varieties are substitutes: when σ is close to 1 the desire to spread consumption over all varieties increases. If Y denotes the consumer income, then the demand function for a variety j coming from utility maximization is:

$$c_m(j) = p_m^*(j)^{-\sigma} \mu Y (P_M)^{\sigma-1} \qquad j \in [0, N] \tag{3}$$

where P_M is the price-index of the differentiated product given by:

$$P_M \equiv \left[\int_0^N p_m^*(j)^{-(\sigma-1)} dj \right]^{-1/(\sigma-1)} \tag{4}$$

Technology is the same across locations. The relation between the amount of labor used $(l(j))$ and the quantity of variant j produced $(c(j))$ is given by:

$$l(j) = f + \beta c(j) \tag{5}$$

[10]In the original Helpman [1998] formulation, as well as in Krugman [1991] and Krugman [1992], N is not a mass but instead the finite number of varieties provided by the market. However, as pointed out by Fujita and Thisse [2001], this approach is conceptually misleading for the monopolistic competition framework. In fact, in order to be consistent with the requirement that firms are negligible with respect to the market, we should consider a continuum of them. If we do not and use instead an integer number of firms, strategic interactions actually dominates (d'Aspremont, Dos Santos Ferreira and Gerard-Varet [1996]). However, the way N is actually treated by Helpman, is such that final results are virtually unchanged. Nevertheless, we prefer to use here the continuum formulation.

where f and β are, respectively, the fixed and the marginal labor requirements. The presence of the fixed cost f clearly imply increasing returns. Each firm sells one variety in equilibrium and, without loss of generality, we choose the unit for labor such that $\beta = 1$. Firms know consumers' demand and choose prices in order to maximize their profits given by:

$$\pi(j) = p_m(j)q(j) - w[f + q(j)] \tag{6}$$

where w is wage paid by our generic firm and $q(j)$ is its output. Since each firm has a negligible influence on the market, it may accurately neglect the impact of a price change over both consumers' income and the price index in equation (3). Consequently, each firm faces an isoelastic downward sloping demand with elasticity given by our parameter σ. Solving first order conditions yields the common equilibrium relation:

$$p_m(j) = \frac{w}{1 - (1/\sigma)} \tag{7}$$

Under free entry, profits are zero. This implies, together with equation (7), that the equilibrium output is a constant given by:

$$q(j) = q = (\sigma - 1)f \tag{8}$$

Note that this relation is true wherever our firm is located. As a result, in equilibrium a firm's labor requirement is also unrelated to firms' distribution:

$$l(j) = l = \sigma f \tag{9}$$

so that the total mass of firms in the manufacturing sector (N) is constant and equal to $L/\sigma f$. Equation (8) has also another important drawback. Taking the ratio between marginal (mgc) and average cost (avc) and using (8) we get:

$$\frac{mgc(j)}{avc(j)} = \frac{w}{w[f + q(j)]/q(j)} = \frac{\sigma}{\sigma - 1} \tag{10}$$

Thus, the parameter σ is (in equilibrium) also an (inverse) measure of increasing returns to scale as it reflects the gap between marginal and average costs.[11]

We can now summarize the long-run spatial equilibrium of our economy by means of five equations introducing space indexes on preferences and technology. The first equilibrium requirement comes from

[11] This actually represents a weakness of the model. The parameter σ is at the same time the elasticity of substitution between any two varieties, the price-elasticity of consumers' demand, and an inverse measure of increasing returns to scale. This will cause some interpretation problems in our econometric analysis

utility maximization. If $E_{H,i}$ denotes consumers' expenditure on houses in location i, and Y_i the corresponding income, then $\forall i = 1, 2, ..., \Phi$ we have:

$$E_{H,i} \equiv p_{H,i} H_i = (1 - \mu) Y_i \tag{11}$$

Since there is free entry and exit and, therefore, zero profit in equilibrium the value of the manufacturing production in each region equals factor earnings ($w_i \lambda_i L$). If we now suppose that each individual owns an equal share of the total housing stock, then income in location i is given by[12]:

$$Y_i = \left[\lambda_i \frac{1-\mu}{\mu} \sum_{k=1}^{\Phi} \lambda_k w_k L \right] + \lambda_i w_i L \tag{12}$$

Moreover, for a spatial distribution of workers to be an equilibrium, there should be no incentive to move. As they are perfectly mobile, this implies an equalization of real wages in the long run[13]:

$$\frac{w_i}{(P_{M,i})^{\mu} (P_{H,i})^{1-\mu}} = \frac{w_k}{(P_{M,k})^{\mu} (P_{H,k})^{1-\mu}} \qquad \forall i, k = 1, 2, ..., \Phi \tag{13}$$

Finally, the last two equilibrium relations are:

$$P_{M,i} = \kappa_1 \left[\sum_{k=1}^{\Phi} \lambda_k (w_k \, v_{i,k})^{1-\sigma} \right]^{1/(1-\sigma)} \tag{14}$$

and

$$w_i = \kappa_2 \left[\sum_{k=1}^{\Phi} Y_k (P_{M,k} \, v_{i,k})^{\sigma - 1} \right]^{1/\sigma} \tag{15}$$

with $\kappa_1 \equiv \rho^{-1} (H/\sigma f)^{1/(1-\sigma)}$ and $\kappa_2 \equiv \rho \, [\mu/(\sigma-1)f]^{1/\sigma}$. Equation (14) comes from optimal pricing rule (7) and zero profit condition (8). Condition (15) comes from firm equilibrium labor requirement (9) and consumers' demand (3). Equations (11) trough (15) constitute a simultaneous system of $\Phi \times 5$ equations in the $\Phi \times 5$ unknowns $(P_{H,i}, Y_i, w_i, \lambda_i, P_{M,i})$ that summarize the equilibrium of our spatial economy.

[12]It is important to point out that the hypothesis of an equal sharing of the housing stock is not crucial to our analysis. Using alternative assumptions, like that of immobile or even absentee landlords, Helpman [1998] finds no qualitative changes in model behavior. More importantly (12) will not be used to obtain the reduced form equation we will actually estimate.

[13]Contrary to Krugman [1991], it is really unlikely that (13) does not hold in equilibrium because it would require the price of houses in the abandoned locations to be zero. This is one of the reasons that lead us to prefer Helpman's model for empirical purposes.

3 A market potential approach

The NEG literature offers the possibility to treat agglomeration in a flexible and rigorous way by means of increasing returns, imperfect competition, and product differentiation. To understand the forces at work in Helpman [1998] it is useful to consider the following simplified thought experiment. Suppose that we have just two locations with the same exogenous housing stock, and that the economy starts with a symmetric distribution of firms and workers. With just two location we have, supposing symmetry, just one distance to care about: $v_{i,k} = v$. The only candidate for equilibrium in a constant returns to scale world with perfect competition would be the symmetric one because the two locations are a priori identical. This is actually not the case in Helpman [1998] model. Suppose in fact that, for whatever reason, one firm decides to move from one region to the other. How does this affect firms profitability? The presence of one more firm will increase competition in the product and labor markets of the location receiving the firm, thus tending to reduce local profits and to make relocation unprofitable. If there was no mobility of workers, this would be the end of the story and regions would remain identical. However, the rise in the number of local varieties that can be bought without incurring in transportation costs, as well as the rise in labor demand and wages tend to attract more workers. This migration increases local expenditure (a demand linkage) and eases competition in the labor market, so tending to increase local profits and to attract more firms. The demand linkage is here particularly important because increasing returns makes production expansion attractive, and market power gives to firms the possibility to better exploit such potential gains.

Whether the overall effect of entry is to increase the profitability of local firms (encouraging further entry thus leading to an asymmetric equilibrium distribution of economic activities), or to lower that profitability (leading to exit and reestablishing symmetry), depends on parameters of the model (σ, μ, v). As long as $\sigma(1-\mu) > 1$, agglomeration never occurs and economic activities will be equally distributed. If instead $\sigma(1-\mu) < 1$ then, depending on the level of transportation costs v, we will observe agglomeration or dispersion.[14] Conforming to intuition both a smaller degree of substitution between varieties (lower σ), and a greater share of manufacturing consumption (higher μ) causes centripetal forces to strength.[15] However, the effect of a transportation costs change in Helpman [1998] is different from Krugman [1991]. In Krugman [1991] agglomeration occurs if transportation costs are sufficiently small (values of v close to one), whether in Helpman [1998] is the other way round. This is due to the different hypothesis on the homogenous good H.[16]

[14] If we relax the assumption that the housing stock is the same in the two regions things do not change that much. If $\sigma(1-\mu) > 1$ economic activities will be distributed only according to exogenous factor endowments, even if with a slight disproportion. If instead $\sigma(1-\mu) < 1$ then, depending on the level of transportation costs, we will again observe agglomeration or dispersion but agglomeration can now occur only in the location with more housing stock.

[15] When $\sigma(1-\mu) > 1$ an increase of μ, or a decrease of σ, exacerbate the disproportion between the number of firms residing in one location and the corresponding fixed endowments. On the other hand if $\sigma(1-\mu) < 1$ simulations show that the effect it to restrict the range of transportation costs for which symmetric equilibrium is stable.

[16] There are other models than Helpman [1998] in which a concentration of consumption and production cannot take place

When we come back to our framework, i.e. considering an arbitrary number of locations and fixed factor distribution, the story becomes much more complicated and few analytical results are available. The first thing to say is that we normally observe a multiplicity of equilibria. Our simulations shows, coherently with the simulations of Krugman [1992] of a multi-location version of Krugman [1991], that agglomeration takes place by means of a self-reinforcing process in which small initial asymmetries among locations are then magnified by market forces, leading to what Fujita and Thisse [1996] call *putty clay geography*: there is a priori great flexibility on where particular activities locate, but once spatial differences take shape they become quite rigid. The actual equilibrium configuration of our space-economy is thus path-dependent[17] and markets-centrality, as well as factor endowments[18], constitutes preferential requirements for a location to become a cluster of firms and consumers. Other things equal if a location provides a better access, somehow defined, to consumers' demand some firms will initially relocate there in order to take the advantages that markets-proximity, due to their increasing returns technology, gives them. If the balance is in favor of centripetal forces, this will in turn increase local wages and goods expenditure attracting workers as well as other firms. It becomes now clear the connection of this model, with older traditions in economics and in particular with the market-potential literature.

Actually, Harris (1954) market-potential function relates the potential demand for goods and services produced in a location with that location's proximity to consumer's markets, or:

$$MP_i = \sum_{k=1}^{\Phi} Y_k g(d_{ik}) \tag{16}$$

where MP_i is the market potential of location i, Y_k is an index of purchasing capacity of location k (usually income), d_{ik} is (as usual) the distance between two generic locations i and k, and $g()$ is a decreasing function. The higher is the market potential index of a location, the higher is its attraction power on production activities.

In Helpman model, a good measure the attractiveness of location i is given by the equilibrium nominal wages w_i. Although firms makes no profits in equilibrium (no matter where they are located), the wage

for low values of shipping costs. See for example Adrian [1996], Hadar [1996] and, although in a different framework, Krugman and Venables [1995], and Puga [1999]. However, one should not consider these results as opposite to Krugman [1991] type models, but instead as complement. The general picture coming out of from the NEG literature is, as argued by Ottaviano and Puga [1998], one in which for high trade costs the need to supply markets locally encourages firms to locate in different regions. For intermediate values of trade costs, cost and demand linkages take over and firms and workers cluster together. Finally, for low values of trade costs location is determined by the price of those factors (like unskilled workers) and goods (like houses) that are not mobile.

[17] This is why it is usually said that history matters.

[18] The fact that many NEG models abstract from factor endowments considerations assuming an equal distribution, does not mean that one wants to deny their importance. The a priori equivalence among locations is just a metaphor used to better isolate the forces one wants to show, as well as a convenient working hypothesis. Ricci [1999] shows clearly how both factor endowments and NEG forces matter for the distribution of firms and trade. Moreover, Davis and Weinstein [1998] and Davis and Weinstein [1999] find empirical evidence of a joint influence of comparative advantages and market access in determining trade flows at both international and regional level.

they can afford express their capacity to create value once located in a particular region.[19] In fact, if centripental forces take over, those locations that attract more firms and consumers will also have higher equilibrium nominal wages, thus leading to a positive correlation between agents' concentration and w_i. Following Hanson [1998], we can combine equations (11), (13), (15) and apply logarithms to simplify things in order to get the following expression for $\ln(w_i)$:

$$\ln(w_i) = \kappa_3 + \sigma^{-1} \ln \left[\sum_{k=1}^{\Phi} Y_k^{\frac{1-\sigma(1-\mu)}{\mu}} H_k^{\frac{(1-\mu)(\sigma-1)}{\mu}} w_k^{\frac{(\sigma-1)}{\mu}} f\left(d_{i,k}\right)^{(\sigma-1)} \right] \tag{17}$$

where κ_3 is a function of behavioral parameters (μ, σ, f). Equation (17) really looks like a market-potential function. It tells us that as long as agglomeration forces are active ($\sigma(1-\mu) < 1$), the nominal wage in location i (and thus local firms' profitability) is an increasing function of the weighted purchasing power coming from surrounding locations (Y_k), with weights inversely related to distances d_{ik} (this is the market access component). Crucially, (17) tells us more than the simple market potential equation (16). The distribution of economic activities should in fact depends upon prices, because an increase in other locations' housing stock (H_k) or wages(w_k), cause w_i to increase in the long-run in order to compensate workers for lower housing prices and higher earnings they can enjoy elsewhere. Although quite powerful from an empirical point of view, relations like (16) were not obtained from a theoretical model and, compared to (17), did not control for wages and prices of others locations.

4 Data choice and sources

One of the most common problems in using micro-founded economic models for empirical purposes is the choice of good proxies. Estimation requires actual data, and in some circumstances the choice of the statistic that is best suited to approximate a theoretical variable becomes a difficult task. In the case of H, Y, and d we do not have particular interpretation problems. H is meant to represent those goods and factors that are immobile for consumption or production. Expenditure in housing services actually constitutes a large part of the costs associated with this category. A good proxy is thus given by the total

[19] An alternative modelling strategy, focusing more explicitly on profits, have been proposed by Puga [1999]. Helpman [1998] and Krugman [1991], as well as almost all models belonging to the same class, assume that profits are zero in the short-run with workers moving from one location to another in order to equalize real wages in the long-run. In this case firms just follow workers in order to find the labor they need to produce. Puga [1999] instead assumes that inter-location labor markets instantaneously clear in the short-run, leading to real-wage equalization, while firms' profits can differ from zero. In the long-run however firms move toward those regions offering higher gains and market forces will drive profits to zero. Conceptually, these short-run profits are better suited than nominal wages to express a firm gain from relocation. However, as find out by Puga [1999], using these two alternative dynamics produce virtually no difference, that is why we use nominal wages as a measure of such incentives.

housing stock, that is measured in square meters. The variable Y should instead represent the demand of goods, and a reasonable solution is to take total households disposable income as a measure of a province purchasing power. Finally, d is the distance between two generic locations. The unavailability of more sophisticated measures of distances has lead us to use a physic metric. In particular we adopt the crow fly distance between the centers of each province (as obtain by polygonal approximation) using GIS software.

However, when we think about w some complication arise. One natural solution, followed by Hanson [1998], is to consider it as just labor income, thus using county statistics on average earnings of wage and salary workers. Although this solution may be to some extent acceptable for US, it seems difficult to argue the same for Europe and in particular for Italy. First, it is a wide-spread opinion that in Europe conditions of local supply and demand play a little role in the determination of wages[20], thus making them unsuited to express re-location incentives. In some countries, and this is the case for Italy, wages are in fact set at national level for many production sectors. Second, the relatively scarce mobility of people prevents the prices system to clear labor markets excess-supply.[21] Agglomeration externalities are thus likely to magnify regional imbalances in both income and unemployment rates rather than shifting massively production activities.

In line with these considerations, US economic activities are more spatially concentrated than in Europe. The 27 EU regions with highest manufacturing employment density account for nearly one half of manufacturing employment in the Union and for 17% of the Unions total surface and 45% of its population. The 14 US States with highest manufacturing employment density also account for nearly one half of the countries manufacturing employment, but with much smaller shares of its total surface (13%) and population (21%). Figure **??**, borrowed from Hanson [1998], gives an idea of US production concentration. It depicts counties employment density in 1990 as relative to US average: the 100 most economically active counties, with an average employment density of 1,169 workers per square kilometer accounted for 41.2% of US employment, but only 1.5% of US land area in 1990.

By contrast, in Europe agglomeration is more a matter of income disparities and unemployment. 25% of EU citizens live in so-called Objective 1 regions. These are regions whose Gross Domestic Product per capita is below 75% of the Unions average. By contrast only two US states (Mississippi and West Virginia) have a Gross State Product per capita below 75% of the countries average, and together they account for less than 2% of the US population. Moreover, regional employment imbalances are a special feature of European economic space. The case of Italy is best known, with Campania having a 1996 unemployment rate 4.4 times as high as Valle d'Aosta. But large regional differences exist in all European countries, as shown by figure **??** borrowed from Overman and Puga [1999]. In the United Kingdom, Merseyside has an unemployment rate 3.2 times that of the Surrey-Sussex region; in Belgium, the unemployment rate of Hainut is 2.2 times that of Vlaams Brabant; in Spain, Andalucía has an unemployment rate 1.8 times that

[20] See Bentolila and Dolado [1994], and Bentolila and Jimeno [1998] for an empirical assessment.

[21] Eichengreen [1993] estimates that the elasticity of interregional migration with respect to the ratio of local wages to the national average is 25 times higher in the US than in Britain. The difference with respect to Italy is even larger.

of La Rioja; in France, Languedoc-Roussillon has a rate twice that of Alsace; and so on.

Both figure **??** and **??** suggest the existence of forces shaping the distribution of economic activities in asymmetric way. However, the point is that the structural differences between US and EU cause these forces to have a more visible impact on different economic indicators. At this point, it is probably better to come back to Helpman [1998] to look for some guiding insights. In that framework, w is the zero-profit earning of the only production factor (labor), and *is meant to be a measure of the attractiveness of a location for firms*. As long as mobility is limited, the transfer of firms in some locations would produce unemployment in the abandoned ones while pushing factor market to full employment in the formers. However, the fact that basic wages are more or less fixed does not prevent firms to give them, if they have the means, other form of remunerations in order to attract them. Therefore, one can think to use total labor expenditure per employee as a measure of the shadow wage. However, labor is not the only production factor in real world. In Helpman [1998] it stands for the aggregate of mobile factor, as opposed to the immobile ones (H), and so capital remunerations should, for example, be included in the construction of a good proxy too. Furthermore, profits need also to be accounted for as they are, in principle, precisely those indicators leading firms' to relocate. In this light, it thus seems problematic to associate w only to wages, and this criticism apply to the US case too.

The solution we will adopt address these issues. Expenditure in housing services actually represent a large part of fixed factors remunerations. Using statistics on rented house number and prices from ISTAT, we have thus constructed a measure of house spending per province and, after subtracting it to GDP, we have divided for active population to get our w.[22] The variable obtained is meant to capture the average remuneration of all mobile factors, as well as profits, and it is only indirectly related to local wages.[23] In section 6, we will provide some empirical arguments in order to further justify our measure of w for the Italian economy.

Table 1 contains summary statistics on w, H, and Y, as well as on provinces surface and population. All nominal variables are in 1996 prices and the unit is one million liras. Housing H is measured in squared meters, while population is in thousand of people and provinces surface is expressed in squared kilometers. Data have an yearly basis and refers to the interval 1991-1998. Statistics on rented-house number and prices come from ISTAT. Data on GDP, population, employees, housing stock, and households' disposable income come from SINIT database (Sistema Informativo per gli Investimenti Territoriali). The latter dataset have been collected from the "Dipartimento Politiche di Sviluppo e Coesione - Ministero dell'Economia e Finanze". Finally, distances have been obtained with GIS software and are expressed in kilometers.

[22] Actually, we subtract people looking for their first job from active population before computing w. The number of those looking for their first occupation is in fact closely related to factors (like family habitudes), that are both external to our model and vary a lot across Italy, thus introducing a potential source of bias.

[23] Some empirical investigations, more rooted in the labor markets literature and explicitly dealing with the spatial distribution of local wages, can be found in Clark and Ballard [1981], Angel and Mitchell [1991], Bover, Bentolila, and Arellano [2000], and Duranton and Monastiriotis [2000].

5 Econometric issues

The main goal of our estimations is to obtain a measure of structural parameters from (17). However, the data-set we have is a panel covering two dimensions: space and time. Therefore, the actual formulation we use is:

$$\ln(w_{i,t}) = \kappa_3 + \sigma^{-1} \ln \left[\sum_{k=1}^{\Phi} Y_{k,t}^{\frac{1-\sigma(1-\mu)}{\mu}} H_{k,t}^{\frac{(1-\mu)(\sigma-1)}{\mu}} w_{k,t}^{\frac{(\sigma-1)}{\mu}} f\left(d_{i,k}\right)^{(\sigma-1)} \right] + \varepsilon_{i,t} \tag{18}$$

where indexes i and t corresponds, respectively, to space and time, while $\varepsilon_{i,t}$ is a random term that, for the moment, is just assumed to be serially uncorrelated in the time dimension, that is $Cov(\varepsilon_{i,t}, \varepsilon_{i,s}) = 0, \forall t \neq s$.[24]

The first choice to make is the geographical reference unit. On one hand, this should not be too large in order to account for the nature of externalities that the model wants to capture. Helpman [1998] is in fact best suited to describe agglomeration forces at low/medium scale spatial level, because the hypothesis of labor mobility is certainly not defendable, especially for Italy, on large scale. Actually, the tension between an easy access to cheap commodities, and high costs of non-tradable services like housing is certainly a good metaphor for metropolitan areas, but the more we depart from this example the more interpretation become difficult because other forces are certainly at work. For this reason, too high a geographical detail could also misrepresent the tensions at work in our model, as well as to require an intractable amount of information. To give an example, if we decide to work on the about 8.100 Italian municipalities, we will need a matrix of distances with $8100 * (8100 + 1)/2 = 32,809,050$ free elements to evaluate. Our choice is a compromise between these two different needs, and will actually consist in taking the 103 Italian provinces as reference units.

Turning to more technical questions, we should argue why we choose just (17) in order to get the estimates of structural parameters. In principle, this objective would be better achieved using simultaneous equations techniques on equations (11) trough (15). Apart from the technical problems of such an approach, is the unavailability of reliable statistics for prices, especially of manufacturing goods ($P_{M,i}$), at any interesting geographical level that makes this solution unapplicable. Data on prices can in fact be found at regional level for Italy: this is probably too much aggregate a unit for our purposes because of the low inter-regional labor mobility, as well as for the limited number of cross-section observations (just 20) we would end-up with. Equation (17) is instead a reduced-form, in algebraic sense, of the model that does not contain these two variables, and for which it is thus possible to find adequate local data and estimate, even if this imply that some information is lost, our structural parameters.[25]

[24] Later on, we will expicitely test this assumption.

[25] Equation (17) comes from the combination of equilibrium relations (11), (13), and (15). Consequently, we are not using the information contained in both equation (12) and (14) that, together with the other three, fully describe the long-run

Another important aspect is related to missing variables like the presence of local amenities (nice weather, ports, road hubs, etc.) and localized externalities (especially human capital ones) that clearly influence the distribution of economic activities and earnings, but are not included in our analysis. As long as these variables are correlated with regressors, and this is indeed very likely to hold, standard econometric techniques would fail. Anyway, when one thinks about both amenities and human capital externalities it is clear that if these factors change over time, this change is very slow. The quality of the working force, as well as the presence of infrastructures and the network of knowledge exchange is thus reasonably constant (for a given location) in a short interval of time. We can thus try to overcome the problem of these missing variables with an appropriate choice of the estimation interval, (that should not be too long) in order to treat them as, using standard panel terminology, correlated fixed effects μ_i (that are time invariant) to be included in the random term $\varepsilon_{i,t}$ that becomes $\varepsilon_{i,t} = \mu_i + u_{i,t}$. To get rid of the correlation between μ_i and the regressors we could, for example, either apply a time-difference on (18), with $\triangle\varepsilon_{i,t} = \varepsilon_{i,t} - \varepsilon_{i,t-1}$ simplifying to $\triangle u_{i,t} = u_{i,t} - u_{i,t-1}$, or use a within transformation.[26] In both cases the term μ_i vanishes, shifting all problems of efficiency and consistency to the properties of $u_{i,t}$.[27]

Equation (18) is non-linear. Once applied the opportune transformation (time-difference or within), one can think of using non-linear least squares type techniques. However, the nature of the variables involved raises a clear endogeneity issue, making the properties of such an estimation method doubtful. First, the presence on the right hand side of a weighted sum over space of the same variable appearing as independent ($w_{i,t}$), is in fact a source of bias. In accordance with spatial econometrics theory, this sum is in fact interpretable as a space-lagged endogenous variable and it is well known that, in this case, least squares method does not work regardless of error properties[28]. Furthermore, in the structural form of our model the variables $w_{i,t}$ are determined simultaneously with incomes $Y_{i,t}$. The circularity between factor earnings and income is certainly not debatable in economic theory, and in our framework implies that the explanatory variable $Y_{i,t}$ is correlated with disturbances $u_{i,t}$. Finally, even if the amount of fixed factors $H_{i,t}$ is supposed to be exogenous in Helpman model, it is not difficult to imagine that, for example, pressures on the housing market do not simply lead to price movements, but also encourage construction of new buildings.

The solution proposed by Hanson [1998] to account for these issues is to use non-liner least squares, while trying to break endogeneity problems using more spatially aggregate variables as regressors on the right hand side of equation (18). Following his reasoning, $u_{i,t}$ should in fact reflect temporary shocks that influence local business cycles. The finest the geographical unit we use for locations, the smaller is

equilibrium of our economy. Clearly, as long as simultaneity is accounted for, this just imply a potential loss in estimates' precision but not a bias.

[26]Note that, incidentally, by using either time-difference or whitin transformation we are eliminating κ_3 and so we loose the parameter f.

[27]Hanson [1998] actually uses a time-difference approach. In addition he also tried to control directly for localized externalities and factor endowments using data on weather, proximity to ports, etc. Anyway, the joint use of these two tools did not produce significant changes in his estimation results, as compared to the time difference specification only.

[28]See Anselin [1988].

the impact of such shocks on more geographically aggregated variables. Furthermore, if these shocks are really local, the spread on other regions should be quantitatively negligible. Now, if this is true, than there should not be any significant correlation between the shock $u_{i,t}$ of our small location i and (for example) the state-level values of w, Y, and H. Therefore, one can take the finest possible geographical level for the dependent variable w on the left-hand side of (18) in order to work with small locations' shocks $u_{i,t}$, while using state level values for the explanatory variables figuring on the right-hand side. Actually, Hanson [1998] uses data on w for the 3075 US counties as dependent variables and, for each county i, he utilizes data on w, Y, H, and distances at continental state level as independent variables. Formally speaking, the two indexes i and k do not correspond anymore to the same location set, with index $i = 1, 2..., \Phi$ corresponding to US counties, and $k = 1, 2, ..., \Phi^*$ corresponding to US continental states.[29]

Hanson's idea sounds like instrumentation. He actually uses state level values on the right-hand side precisely because he needs something that is uncorrelated with disturbances, but still linked with the (real) explanatory variables at county level. Indeed, these are the features of good instrumental variables. Therefore, one can think of keeping county level on the right hand side, and use geographically aggregated data directly as instruments for the estimation. Clearly, as long as Hanson strategy works, the other should work as well. Furthermore, an instrumental variable approach would be conceptually preferable because it allow us to maintain an homogeneous space unit on both sides of (18). In the spatial econometrics literature, it is in fact well known that the level of aggregation matters a lot. In particular, the fact that Hanson actually mixes state and counties variables in the same equation makes interpretation problematic, and could lead to an estimation bias. In order to explore the extent of this possible inhomogeneous data bias, we will perform a comparative estimation using the two techniques: a non-linear least squares Hanson type, and a non-linear instrumental variables one.[30] However, there is another aspect in favor of instrumental variables: efficiency. By aggregating explanatory variables, Hanson looses a lot of information ending with a sum of just 49 terms instead of 3075. By contrast, all the information contained in county data would be preserved with instrumental variables as one can keep a fine geographical level also on the right-hand side. Efficiency is not really a problem for Hanson's analysis because he has still a lot of data to fit. However, due to the relative small number of Italian provinces (103) compared to that of US counties (3075), efficiency could be an issue in our analysis that a non-linear instrumental variables approach may effectively address.

There is, anyway, something unclear in the crucial identifying assumption on which these two estimation procedure rely. Technically speaking, both amount to assume that disturbances $u_{i,t}$ are spatially uncorrelated and, furthermore, that they are uncorrelated with spatially aggregate values of w, Y, and H. The first assumption is quite clear, and can indeed be tested using spatial econometrics tools like

[29]In equation (18) for instance he has, for a given year t, a sum of $\Phi^* = 49$ terms (the number of US continental states plus the district of Columbia) on the right hand side, for each of the $\Phi = 3075$ equations to fit.

[30]A good exposition of non-linear instrumental variables properties and the associated inference techniques can be found in Hamilton [1994].

Moran or LM spatial correlation type tests[31]. The second is, on the contrary, quite obscure and needs to be better clarified. Taking for example the variable w, for the shock of county i to be uncorrelated with the state-level values of w (which are nothing else that averages of the corresponding Φ county-level values w_i), we clearly need that $Cov(u_{i,t}, w_{k,t}) = 0 \; \forall \, i \neq k$, where indexes i, and k both refers to counties ($i, k = 1, 2..., \Phi$). In other words, our local shock should not spread over other locations, resulting in a negligible degree of "spatial interaction". On one hand, the fact that error terms are not spatially correlated limits the degree of spatial interaction in the sense that $u_{k,t}$ has, for example, no impact on $w_{i,t}$ through $u_{i,t}$ because the latter is uncorrelated with $u_{k,t}$. Even in this case, $u_{k,t}$ does have an impact on $w_{i,t}$ through $w_{k,t}$, because the latter figures as an explanatory variable in (18), and $w_{k,t}$ is it-self a function of $u_{k,t}$. Therefore, as long as estimates are significant, the correlation between $u_{k,t}$ and $w_{i,t}$ through $w_{k,t}$, could not be negligible, and so aggregate variables cannot be used as instruments. Put differently, as long as our theoretical model works and has something interesting to say about the spatial relation between local factor earnings, consumers' expenditure, and non-tradable goods, then the aggregation trick does not work.

A possible way-out from this endogeneity trap that, at the same time, would allow us to preserve the same space dimension for all variables, could be to better exploit the information coming from the time dimension, using dynamic panel data techniques à la Arellano and Bond [1991]. Indeed, NEG models are conceived mainly to reply to theoretical questions rather than to be used for empirical purposes. Compared to applied macro-economic models, they are in fact represented by systems of equilibrium equations in which almost all variables are endogenous, so making the identification task problematic to solve for a given time t (i.e. using only the cross-section dimension). This is precisely the reason for which a panel approach is preferable. Now, since endogeneity comes from the simultaneous nature of these models linking, in equilibrium, our Φ economies all together, one can think of using the weak-exogeneity assumption and to apply the appropriate GMM estimator to directly to (18). However, this approach rest on the hypothesis that this simultaneity problem is fully contemporaneous, ruling out any dynamic behavior.[32] By contrast, it is really unlikely that data do not exhibit a time dynamics, meaning that the impact of out shock $u_{i,t}$ entirely exhaust its impact at t without spreading over time. For example, frictions in the factors market, like the presence of unobserved sunk costs for migration or unions' power, would cause variables to adjust in a sluggish way toward their equilibrium level, justifying the time persistency of a shock. This is why we prefer to resort to dynamic panel data techniques à la Arellano and Bond [1991].

In particular, in order to account for the time dynamics, a time-lagged value of $\ln(w_{i,t})$, as well as a complete set of time dummies, will be added to regressors in the estimation of (18). As long as tests

[31]See Anselin [1988], and Anselin and Kelejian [1997].

[32]Unreported GMM estimations (based on the weak-exogeneity assumption) on a linearized version of equation (18), support the introduction in the model of some dynamic component. In particular, the Sargan test on over-identifying restriction rejects the validity of instruments, and this could be reasonably due to some missing variable. Furthermore, the tests on residuals detect a significant time correlation, thus suggesting the presence of a mispecified time-dynamics is the data.

on residuals will not detect a significant time correlation, we can be confident that this remedy is able to control for the time dynamics. Then, following Arellano and Bond [1991] idea, we can apply a first difference (in order to eliminate fixed effects) and then use past levels of endogenous variables, starting from $t-2$, as instruments for the estimation. Although, contrary to the usual panel framework, observations are not independent in the cross-section dimension (and this is a peculiarity of spatial data), convergence is reached, as showed by Anselin and Kelejian [1997], as Φ goes to infinity if error terms are spatially uncorrelated.

Formally speaking, the set of identifying restrictions on which our procedure relies is:

1. $Cov(u_{i,t}, u_{k,t}) = 0 \, \forall \, i \neq k$

2. $Cov(u_{i,t}, u_{i,s}) = 0 \, \forall \, t \neq s$

3. $E[u_{i,t}|x_{i,s}] = 0 \, \forall \, t > s$

where $i, k = 1, 2..., \Phi$ and $s, t = 1, 2..., T$. The first set of restrictions requires absence of spatial correlation, and can be investigated by means of a Moran test. The second calls for absence of residual time-dynamics. The Arellano and Bond [1991] GMM estimator is in fact incompatible with disturbances having an AR structure: the dynamic need to be captured into model, as we are trying to do by adding a time-lagged value of $\ln(w_{i,t})$, as well as a complete set of time dummies, to (18). Tests on residuals time correlation will then allow to investigate the validity of such an assumption. Finally, the third type of conditions qualifies weak exogeneity and, together with the others, makes past values of endogenous variables good instruments. It is important to stress that, contrary to Hanson procedure, the validity of instruments could be directly assessed here by means of a Sargan test on over-identifying restrictions. Furthermore, our strategy allows us to keep the same geographical dimension for dependent, explanatory, and instrumental variables, thus avoiding a possible inhomogeneous data bias.

Two final observations are in order. First, to actually implement estimations we should define distance weights $f(d_{i,k})$. These weights should measure the amount of economic interaction between location. Helpman [1998] is essentially a trade model, so a good proxy for economic interaction is given by trade flows. Hanson [1998] uses the exponential form $f(d_{i,k}) = \exp^{-\tau d_{ik}}$, where $\tau \in [0, \infty)$ is an (inverse) measure of transportation costs to be estimated, and $d_{i,k}$ is distance between i and k. For our dynamic panel estimation, we will instead use something more rooted in trade theory: the power function $f(d_{i,k}) = \theta \, d_{i,k}^{\psi}$. This functional form have been extensively used in both gravity equation and home bias literature[33]. To make spatial econometrics techniques directly applicable we will estimated θ, while using for ψ values coming from the literature[34]. The distance weight $f(d_{i,k})$ in (18) is raised to the power $\sigma - 1$, and so we are actually interested in $\psi(\sigma - 1)$. Following Head and Mayer [2000], a reasonable estimate for $\psi(\sigma - 1)$

[33] See Head [2000]

[34] In spatial econometrics, distance weights should in fact be exogenously defined up to a constant, so that we need to impose an a priori value to θ.

is -1, so that the distance decay we will use is: $f\left(d_{i,k}\right)^{\sigma-1}=\theta d_{i,k}^{-1}$. Furthermore, as standard in spatial econometrics, we will give a zero weight to observations referring to the same location, i.e. $f\left(d_{i,i}\right)^{\sigma-1}=0$.

Second, equation (18) is not linear. This certainly complicates the implementation of dynamic panel techniques and, more importantly, could cause estimations to be extremely unstable. As known in applied econometrics, the combination of non-linearity, endogeneity, and instrumentation is dangerous mix that cause criterion functions to have many local minima, thus making interpretation of results ambiguous. Note that this last critic applies to Hanson procedure as well. The solution we adopt is then to estimate a linearized version of equation (18). This approach is not new for NEG applied models, and have been pioneered by Combes and Lafourcade [2001] with promising results. In Appendix 1, we formally derive the following linear counterpart of (18):

$$\ln(w_{i,t})=a+\sum_{k=1}^{\Phi}[(B_1\bar{Y}_{k,t}+B_2\bar{H}_{k,t}+B_3\bar{w}_{k,t})\,d_{i,k}^{-1})]+\varepsilon_{i,t} \tag{19}$$

where $B_1=\theta\frac{1-\sigma(1-\mu)}{\sigma\mu}$, $B_2=\theta\frac{(1-\mu)(\sigma-1)}{\sigma\mu}$, $B_3=\theta\frac{\sigma-1}{\sigma\mu}$, and for example $\bar{Y}_{k,t}=\ln(Y_{k,t})\frac{Y_{k,t}}{\sum_{k=1}^{\Phi}Y_{k,t}}$.

Equation (19) is now linear in parameters and, after adding time dummies and a time-lag of $\ln(w_{i,t})$ to control for time-dynamics, we get the final regression equation:

$$\ln(\mathbf{w}_t)=\mathbf{i}\,dum_t+\ln(\mathbf{w}_{t-1})A+\mathbf{W}\,\bar{\mathbf{Y}}_tB_1+\mathbf{W}\,\bar{\mathbf{H}}_tB_2+\mathbf{W}\,\bar{\mathbf{w}}_tB_3+\boldsymbol{\varepsilon}_t \tag{20}$$

where bold variables are column vectors containing observations for the Φ locations at time t, $\mathbf{W}$ is a $\Phi x\Phi$ spatial weighting matrix with generic element $\mathbf{W}_{i,k}=d_{i,k}^{-1}$, $\mathbf{i}$ is a vector of ones, and dum_t is a time-dummy. Equation (20) will be the one we will actually use for our dynamic panel investigations. With estimates of B_1, B_2, and B_3 in our hands, we can then trace back the implied values of μ, σ, and θ and, using the Delta method, make inference on them.

To summarize,we will first use data on the 103 Italian provinces to estimate equation (18) using both Hanson non-linear least squares (NLLS) procedure, and the non-linear instrumental variables (NLIV) technique we proposed[35]. The two methods consist of cross-sections and rest on the same statistical assumptions, with the second being preferable because it does not mix observations referring to different geographical units. This will allow us to compare directly results with Hanson [1998], as well as to shed some light on the bias coming from space-inhomogeneous observations. The two points in time we took to make time-difference are 1991 and 1998. We will then go through our preferred specification, that is the panel a panel estimation of (20) using Arellano and Bond [1991] estimator. At the cost of linearization, this method should allow us to address properly the endogeneity issue. Crucially, a test on the validity of instruments could be actually performed in this framework. The database used in this case will consist of yearly data for the entire period 1991-1998.

[35]To make results directly comparable to Hanson [1998], we will use the exponential function for spatial weights in both NLLS and NLIV estimations.

To account for possible structural differences between continental Italy and the two island of Sicily and Sardegna, we also got estimates on continental provinces only for all specifications. Further details about estimation techniques, spatial aggregation, and instruments are given in Appendix 2.

6 Estimation results

Tables 3 and 4 show respectively NLIV and NLLS estimates of the non-linear market potential function (18) while Table 5, which is the most important for us, contains our panel estimations for the dynamic linearized form (20). The first column of each table refers to results obtained using data on all provinces while, in the second, data on continental provinces only have been used. However, in all specifications, the two set of estimations do not differ significantly, and so that we will refer directly to estimates on all provinces. First of all, one can notice that punctual estimates of table 4, which are obtained with the same NLLS methodology proposed by Hanson [1998], looks very similar to his findings. Although precaution is needed, because our limited data set dimension probably causes standard errors to be quite high, this suggest that the different proxy we used for w should be a good one for Italy. We are in fact able, replicating this technique, to get something that is perfectly consistent with the results he got using local wages for US.

However, a closer comparison of Tables 3 and 4, reveals immediately two important things. Although both procedures rest on the same statistical hypothesis, NLIV estimates are more precise and, with particular reference to σ, quite different from NLLS ones. As we argued in the above section, precision is a consequence of the more efficient way in which NLIV treats the information. The spatial aggregation of regressors in NLLS thus lead to loose lots of information and, more importantly, it is probably the cause of the differences in parameters' estimates. The fact that Hanson's procedure actually mixes county with state data in the same regression equations could in fact lead to an aggregation bias. Coherently with our NLLS results, in Hanson [1998] values of σ lies between 6 and 11. By contrast, NLIV here indicates something around 2, suggesting that the magnitude of the aggregation bias is important. In both cases the crucial specification test, the Moran statistic, does not detect a significant spatial correlation in residuals[36]. As we argued in the previous section, this does not suffice to rule out endogeneity problems. It is in fact the significance of the estimates itself that suggests that the aggregation trick does not work. As long as one is successful in controlling for the time-dynamics, panel data provides instead a space-homogenous framework in which we can actually overcome endogeneity. Crucially, explicit tests on identifying restrictions and instruments validity can be performed in this case.

[36] The null hypothesis of the test is the absence of spatial autocorrelation. The test statistic can be corrected, as we actually do here, to account for both endogeneity in regressors and instrumentation, and is asymptotically distributed as a standardized normal. See Anselin [1988], and Anselin and Kelejian [1997] for further details.

Table 5 shows our panel results, that we are going to discuss in details. We can first note that the implied values of σ, μ, and θ are all very precisely estimated, with values lying in the corresponding interval predicted by theory. For the case of μ, it is in fact between 0 and 1 and in line with more reasonable values of the expenditure on traded goods than Hanson's estimates. Actually, in our stylized model product M is probably best seen as the aggregate of traded goods, as opposed to the non-traded ones (H), like housing and non-traded services. In Italy, the share of expenditure on housing is around 0.2 (and for US is almost the same), implying that estimated μ cannot be smaller than 0.8. However in Hanson [1998], as well as in our NLLS and NLIV estimates, μ is always too high with values around 0.9 or even bigger.

For the elasticity of substitution, we got estimates between 3 and 4 that are significantly different from Hanson's findings. Although recent empirical studies indicate, using sectorial data, values of the elasticity of substitution between 4 and 9[37], we do not believe that these values are coherent with our underlying theory. Helpman [1998] is in fact a very aggregated vision of the economy with just two sectors: traded goods (M), and non traded ones (H). Consequently, the aggregate M contains goods that are actually very different from consumers' point of view (like cars and shoes), and we cannot certainly expect to find high values for their elasticity of substitution.

The other structural estimates to interpret are those of $\sigma/(\sigma-1)$, and $\sigma(1-\mu)$. Concerning the quantity $\sigma(1-\mu)$, one can see that it is significantly lower than 1, and in our framework this means that centripetal forces are active. Agglomeration can thus occur, and its strength depends on the level of transportation costs. Similar results have been obtained by Hanson [1998]. Finally, $\sigma/(\sigma-1)$ should express the equilibrium ratio between marginal and average costs. The value we got is quite high compared to both Hanson's findings and intuition, implying that firms have a mark-up of about 40% over marginal costs. This is probably due to the simplifying assumptions of Helpman [1998] that actually cause σ to be at the same time the elasticity of substitution between goods, the price-elasticity of consumers' demand, and an inverse measure of increasing returns to scale. However, by definition, σ is an elasticity of substitution in Helpman [1998] model, and this should be the preferred interpretation.

As earlier mentioned, the crucial difference between our theory-based market potential (17) and the Harris type (16), is that the second does not control for wages and prices of others locations. In Helpman [1998], an increase in other locations' housing stock (H_k) or wages(w_k), cause w_i to increase in the long-run in order to compensate workers for lower housing prices and higher earnings they can enjoy elsewhere. Our estimations suggest that both variables actually play a significant role, as explicitly measured by the significance of B_2 and B_3, in understanding the forces at work is a space economy.

Turning to endogeneity and correlation issues, we can notice that all specification tests support our panel estimation. The Sargan test on over-identifying restrictions does not in fact reject the validity of our instruments. We actually used all past levels of $\ln(w_{i,t})$, $\mathbf{W}_i\bar{\mathbf{w}}_t$, $\mathbf{W}_i\bar{\mathbf{Y}}_t$, and $\mathbf{W}_i\bar{\mathbf{H}}_t$, where $\mathbf{W}_i$ refers the generic i column of the spatial weighting matrix $\mathbf{W}$, starting from $t-2$ as instruments for estimation. Table 2 contains the (total) contemporaneous serial correlation matrix between $\ln(w_{i,t})$, $\mathbf{W}_i\bar{\mathbf{w}}_t$, $\mathbf{W}_i\bar{\mathbf{Y}}_t$,

[37] See Feenstra [1994], and Head and Ries [2001].

and $\mathbf{W}_i\bar{\mathbf{H}}_t$. Furthermore, the two test on time autocorrelation behave in the correct way. If the $u_{i,t}$ are actually not correlated over time, then one should detect a significant (negative) first order correlations in differenced residuals $\triangle\hat{u}_{i,t}$, and an absence of "pure" second order correlation[38]. As one can see, this is actually what we found. This suggests that the inclusion of the dynamic term $\ln(\mathbf{w}_{t-1})$ in our equation, which turns out to be strongly significant, has probably allowed us to properly "capture" the time-dynamics (that we need to control for) into the model. Finally, to exclude the presence of residual spatial correlation an adequate test is needed too. Anyway, as far as we know, there is still no test procedure that exploits both the time and cross-section information (coming from panel estimations), that at the same time accounts for endogeneity and instrumentation. However, one can certainly test year by year, and this is what we have actually done in Table 6 where the Moran statistic have been calculated for those years in which a sufficient number of instruments were available. As one can see, we did not found evidence of a significant spatial correlation.

Finally, in order to have an idea of the spatial extent of agglomeration forces, we have simulated the effect on w caused by an exogenous temporary shock on income, as measured by equation (20). Using our panel estimates from Table 5 (first column) we have first evaluated equilibrium wages by means of (20), using actual data on $\ln(w_{i,t-1})$, $\bar{w}_{k,t}$, $\bar{Y}_{k,t}$, and $\bar{H}_{k,t}$ for t =1992. Then, we have decreased the 1992 income of the 5 Latium' provinces of 10% before re-computing $\ln(w_{i,t})$. Finally, as (20) contains a dynamic term linking $\ln(w_{i,t})$ with its past values, we have computed the sum of yearly changes on $\ln(w_{i,t})$ induced by this shock on income, occurring in 1992, over the entire period 1992-1998. Figure **??** shows the implied total percentage decrease in the values of $w_{i,t}$ consequent to this simulated shock. Although we are actually under-evaluating the effect of such shock[39], Figure **??** points out clearly that the impact is certainly not negligible and, contrary to Hanson [1998], it is not so geographically bounded. The latter result is partially due to the different choice of the spatial weights. In fact, Hanson uses an (inverse) exponential space decay. As it is well known, this function goes to zero very fast and so it tends "naturally" to limit the extent of spatial interaction, as opposed to the polynomial function we used. Interestingly, the shock seems to be "asymmetric", in the sense that south provinces are more affected than north ones. This is certainly not surprising in the light of Italian economic geography. Everything equal, the relative importance of Latium purchasing power is in fact higher for the south where local demand, as measured by households disposable income, is lower than in the richer north.

[38] See Arellano and Bond [1991].

[39] In fact, equation (17) does not make use of aggregate budget constrain (12), and so it does not directly account for the consequent chain of changes in equilibrium incomes and factor earnings of all other provinces, as coming from (12).

7 Conclusions

The NEG literature has provided a series of fully-specified general equilibrium models capable to address rigorously the agglomeration phenomenon. The combination of increasing returns, market imperfections, and trade costs creates new forces that, together with factor endowments, determine the distribution of economic activities. These spatial externalities makes agents' location choice highly interdependent, thus allowing to understand the spatial correlation between demand and production observed empirically by the market potential literature.

Following the approach of Hanson [1998], we have first derived a theory-based market potential function (obtained from a multi-location extension of Helpman [1998] model), relating the attractiveness of a location to the spatial distribution of factor earnings, consumers' expenditure, and non-tradable goods. Using a time-space panel data on Italian provinces, we have then estimated a linearized version of this equation by means of an innovative estimation technique, based on Arellano and Bond [1991] and Anselin and Kelejian [1997], that is needed in order to effectively address those endogeneity issues that arise when dealing with structural models and spatial data. In fact, we provide evidence that the spatial aggregation approach used by Hanson [1998] may suffer from a serious bias problem. In particular, the difficulty to solve the underlying simultaneity problems for a given time t, suggests the use of panel data, while taking into account goods and/or factors market frictions calls for a dynamic panel framework à la Arellano and Bond [1991].

Our results are consistent with the hypothesis that product-market linkages, coming from increasing returns and trade costs, actually influence the geographic concentration of economic activities. Furthermore, they underline the role of theory in identifying the forces at work in a spatial economy, and especially those economic indicators that "capture" such tensions. Interestingly, simulations suggest, contrary to Hanson [1998], that the impact of such spatial externalities is not so limited in geographical extent. However, this latter result may be partly due to the different choice of the spatial decay matrix. We have also experimented, with promising results, a new proxy variable for local equilibrium wages. The choice we made for w seems in fact to be capable to capture local agglomeration forces for Italy, and to give results comparable with Hanson [1998] findings.

There are several possible directions for further research. One natural extension of our framework would be to obtain estimates using European data. As shown by Overman and Puga [1999], national borders are in fact less and less important in Europe, while regions are becoming the best unit of analysis. What really matters is spatial proximity, therefore a theory-based investigation on agglomeration forces at European level would be desirable. A second issue is related to the simplifying assumptions that leads Helpman [1998] to be cumbersome for empirical interpretation. As we already saw, the fact that σ is at the same a measure of 3 different things is very annoying. A promising approach in tackling this problem is given by Ottaviano, Tabuchi, and Thisse [2001]. Using a more elaborated demand structure and transportation technology, this model allows in fact to clearly separate (by means of different parameters) elasticity of demand, elasticity of substitution and increasing returns, as well as firms' pricing policies. Finally, as shown in Krugman and Venables [1995], Puga [1999], and Combes [1997], input-output linkages can also be the source of agglomeration externalities. This is particularly true for Europe in which the mobility of firms and goods is certainly higher than that of people. This, however require the use of a more detailed modellization of production than the two goods-type we have in Helpman [1998].

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Appendix 1: Linearization

Consider a long-run equilibrium where transportations costs are negligible. In such an equilibrium $w_{k,t} = w^*$, and incomes $Y_{k,t} = Y_k^*$ are just proportional to exogenous housing stocks $H_{k,t} = H_k^*$, i.e. $Y_k^*/H_k^* = \chi$. Computing the derivatives of (18) with respect to $Y_{k,t}$, $H_{k,t}$, and $w_{k,t}$ (for $k = 1, 2 ... \Phi$), evaluated at our long-run equilibrium w^*, H_k^*, Y_k^* and simplifying things one gets:

$$\ln(w_{i,t}) \simeq \ln(w^*) + \sum_{k=1}^{\Phi} [(B_1 \frac{Y_{k,t}}{\sum_{k=1}^{\Phi} Y_k^* v_{i,k}^{(\sigma-1)}} + B_2 \frac{H_{k,t}}{\sum_{k=1}^{\Phi} H_k^* v_{i,k}^{(\sigma-1)}} + B_3 \frac{w_{k,t}}{w^*} \frac{H_k^*}{\sum_{k=1}^{\Phi} H_k^* v_{i,k}^{(\sigma-1)}}) \, d_{i,k}^{-1})] -$$

$$- \sum_{k=1}^{\Phi} [(B_1 \frac{Y_k^*}{\sum_{k=1}^{\Phi} Y_k^* v_{i,k}^{(\sigma-1)}} + B_2 \frac{H_k^*}{\sum_{k=1}^{\Phi} H_k^* v_{i,k}^{(\sigma-1)}} + B_3 \frac{w^*}{w^*} \frac{H_k^*}{\sum_{k=1}^{\Phi} H_k^* v_{i,k}^{(\sigma-1)}}) \, d_{i,k}^{-1})] \tag{A1}$$

where $v_{i,k} = f(d_{i,k})^{(\sigma-1)} = \theta d_{i,k}^{-1}$. Grouping second and third term together and rearranging then:

$$\ln(w_{i,t}) \simeq \ln(w^*) + \sum_{k=1}^{\Phi} [(B_1 \frac{Y_{k,t} - Y_k^*}{Y_k^*} \Xi + B_2 \frac{H_{k,t} - H_k^*}{H_k^*} \Xi + B_3 \frac{w_{k,t} - w^*}{w^*} \Xi) \, d_{i,k}^{-1})] \tag{A2}$$

where the quantity $\Xi = \frac{Y_k^*}{\sum_{k=1}^{\Phi} Y_k^* v_{i,k}^{(\sigma-1)}} = \frac{H_k^*}{\sum_{k=1}^{\Phi} H_k^* v_{i,k}^{(\sigma-1)}}$ by equilibrium conditions. Now, terms like $\frac{Y_{k,t} - Y_k^*}{Y_k^*}$ are percentage deviations from our long-run equilibrium values, and we could therefore approximate it with $\ln(\frac{Y_{k,t}}{Y_k^*}) = \ln(Y_{k,t}) - \ln(Y_k^*)$, where the second term, being time-invariant, will go in the location specific effect μ_i. If we finally approximate the term $\Xi = \frac{Y_k^*}{\sum_{k=1}^{\Phi} Y_k^* v_{i,k}^{(\sigma-1)}}$ with $\frac{Y_{k,t}}{\sum_{k=1}^{\Phi} Y_{k,t}}$, we get equation (19).

Appendix 2: Estimations

To construct instruments for NLIV, and regressors for NLLS, we have adopted the following procedure. We first divide Italy in 11 zones using NUTS-1 regions. After having transformed (18) with a time difference, for NLIV estimation we have then used, for each province, the change (over the time interval 1991-1998) in the logarithm of the variables w, Y, and H of the corresponding zone (reconstructed aggregating provinces data) as instruments. We thus have a set of exactly 3 instruments for the 3 parameters to estimate in (18), and so there is no need of an optimal weighting matrix. For NLLS, we have instead used directly levels of w, Y, and H, corresponding to the eleven zones, as regressors before making first difference and applying least squares. In both cases, we have also neutralized,as in Hanson [1998], the specific contribution of each province in the formation of the corresponding zone aggregate variable. As a remedy for spatial heterogeneity, we have used White (1980) type heteroschedasticity-consistent standard errors. For the Moran test, we used the pseudo-regressors as explanatory variables. Finally, all estimations have been performed with Gauss for Windows 3.2.38.

Panel estimates are two-step GMM ones and have been performed with DPD 98 for Gauss. The model is estimated in first differences, using past levels of all explanatory variables, form $t-2$ and later, as instruments. The reason why we actually treated all variables as endogenous is that, in unreported estimations, we actually found evidence that also the housing stock process suffers of simultaneity. Estimations includes time-dummies, while standard errors and tests are all heteroschedasticity consistent.

Table 1: Summary Statistics

	Mean	Standard Dev.	Min	Max
w	65.1	12.98	42.63	100.52
Y	13,055,315	16,166,672	1,772,886	115,120,309
H	19,247,567	19,714,984	3,271,507	130,723,464
Surface	2,925.64	1,750.38	211.82	7,519.93
Population	557.87	615.56	92.15	3,781.79

All nominal variables are in 1996 prices and the unit is one million liras. Housing H is measured in squared meters, while population is in thousand of people and provinces surface is expressed in squared kilometers. Data have an yearly basis, and refers to the interval 1991-1998

Table 2 : (Total) Contemporaneous correlation matrix of panel instruments

	$\ln(w_{i,t})$	$\mathbf{W}_i\bar{\mathbf{w}}_t$	$\mathbf{W}_i\bar{\mathbf{Y}}_t$	$\mathbf{W}_i\bar{\mathbf{H}}_t$
$\ln(w_{i,t})$	+1	+0.54	+0.36	+0.32
$\mathbf{W}_i\bar{\mathbf{w}}_t$	+0.54	+1	+0.74	+0.81
$\mathbf{W}_i\bar{\mathbf{Y}}_t$	+0.36	+0.74	+1	+0.70
$\mathbf{W}_i\bar{\mathbf{H}}_t$	+0.32	+0.81	+0.70	+1

Variables are in levels, and the entire sample period (1991-1998) have been used to compute variances and covariances

Table 3: NLIV estimates for Helpman [1998]

μ (stand. error)	0.8741** (0.1939)	0.8687** (0.1726)
σ (stand. error)	1.9196** (0.4876)	2.0219** (0.5327)
τ (stand. error)	0.1895** (0.0523)	0.1698** (0.0491)
$\sigma(1-\mu)$ (stand. error)	0.2417 (0.1314)	0.2250* (0.1126)
$\sigma/(\sigma-1)$ (stand. error)	2.0874** (0.3071)	1.9786** (0.3201)
Wald test joint sign. (degrees of freed, impl. prob)	63.231 (df=3, p=0.000)	68.818 (df=3, p=0.000)
Moran test spat. correl. (implied prob)	1.212 (0.2255)	0.961 (0.3365)
Adjusted R^2	0.4201	0.5136
General. R^2	0.3392	0.3448
Provinces	All	Continental
N° of observ	103	90

Table 4: NLLS estimates for Helpman [1998]

μ (stand. error)	0.9106* (0.4561)	0.9394 (0.5652)
σ (stand. error)	5.9128 (3.9692)	6.7531* (3.3469)
τ (stand. error)	0.9351 (2.0882)	0.7495 (1.1421)
$\sigma(1-\mu)$ (stand. error)	0.5877 (1.7527)	0.2880 (1.0182)
$\sigma/(\sigma-1)$ (stand. error)	1.2035* (0.6077)	1.2664* (0.5872)
Wald test joint sign. (degrees of freed, impl. prob)	14.228 (df=3, p=0.0026)	15.124 (df=3, p=0.0017)
Moran test spat. correl. (implied prob)	0.522 (0.6016)	0.991 (0.3216)
Adjusted R^2	0.2521	0.1987
General. R^2	0.2346	0.2893
Provinces	All	Continental
N° of observ.	103	90

** Indicates estimates significant at 1% level, while * indicates estimates significant at 5%.

Table 5: Panel estimates for Helpman [1998]

$\ln(\mathbf{w}_{t-1})$ (stand. error)	0.3004 (0.0355)	0.2731 (0.0348)
$\mathbf{W}\,\bar{\mathbf{Y}}_t$ (stand. error)	11.1843 (1.5507)	10.9123 (1.7516)
$\mathbf{W}\,\bar{\mathbf{H}}_t$ (stand. error)	27.7367 (4.2910)	28.3625 (4.5608)
$\mathbf{W}\,\bar{\mathbf{w}}_t$ (stand. error)	122.4511 (9.2635)	117.8225 (8.9225)
μ (stand. error)	0.7735 (0.0316)	0.759278 (0.0302)
σ (stand. error)	3.4335 (0.6796)	3.2778 (0.7345)
θ (stand. error)	133.6351 (10.3401)	128.7353 (10.8708)
$\sigma(1-\mu)$ (stand. error)	0.7777 (0.0713)	0.7890 (0.0889)
$\sigma/(\sigma-1)$ (stand. error)	1.4109 (0.0914)	1.4390 (0.0849)
Wald test joint sign. (degrees of freed, impl. prob)	333.1169 (df=4, p=0.000)	322.6295 (df=4, p=0.000)
Sargan test (degrees of freed, impl. prob)	94.1325 (df=80, p=0.3621)	101.2946 (df=80, p=0.1953)
1^{st}order time corr. (implied prob)	-3.643 0.0003	-3.982 0.0000
2^{nd}order time corr. (implied prob)	0.389 0.6972	-0.104 0.9172
Adjusted R^2	0.4711	0.4568
Provinces (Number)	All (103)	Continental (90)
N° of sample observ.	618	540

Table 6: Moran Test for panel estimations

Years	Moran test all prov.	Moran test cont. prov.
$93-94$	+0.2014 (0.8404)	+0.4114 (0.6808)
$94-95$	+0.1301 (0.8965)	-0.5632 (0.5733)
$95-96$	-0.7910 (0.4289)	-0.3120 (0.7550)
$96-97$	-0.6370 (0.5241)	+0.1425 (0.8867)
$97-98$	-0.4814 (0.6302)	-0.7123 (0.4763)

In table 6 test statistics have been computed with residuals of the model estimated in first differences. Implied probability is reported in parenthesis.

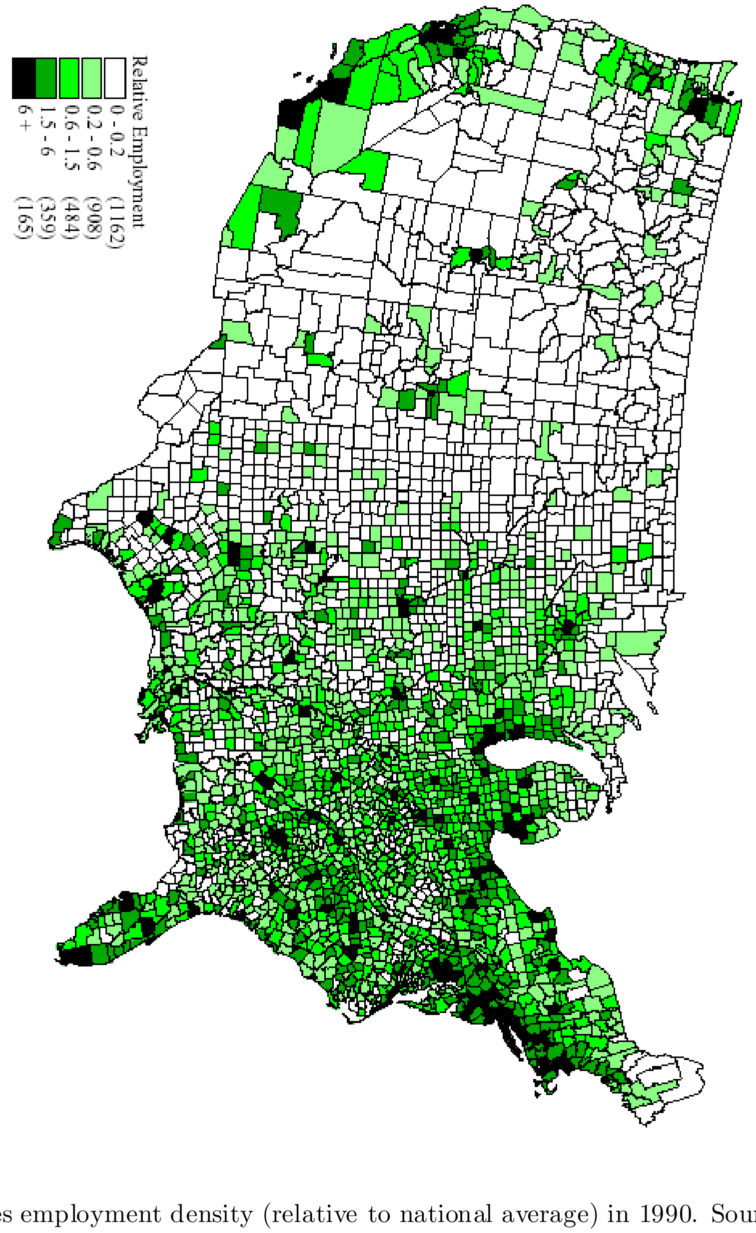

Figure 1: US counties employment density (relative to national average) in 1990. Source: Hanson [1998].

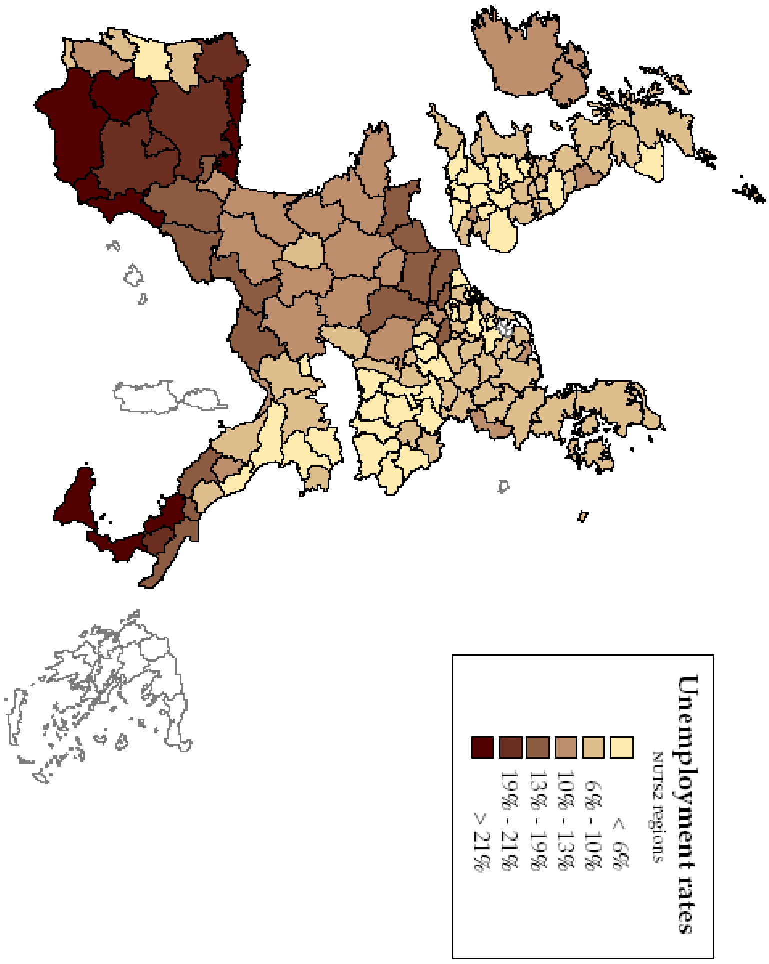

Figure 2: European regional unemployment rates in 1996. Source: Overman and Puga [1999].

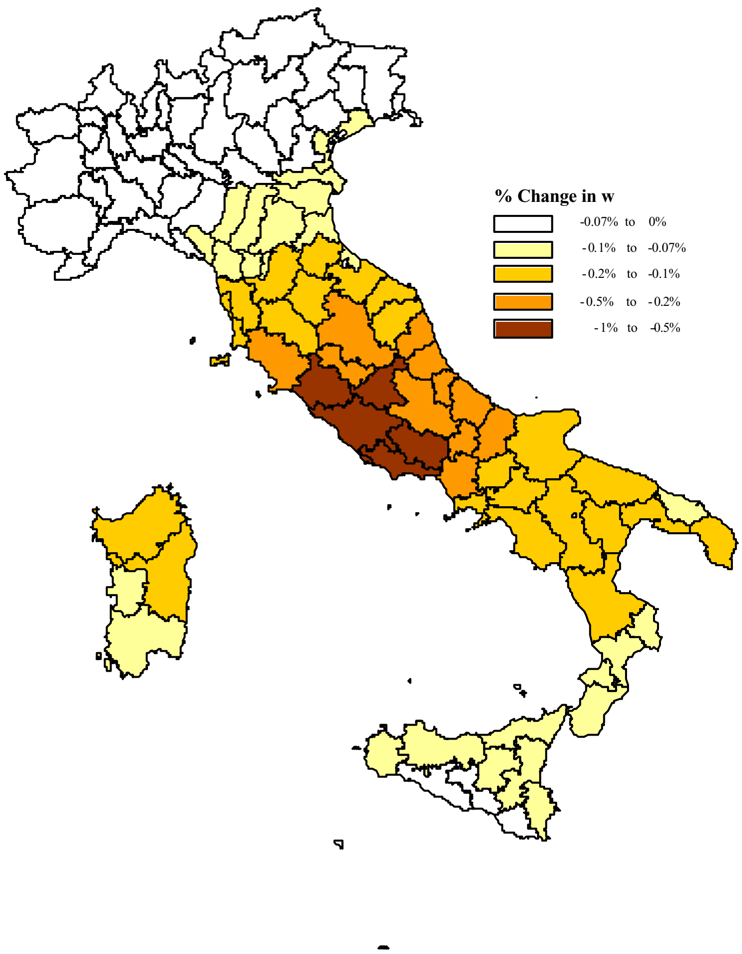

Figure 3: Simulated w changes from income shock to Latium.