IMPROVING THE TRADITIONAL MEASURES OF AGGLOMERATION WITH NEIGHBOURING EFFECTS

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1. Introduction

The growing complexity of modern production systems has made crucial the recourse to new analytical methods whose suitable implementation requires the use of statistical data at an increasingly sectoral and territorial detail. In this paper we propose a methodological contribution to the agglomeration literature through the transformation of traditional measures, with the aim of overcoming their limits in the analysis of specific aspects of the socio-economic activities geographic distribution.

The attempt to improve the agglomeration measures is justified by the relevance of the economic phenomena tied to the agglomeration, some aspects of which are the existence of externalities, commuting flows, inequality in the degree of development across space, and congestion that provokes diseconomies of agglomeration. Indeed, the indicators currently used to analyze geographic concentration are based on the hypothesis that the agglomeration forces among plants appear only within the territory where they have their origin, without any consideration of the effects exerted out of its borders. In this respect, we want to examine the spatial dependence among agglomerative factors in neighbouring areas focusing on the indicators recently employed in related studies (Maurel and Sédillot, 1999; Maré and Timmins, 2006) on the basis of the seminal work of Ellison and Glaeser (1997).

In all studies aiming to identify and evaluate agglomeration, attention has been essentially paid to the production structure of the examined areas because, according to Rosenthal and Strange (2003), "industrial organization affects the benefits of agglomeration" in all the forms they assume. The complex discussion concerning the competitive advantages, which are determined outside of the firm but within the territory wherein it is located, has generated different classifications, regarding particularly the distinction among static and dynamic external economies. (Henderson et al., 1997). Consequently, the spatial proximity mechanisms that influence the organization of production activities in a particular location are also responsible of the "patterns of uneven regional development" and favour processes of polarization and dispersion (Cantwell, 2004). But the analysis of agglomeration forces limited to individual geographical partitions does not allow to distinguish between the effects deriving from the geographic concentration and the spatial interdependence among the economic activities localized nearby. In fact, "neglecting the spatial features of data is doomed to produce serious biases when quantifying a concept like industrial agglomeration" (Arbia, 2001). Only the contemporary consideration of the instruments useful to identify the sources of externalities grants detecting the intensity and the directions of spillover mechanisms (La Fourcade and Mion, 2007). The empirical studies in this field have, however, privileged, in nearly wide-ranging cases, a sectoral point of view with the aim of verifying the existence of interaction processes in the plants' location decisions, thus giving a scant relief to the size and to the characteristics of the territorial units employed in the analysis. This has been so even when, using the words of Rosenthal and Strange (2003) "agglomeration should ideally be studied at a much more refined geographical level than has been the norm".

In this paper we aim at changing the scope of the analysis of agglomeration economies by using modified measures of agglomeration and the set of Sicilian Local Labour Systems (LLS henceforth), which are limited geographic realities corresponding to a spatial aggregation level less than NUTS3. On the basis of the specific identification process of LLSs in Italy, (Sforzi, 1989; Basile and Mantuano, 2007) we think that this territorial breakdown can provide a more adequate distinction between the clustering among firms and the interdependence phenomena, even in a region like Sicily presenting a structural disadvantage compared to the other Italian regions, particularly those more developed in the Centre and North of the country. In this respect, we believe, that focusing on the spatial dimension of economic development will make easier the identification of the "*centripetal forces* that pull economic activity together and the *centrifugal forces* that push it apart" (Fujita and Krugman, 2004) evaluating, in the meantime, the characteristics and the tendency of local growth.

2.Theoretical Construct of Agglomeration

The economic literature of the last three decades has been more and more oriented to integrate conveniently the results of the empirical analyses addressed to the determination of the growth factors explaining the different speeds in the development process (Santa María Beneyto et al. 2005, Pellegrini 2005, Paci and Usai 2006, Di Giacinto and Pagnini, 2008). Indeed, the growing achievement of the endogenous growth models has induced many authors to consider the factors explaining territorial disparities in a more comprehensive manner than Solow's approach.[1] In particular, for a long time several theoretical contributions (Romer, 1986; Lucas, 1988; Goto and Suzuki, 1989; Sala-i-Martin, 1990) have identified the elements fostering and/or strengthening the development of an area. Nevertheless, the complexity of economic phenomena and, above all, the various forms of interaction among them have stressed the opportunity of employing units of observation at a higher level of spatial disaggregation, for a suited distinction between the positive and negative aspects that reinforce or restrain, respectively, growth at the local level. It is worthwhile the explicit reference, and the subsequent consideration in the empirical practice, of the motivations influencing the localization choice of business units, stressing on the elements (transport costs) that cause the dispersion of production activities in the space or, on the contrary, produce their concentration (agglomeration economies) (Capello, 2004). Specifically, inside the last typology of elements it is customary including natural advantages like local structural characteristics, resource endowments and labour costs (Ellison and Glaeser, 1997). Thus, industrial agglomeration phenomena have received a particular attention by many authors interested in the assessment of positive market externalities through the recourse to the models of the so-called "new economic geography" (for a survey, see Fujita et al., 1999).

It should be noted that "while the whole literature on agglomeration externalities stems from the shared need to explain the emergence and persistence of economic geographical concentration, it in fact encompasses quite different approaches and concerns" (Le Blanc, 2004). One of the main theoretical strands established in the first half of last century, the *localization theory*, was due to Christaller (1933), Hoover (1948) e Lösch (1954) (all quoted in Capello, 2004). According to their thought, localization behaviour of economic agents has become particularly prominent and the consequent territorial distribution of activities constitutes a key element for the analysis of the economic system structure and evolution. Afterwards, the proponents of the *regional growth theory* (Ohlin,1933; Camagni, 1999) focused their attention to more or less wide portions of territory inside the same national entity, aiming to explain the different expressions of local growth (Capello, 2004). The attempt to analyze the causes of the disparities in the local economic development has stimulated a number of studies on the influence of physical proximity generating positive externalities among the subjects involved. So, from different perspectives and by unlike analytical tools, scholars from various backgrounds (economists, geographers, historians) have contributed to outline the causes of regional specialization processes focusing on several aspects like "regional endowments or raw materials intensity, comparative advantage localization externalities, or, more recently, transport costs and market potential" (Lafourcade and Mion, 2007).

But the differences in the respective theoretical domains and in the analytical methods have determined unavoidable mixtures and/or contrapositions in the interpretation of the phenomena inquired, also depending on the various purposes of the analyses. A remarkable difficulty in the study of production localization lies both in the definition of the process and in the evaluation of its effects on the distribution of economic activities. From the specific consideration of the factors related to the various localization patterns derives, in fact, the correct identification of the adequate

[1] A complete survey on the endogenous growth theories, exceeding the bounds of this paper, is quoted in Barro (1991), Quah (1993), Ardeni (1995), Boggio and Seravalli (2003), Capello (2004), Musu (2007).

tools for the measurement of the positive (negative) spillovers making easier (uneasier) the growth path at the different territorial levels. A fundamental distinction concerns the modalities of aggregation among the production units as to the area in which the process occurs. Indeed, an essential feature of geographic concentration is constituted by the fact that individual plants locate near to each other without any specific consideration of the industrial concentration, (Santa Marìa Beneyto et al., 2005) whose principal characteristics, as is common knowledge, are the number of the enterprises and their dimensional disparity in terms of market shares (Carlton e Perloff,1994). Later, different spatial features have been identified in the production activities depending on the scale of the geographical unit considered as well as on the kind and extent of the externalities brought about.
Furthermore, the perusing of the characteristics and intensities of interaction among the areas has determined the belief that the use of the afore-mentioned measures can produce "serious biases when quantifying a concept like industrial agglomeration" (Arbia, 2001). Following these considerations new hypotheses have been formulated as to the nature of agglomeration processes with a specific reference to the concepts of continuous or discrete space and a new measurement system has been constructed for taking into account the position of production plants in the territory.
The indicators proposed, according to this analytical setting, allow estimating the effects of spatial autocorrelation in some territorial units as depending on the location decisions of enterprises operating in neighbouring areas.

3. Agglomeration Measures Literature

3.a) Traditional measures of geographic concentration

Among the initial measures employed for evaluating the geographic distribution of economic activities we can find: the metric by Dollar and Wolff (1988) the localization coefficient also known as Hoover index (1936) (with the derived Balassa indexes) and the specialization index by Beguin (1979). Subsequently, many authors have tried to quantify agglomeration and dispersion phenomena using more adequate statistical tools like the Gini locational coefficient. Since the original work by Krugman (1991), this measure is used in several empirical researches (Audretsch and Feldman, 1996; Amiti, 1997; Haaland et al., 1999; Midelfart Knarvik et al., 2000; Brülhart, 2001; Kim et al., 2000). Notably, Amiti (1997) employed the Gini coefficient to assess the production specialization tendencies in European countries.
The relevance given to the externalities, as the main source of agglomeration processes, is on the base of further analyses (Ellison e Glaeser, 1997, 1999; Maurel e Sédillot, 1999; Duranton and Overman, 2002; Dumais et al., 2002; Devereux et al., 2004; Combes e Overman, 2004) enlivening the scientific debate, especially in the last decade. In particular, the "dartboard" index by Ellison and Glaeser, has been introduced in a proper structural model taking into account all the foremost factors controlling for agglomeration. In a specific way, this measure provides a general definition of the agglomeration and dispersion phenomena starting from a model of location choices.[2] It is important to note that Maurel and Sédillot (1999), in the spirit of Ellison and Glaeser, proposed a concentration index to measure agglomeration in French industries. In this strand it is possible to include the indexes suggested by Devereux, Griffith and Simpson (1999) and Rysman and

[2] The Ellison and Glaeser index has encountered a great favour in the literature of agglomeration processes so we quote a short list of works employing this measure. Klimek and Merrell (1999) resorted to the dartboard index for the evaluation of sales concentration while Holmes (1999) used it to verify vertical relations existing among the firms, Black and Henderson (1999) used the dartboard index to measure the concentration of population and industry in the cities. Subsequently, Rosenthal and Strange (2001) employed the index to analyze manufacturing industry in USA, Ellison (2002) used the index in a particular research aiming to estimate the concentration in the publication of scientific papers, and Gautier and Teulings (2002) applied it as a proxy for the labour market density.

Greenstein (2004). On the other hand, Guillan and Le Gallo (2006), have recently employed a procedure that results from the combination of the Gini index with ESDA in order to estimate the spatial agglomeration patterns for different economic sectors.
Agglomeration patterns resulting from the analyses appear, however, strongly heterogeneous in the industrial sectors belonging to various nations, because of various analytical approaches employed and different timing of the researches.

3.b) Spatial measures of geographic concentration

A coherent evolution of the above-mentioned measures is to be found in the alternative literature embodying distances in the concentration indexes so as to consider them like continuous measures. The analytical methods based on spatial arrangement are useful to explain the structures of economic activities at different geographic scales.[3] To this regard, we can quote the fundamental work by Ripley (1977) who proposed a method based on the K-distance function. The use of this function spread in several fields of research as showed in the works by Busch and Reinhardt (1999). In the spatial statistic literature, it is worthy mentioning the works by Marcon e Puech (2003) that propose an enhancement in the preceding methods based on the distance adopting the "M" function with the aim to analyze geographic concentration and co-location processes of many industries. Notably, the analyses by Busch and Reinhardt (1999) and Duranton and Overman (2005) insert in this particular strand.

3.c) The main requirements of the concentration measures

Because of the remarkable achievement obtained by the agglomeration measures, it is convenient to enumerate the desirable properties for a statistical measure of geographic concentration. Initially, Valeyre (1993) e Jayet (1993) identified some of these characteristics and, recently, Duranton and Overman (2002), and Combes and Overman (2004), have provided a list of the appropriate requirements that spatial measures have to meet. In brief, for a convenient description of the economic activity location, the following properties should be ensured:

1) Comparability of the measures across activities and across spatial scales
2) Consideration both of the agglomeration tendency in the whole manufacturing and of the market concentration level in each sector
3) Uniqueness of the value under the null hypothesis of inexistence of systematic forces acting in the location of activities and evidence as to the significance of the measures adopted
4) Unbiasedness of the measures in relation to the changes both in spatial and industrial Classification

Marcon and Puech (2003) have considered enlarging these requirements by adding another one consisting in "not finding some geographic concentration/dispersion merely due to a '*compensatory effect*' between sectors of activity". Finally, it is a common opinion among many authors that empirical results should allow an economic reading.
The majority of statistical measures has the characteristics of *comparability across activities*, such as the Gini coefficient, the Ellison and Glaeser index, the Maurel e Sédillot index, the measure proposed by Duranton e Overman (2002), the K function by Ripley (1977), the L function by Besag (1977), etc. Besides, the first property envisages the eventuality of comparisons between concentration both at national and regional level and, also, among groups of countries. Accordingly,

[3] The main worthiness of these methods consists in pinpointing at what distance geographic concentration or dispersion become significant. So, the distance-based methods, grounded on the analysis of point distribution in the space, represent a valid answer to the scale problem (Arbia, 1989, Reynolds, 1998).

agglomeration indexes must remain unbiased in the analyses carried out at different geographic scales.
As pointed out above, each localization measure has also to consider industrial concentration degree and, surely, the “dartboard” index and the one by Maurel and Sédillot meet this requirement. On the contrary, the Gini coefficient does not make any difference between the two types of concentration. Not even K and L functions take into account the individual characteristics of production units, considering enterprises like an indistinct set in which dimensional differences are neglected.
The third property, specifically, requires the indicator “should take a unique (known) value under the ‘null hypothesis’ that there is no systematic component to the location of the activity” (Combes and Overman, 2004). Only the measure proposed by Ellison and Glaeser obeys this criterion though it does not guarantee the statistical significance of the results as, on the other hand, it occurs for most indicators used in the analysis of agglomeration phenomena. Last required condition refers to the effects of arbitrary changes brought about in industrial and spatial classifications, because many indicators consider units of observation as points placed in a map without any specific relief to the distance existing among them.

4. Methodology

As previously said, different models of economic geography can lead to various predictions regarding the location of economic activity.
To evaluating agglomeration forces in a particular area we have chosen the agglomeration index provided by Maurel and Sédillot (1999).This measure is a development of the well-known Ellison e Glaeser index (1997) and is based on location decision model.
Lately, a lot of authors have applied this indicator in their studies on the geographic concentration, among others we remember Pagnini (2003), Zhang Hua and Zeng Wei (2007).
In this work, we refer to Maré and Timmins (2006) version of the Maurel and Sédillot index; in fact, they perform a modification of Maurel and Sédillot index reversing the industry’s role with the area’s role having, in this way, a synthesis of agglomeration process for each area.
Hereinafter we resume the meaningful elements of the Maurel and Sédillot probabilistic model.
N represents the number of plants and $z_1, z_2, \ldots z_n$ the share of each plant in industry employment.
M is the number of geographic areas and $x_1, x_2, \ldots x_n$ represent the share of total employment in every area, s_i is the share of a particular industry employment located in a geographic area, and its analytical expression is:

$$s_i = \sum_{j=1}^{N} z_j u_{ij} \qquad (1)$$

Let *i* the geographic area and *j* the industry where $u_{ij} = 1$ if the business unit *j* locates in area *i*, 0 otherwise.
The Maurel and Sédillot index (M&S, henceforth) is an empirical estimate of γ, that is an estimate of the probability of two plants both locating in the same region and it is defined as

$$\gamma = corr(u_{ij}, u_{ki}),\ j \neq k \qquad (2)$$

The probability of *j* and *k* both locating in region *i* is

$$P = \sum_i P(i,i) = \gamma\left(1 - \sum_i x_i^2\right) + \sum_i x_i^2 \qquad (3)$$

Maurel and Sédillot demonstrated that a simple frequency estimator of *p* can be found as

$$\hat{p} = \sum_i \frac{\sum_{\substack{j,k \in i \\ j \neq k}} z_j z_k}{\sum_{\substack{j,k \\ j \neq k}} z_j z_k} = \frac{\sum_i s_i^2 - H}{1 - H} \qquad (4)$$

Let H is the Herfindahl concentration index[4]

$$H = \sum_{j=1}^{N} z_j^2 \qquad (5)$$

Therefore, the formula of M&S index is as follows:

$$\gamma_{MS} = \frac{\hat{p} - \sum_i x_i^2}{1 - \sum_i x_i^2} \qquad (6)$$

After substituting the value of the *p* estimate, the measure is described by the following expression

$$\hat{\gamma}_{MS\_jt} = \frac{\left(\sum_i s_i^2 - \sum_i x_i^2\right) \Big/ \left(1 - \sum_i x_i^2\right) - H}{1 - H} \qquad (7)$$

The index ranges between -1 and 1, with 0 being a random localization of plants.
A negative value is detecting a higher spatial dispersion than expected, in this case plants try to be as scattered as possible. The index takes a positive value where agglomeration economies are present and it means that clustering forces dominate dispersing forces and, consequently, plants in the same *industry* tend to be as close as possible.
The M&S index is an unbiased value of γ parameter showing three advantages. First, it is derived from a simple probabilistic location model. Second, it controls for differences in the size distribution of plants and thus provides a measure of the localization beyond the only concentration of the employment (see properties in par.3), hence an industry will not be regarded as localized only because its employment is concentrated in a small number of plants. The last advantage is that the indicator allows for comparisons among industries.
Now, we regard the special version of M&S index arranged by Maré and Timmins (2006). They propose a measure for "local market area" and time, similar to previous one but the industry's role is replaced by the area's one. Specifically, the new formulation of M&S index is:

[4] Here, to asses the Herfindhal index we had recourse to the Hart approximation (1982), $H_{ijt} = \sum_{k=1}^{K} \left(\frac{E_{kit}}{E_{.it}} \right)^2 \Big/ P_{kit}$ determining concentration by means a database in which firms are divided in dimension classes depending on plant employment, in the hypothesis of equal average size of enterprises belonging to each dimensional class. H will tend to underestimate the actual concentration level, but the error is irrelevant if the number of classes is sufficiently high.

$$LLS\_MS_{it} = \left(\frac{\sum_j s_{jt}^2 - \sum_j x_j^2}{1-\sum_j x_j^2} - H_i \right) * \frac{1}{1-H_i} \qquad (8)$$

However, this index makes a point of the forces operating only inside the area (LLS in our case) like the majority of standard agglomeration measures, irrespective of contiguity effects, and this is a limit of agglomeration indicators. The contiguity effect is determined by the intensity of attractive forces in the neighbouring regions.

The aim of the present paper is to improve the above-mentioned indices controlling for attraction of neighbour LLS. In this way we can emphasize the spatial dependence on the agglomeration processes. For the sake of find this unexplained link we consider a spatial lag operator.

First of all we regard a binary spatial weight matrix with a row standardization.

$$w_{ij}^s = w_{ij} \Big/ \sum_j w_{ij} \qquad\qquad \sum_j w_{ij}^s = 1$$

Like this we include a spatial lag operator of sort $w_{ij}E_{neighbouring}$ working to produce a weighted average of the neighbouring observations. So it is possible to calculate the correlation between the employment in an area and the same variable in a contiguous area ρ= corr(E, w_{ij}E), in term of matrix we have

I+ρW*E=E*I+ρWE$_{\text{Neigh.}}$

Somehow we can reach a new formulation of index (9) considering spatial effects

$$\gamma^S{}_{it} = \left(\frac{\sum_j s_j^{spat^2} - \sum_j x_j^2}{1-\sum_j x_j^2} - H_i \right) * \frac{1}{1-H_i} \qquad (9)$$

We have introduced spatial lag operator in the term (s_j) of index that refers to every share of territory; it is clearly visible that index (10) is different from previous measure (9) for s^{spat} term

$$s_j^{spat} = \sum_i \frac{E_{ij} + \rho * E_{w_{neoghbouri\,ng}}}{E_{i.} + \rho E w_{neightbour\,ing}} \qquad (10)$$

Where ρ is a spatial autoregressive coefficient and W is a spatial contiguity weight matrix.

In this particular version $\gamma^S{}_{it}$ affords not only a geographic concentration measure for each area, rather than for every industry, but also consider both attractive forces within the area and between the areas, this characteristics representing the more innovative part of the measure. The new index is in continuity with the afore-mentioned measures but it overcomes their informative limits and we can have now a more complete and more exhaustive description of the localization forces. It provides as results what is observed at one point is determined, in part, by what happens elsewhere in the territorial system.

5)_ Empirical Result From Case Study

The empirical analysis will be carried out pointing to the dynamics of employment consequent to the effects of the agglomerative forces. Employment data are taken from the Manufacturing and Service Censuses of the years 1981, 1991 and 2001 and refer to the 77 Local Labour Systems (LLS) that represent the result of the spatial aggregation of neighbouring municipalities based on the daily commuting flows of local population owing to work reasons. LLS can be thus described as self-contained economic-territorial spaces which provide a basis to sub-provincial analysis, being a useful tool for the implementation of local development policies.

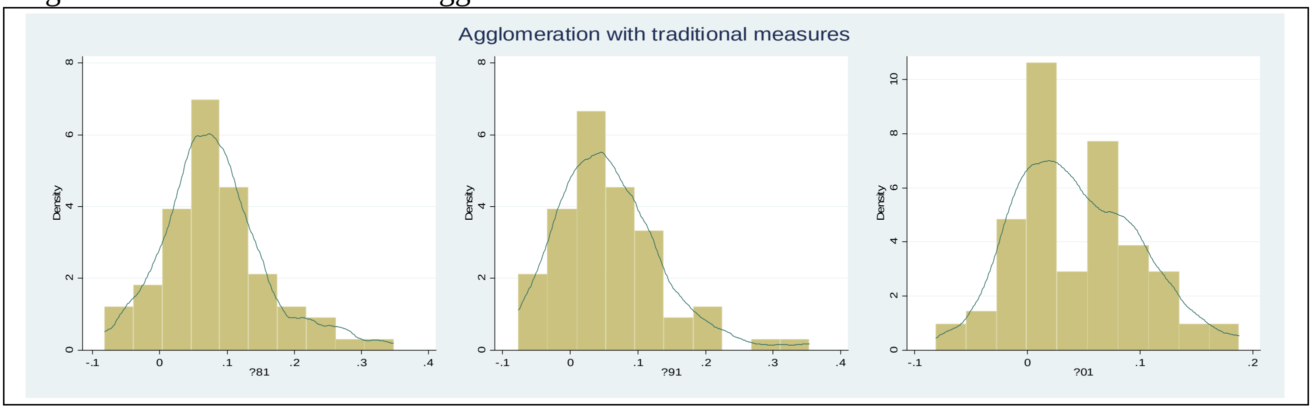
These particular geographical partitions are an appropriate response to the requirements of research work concerning the different modalities in which agglomeration phenomena occur and evolve in the economic activity, considering as well the strong influence of the territory in shaping the socio-economic features of a local community (Becattini, 2001).

Data pertain to the following sections of the classification NACE Rev.1.1: CA Mining and quarrying of energy producing materials; CB Mining and quarrying, except of energy producing materials; DA Manufacture of food products, beverages and tobacco; DB Manufacture of textiles and textile products DC Manufacture of leather and leather products; DD Manufacture of wood and wood products; DE Manufacture of pulp, paper and paper products; publishing and printing; DF Manufacture of coke, refined petroleum products and nuclear fuel DG Manufacture of chemicals, chemical products and man-made fibres; DH Manufacture of rubber and plastic products; DI Manufacture of other non-metallic mineral products; DJ Manufacture of basic metals and fabricated metal products; DK Manufacture of machinery and equipment n.e.c.; DL Manufacture of electrical and optical equipment; DM Manufacture of transport equipment; DN Manufacturing n.e.c.; G Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods; H Hotels and restaurants; I Transport, storage and communication; J Financial intermediation; K Real estate, renting and business activities.

In order to measure the spatial agglomeration for manufacturing and service industries in Sicily, we have used the index proposed by Maurel and Sédillot (1999); such index provides a measure that goes beyond the estimate of employment concentration. In fact, it assesses for the differences in the plants size and moreover it allows to compare among different sectors; particularly, we refer to the version of this index proposed by Maré and Timmins (2006).

The empirical results are showing that agglomeration processes have undergone rather evident temporal changes than spatial ones. Indeed, for each census year, the variability among the LLSs is very low even if some outliers stand out (See the maps in figure 1).

Fig.1 Results from Traditional Agglomeration indices



In 1981 the I_{MS} display a range from a minimum of -0.082 to a maximum 0.347. The 36% of LLSs shows values near 0, so we are induced to believe in the existence of a random territorial distribution of the enterprises while the 40% of the areas presents positive and substantial agglomeration forces. It should be noted that in the last set of areas it is also possible to identify some outliers, characterized by a high agglomeration density but they are too few to set up a proper cluster. In the following census year the index values range between -0.076 and 0.354, whereas in 2001 the range is between -0.081 e 0.188.

Fig.2 Maps of “Maurel and Sédillot Agglomeration Index”

Fig. 1: Agglomeration Index 1981

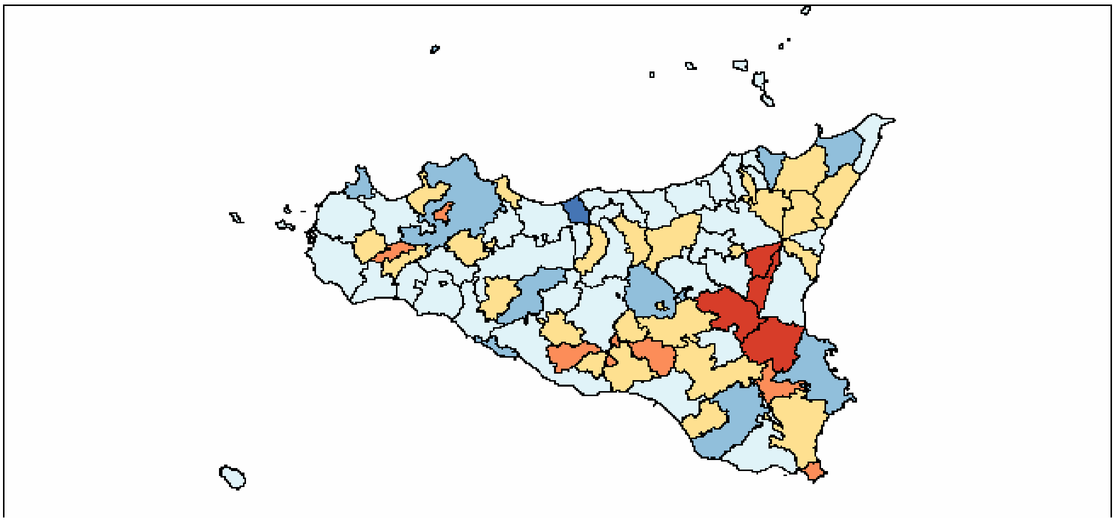


Figura 2: Agglomeration Index 1991

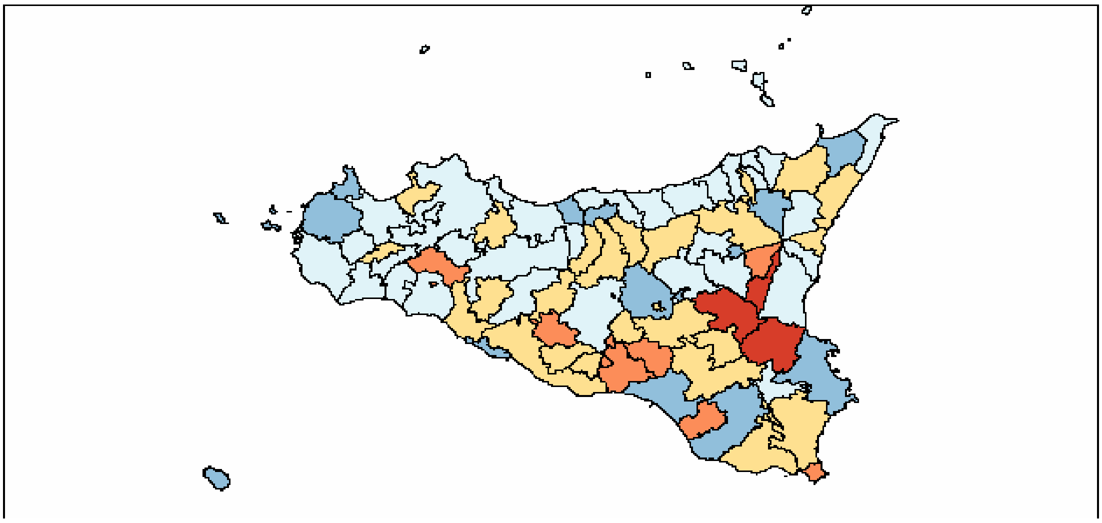
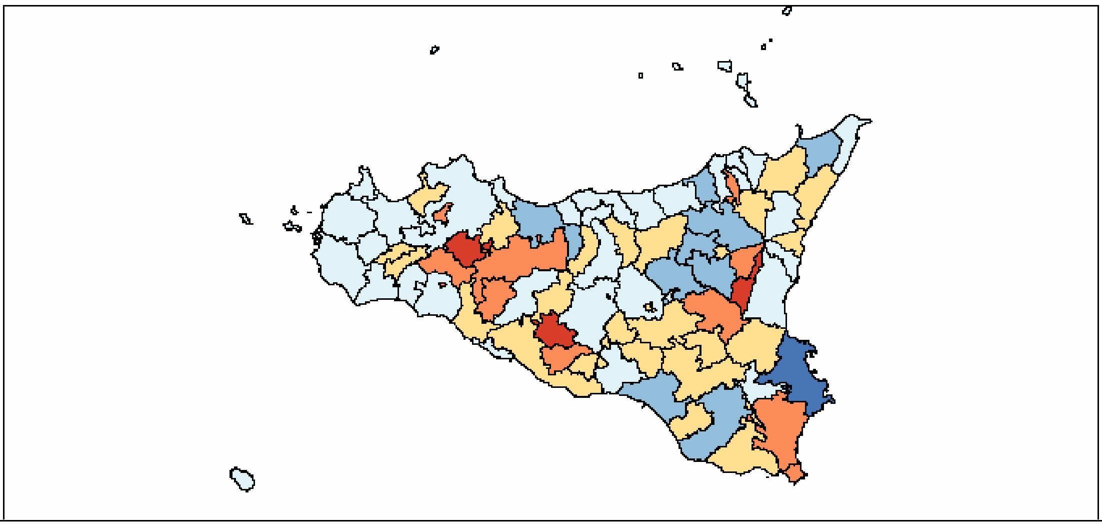


Figura 3 Agglomeration Index 2001



The hypothesis on the base of most traditional agglomeration indices maintains that the external economies breed and remain circumscribed to the single LLS, or area in general terms. So, these indices would have to be invariant regarding the selected territorial partition.
We believe that the effects of the externalities are not run out inside of the borders of the single LLS but they fall down on the adjacent units or whatever near. The value of the agglomeration indices should be increase when we widen the level of geographic aggregation. To pull of our idea we can see that the values of agglomeration indexes, built with reference to NUTS 3, are larger, in mean, than the corresponding values obtained at LLS level. We recall that this territorial partition is smaller than NUTS 3, being an aggregation of two or more municipalities;

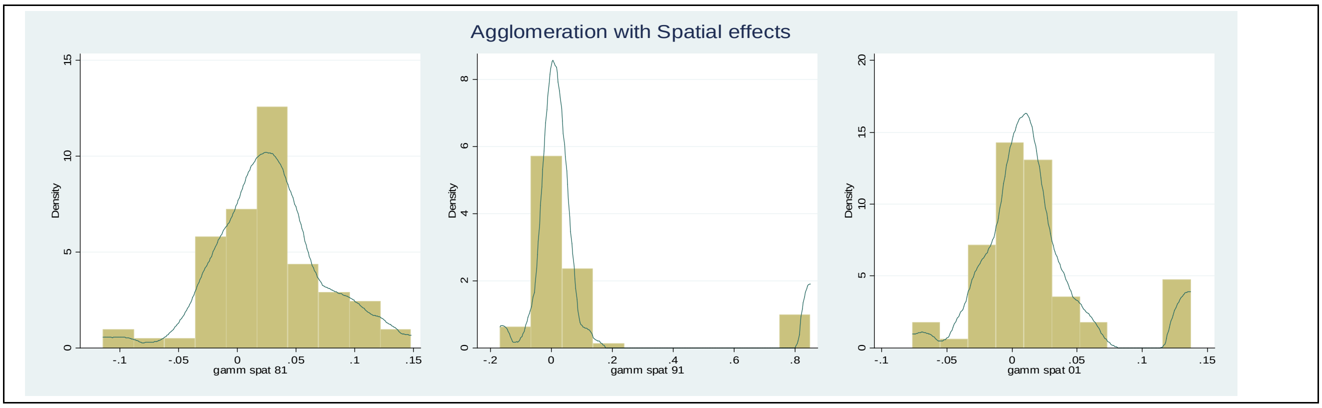
Tab.1_ Values of agglomeration indices for LLS and for provinces

	LLS	NUTS 3
	Mean*	
γ_{ms_81}	0.022	0.348
γ_{ms_91}	0.021	0.355
γ_{ms_01}	0.005	0.394

*Mean of indicators for 21 sectors 2digit

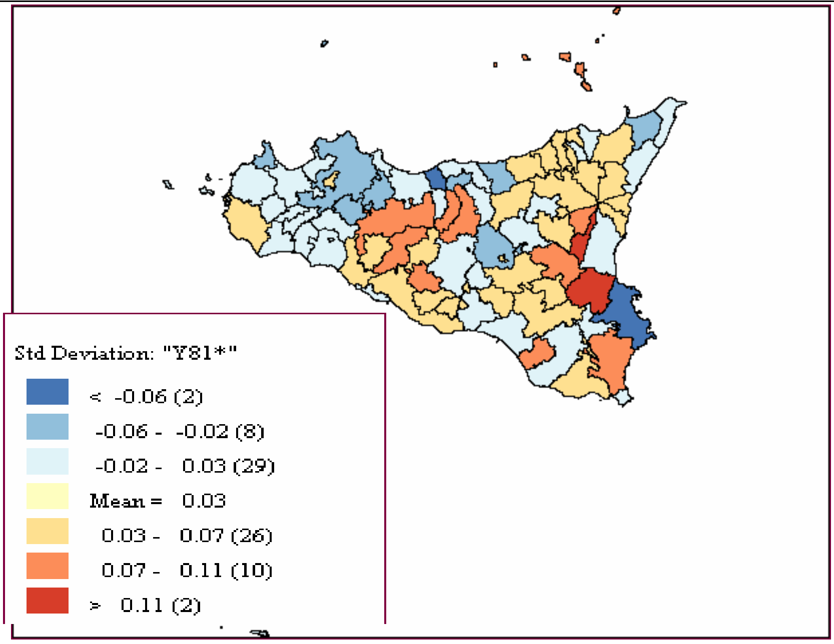
We can see that the γ_{MS} index values increase with the enlargement of geographical area, this would be the sign of external agglomeration economies not getting over their effects inside of a single LLS but extending to more wide geographic areas. The externalities stretch out to spread to the regions contiguous to that one of origin. On the basis of this hypothesis we decided modifying the γ_{MS} index including a spatial lag operator that takes the agglomeration effects of neighbouring LLS into.
Trough the application of the “modified” MS indices to the Sicilian LLSs, the clusters of agglomerated areas take shape, mainly in the two last census years (Fig. 2).
The agglomeration patterns show some differences as opposed with those ones verified by means the traditional agglomeration measures, indeed the variability is more marked in the space than in the time.
The indicator takes most frequently extreme values, nearly all the LLSs present negative values, sign of the existence of dispersion phenomena, maybe attributable to the backwardness of the local realities because of lack in the infrastructure and in a solid entrepreneurship.

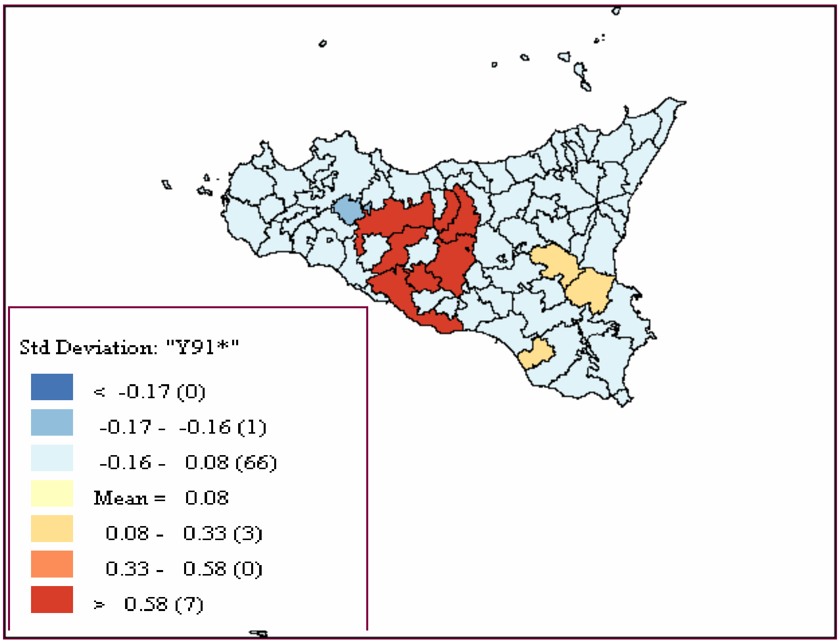
Fig.3_Results from Spatial MS Agglomeration index in Sicilian LLS

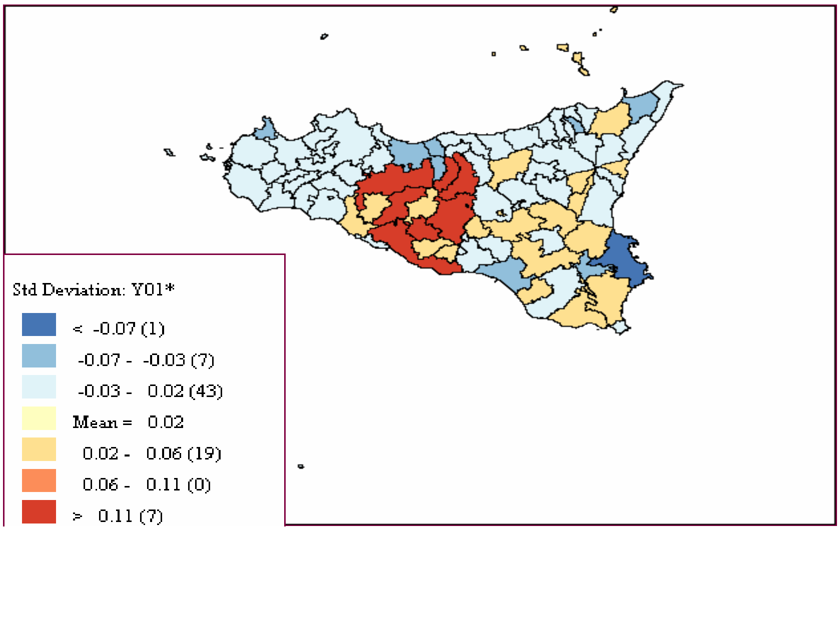


However, we want point out the noteworthy result of a cluster in 1991 formed by seven agglomerated areas, whose clear evidence is represented by the values greater than 0.58.
Moreover, the same cluster persists until 2001, showing an agglomeration value of 0.11.
From the indication obtained from the case-study, we can argue that the new agglomeration indices allow more information than the traditional ones because our measures consider the effects of the attraction forces also in the areas adjoining to that one examined.

Fig.4_ Maps of Spatial MS Agglomeration index in Sicilian LLS

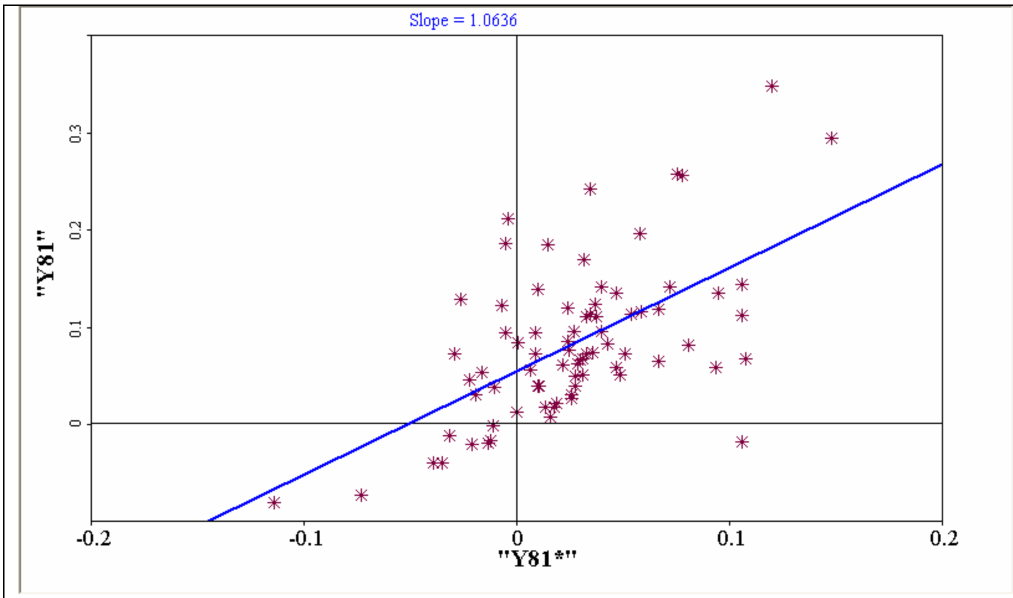

Std Deviation: "Y81*"
< -0.06 (2)
-0.06 - -0.02 (8)
-0.02 - 0.03 (29)
Mean = 0.03
0.03 - 0.07 (26)
0.07 - 0.11 (10)
> 0.11 (2)

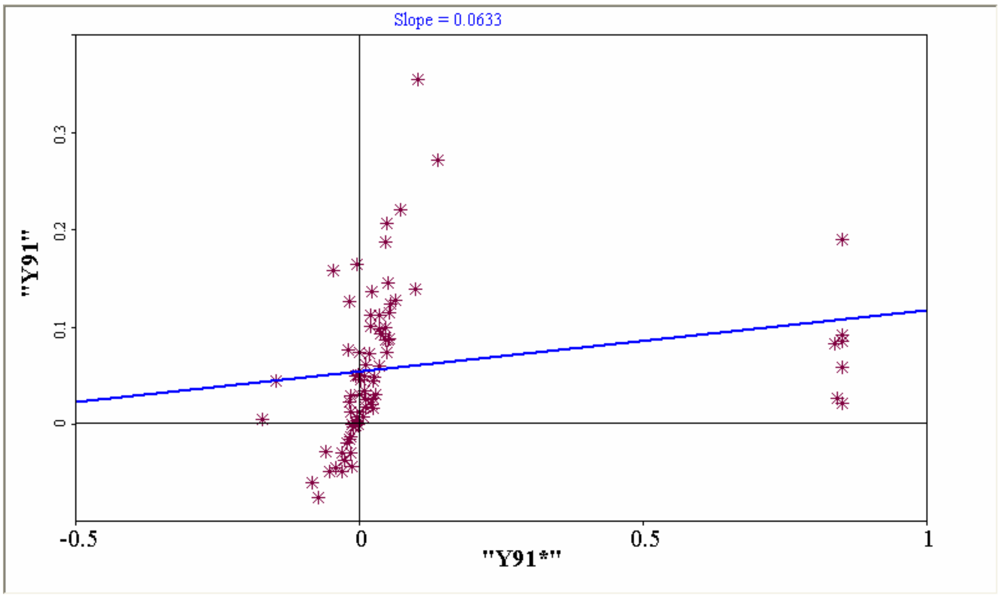

Std Deviation: "Y91*"
< -0.17 (0)
-0.17 - -0.16 (1)
-0.16 - 0.08 (66)
Mean = 0.08
0.08 - 0.33 (3)
0.33 - 0.58 (0)
> 0.58 (7)

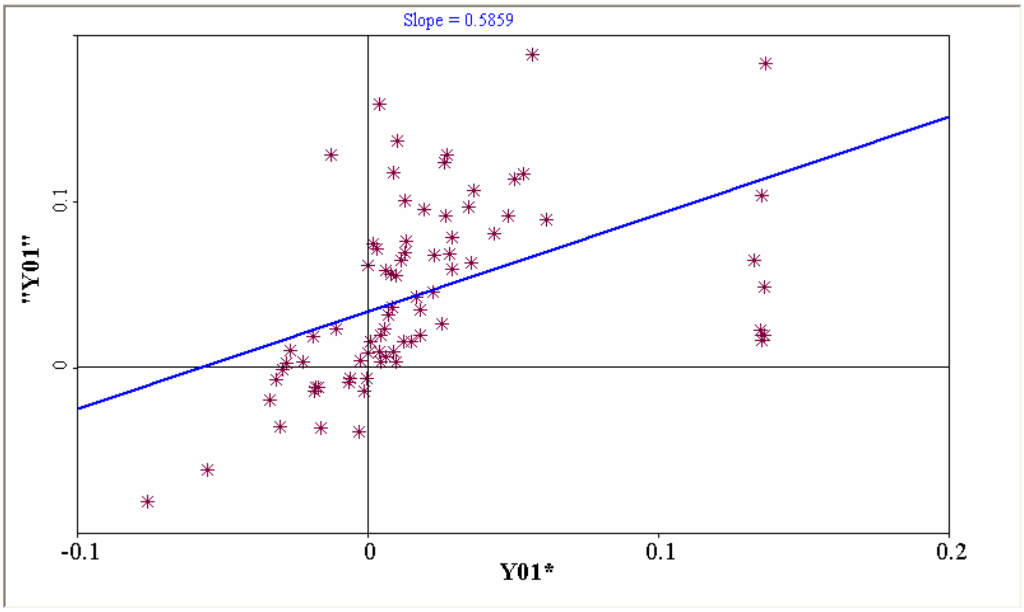

Std Deviation: Y01*
< -0.07 (1)
-0.07 - -0.03 (7)
-0.03 - 0.02 (43)
Mean = 0.02
0.02 - 0.06 (19)
0.06 - 0.11 (0)
> 0.11 (7)

In succession we report a comparison between the two measures we have adopted in this paper: $\boldsymbol{\gamma}_{\mathbf{MS}}$ and $\boldsymbol{\gamma}^{\mathbf{S}}_{\mathbf{MS}}$. From the figure 5, it is possible to evaluate the different performance of our index allowing, particularly on the occasion of the two latest censuses, the sharp distinction of groups of outliers.

Fig.5 Results from traditional Agglomeration index $\boldsymbol{\gamma}_{\mathbf{MS}}$ and Spatial MS Agglomeration index $\boldsymbol{\gamma}^{\mathbf{S}}_{\mathbf{MS}}$ in comparison


Slope = 1.0636
"Y81"
"Y81*"
-0.2
-0.1
0
0.1
0.2
0.3


Slope = 0.0633
"Y91"
"Y91*"
-0.5
0
0.5
1
0.1
0.2
0.3


Slope = 0.5859
"Y01"
Y01*
-0.1
0
0.1
0.2

6. ESDA Analysis

Exploratory spatial data analysis allows summarizing properties of data, detecting their spatial patterns and identifying cases or subsets of cases that are unusual given their location on the map (Haining 2003). Exploratory Spatial Data Analysis has some key characteristics:

- Methods are descriptive rather than confirmatory.
- Aims are to formulate hypotheses and to assess spatial models.
- Techniques are visual and resistant to unusual data values.
- Techniques employ few data transformations.

There are two classes of ESDA statistics: global statistics, which treat all the cases for one, or more, attributes and local statistics, which treat subsets of data one at time and may involve a sweep through the data looking for evidence of smooth and rough elements of the mapped data (Haining 2003).

ESDA techniques are only applicable to spatial data, although some are spatial equivalents of methods developed for non-spatial data, for example time series data.

With the aim to describing spatial properties of an attribute, they pertain the following techniques: smoothing, identifying trends and gradients on the map, spatial autocorrelation and detecting spatial outliers.

We employed spatial autocorrelation that is the propensity for attribute values in neighbouring areas to be similar. In these paper the tools of exploratory spatial data analysis are used to identify the location and the delimitation of agglomeration. Particularly we employed the Moran scatterplots and Lisa statistics. Such a methodology has been applied, among others, by Guillan and Le Gallo (2006) and by Lafourcade and Mion, (2007).

We use the Moran index to measure spatial autocorrelation; considering quantitative variables it compares the every area values with the corresponding data of other ones. The index is represented by the following expression

$$I_{(\gamma_{MS})} = \frac{(N/S_0)\sum_{ij=1}^{N} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{N}(x_i - \bar{x})^2} \qquad (11)$$

Let N = number of Sicilian LLSs as the sample dimension;

$x_i = \gamma_{MS}$ is the variable describing agglomeration phenomenon in the i-area,

$\bar{x}$ = sample mean,

w_{ij} = weight of W matrix;

$S_0 = \sum_{i=1}^{n} w_{ij}$ is the sum of all elements not zero of matrix.

As everybody knows, this indicator expresses the correlation between a variable with itself in the space, it ranges from -1 to 1 measuring the extent to which high values are generally located near to other high values and low values are generally located near to other low values. Where the data are distributed such that high and low values are generally located near each other, the data are said to exhibit negative spatial autocorrelation.

Referring to Moran index "I", it is possible put side by side the Moran scatterplot, it accounts in Cartesian coordinates a plot of normalized variable x in the x-axis against Wx, the normalized x spatial lag, in the y-axis. The Moran scatterplot can be used to depict spatial outliers, defined as zones having values of an attribute very different from their neighbours'ones. The Moran's I is the slope of scatterplot line.

Apart from global Moran we used the local form of Moran's index, obtained multiplying the zone value times the average in the surrounding zones.
Local Indicator of Spatial Association satisfies two criteria: first, the LISA for each observation gives an indication of significant spatial clustering of similar values around that observation; second, the sum of the LISA for all observations is proportional to a global indicator of spatial association (Guillain and Le Gallo, 2006).
The local version of Moran's *I* statistic for each observation *i* is written as:

$$I_i = \frac{z_i}{\sum_{i=1}^{N} \frac{z_j^2}{N}} \sum_{j \in J_i} w_{ij} z_j \qquad (12)$$

where z_i is the value of normalized variable in the i-area and J_i is the set of regions neighbour to i-area.
The null hypothesis is the absence of spatial autocorrelation, so a positive value for I_i indicates spatial clustering of similar values (high or low) whereas a negative value indicates spatial clustering of dissimilar values between an area and its neighbours.
We want connect agglomeration indices with these autocorrelation measures.
Like global Moran, a positive spatial autocorrelation will occur when neighbouring regions will exhibit similar values in their agglomeration. On the contrary, this index will take on negative values when neighbouring regions will be dissimilar: namely, highly agglomerated LLSs alternate with not agglomerated LLSs in space.
In summary, Moran index results with contiguity matrix, 1^{th} 2^{th} and 3^{th} order, applied on traditional and spatial agglomeration measures MS are displayed in the table 2

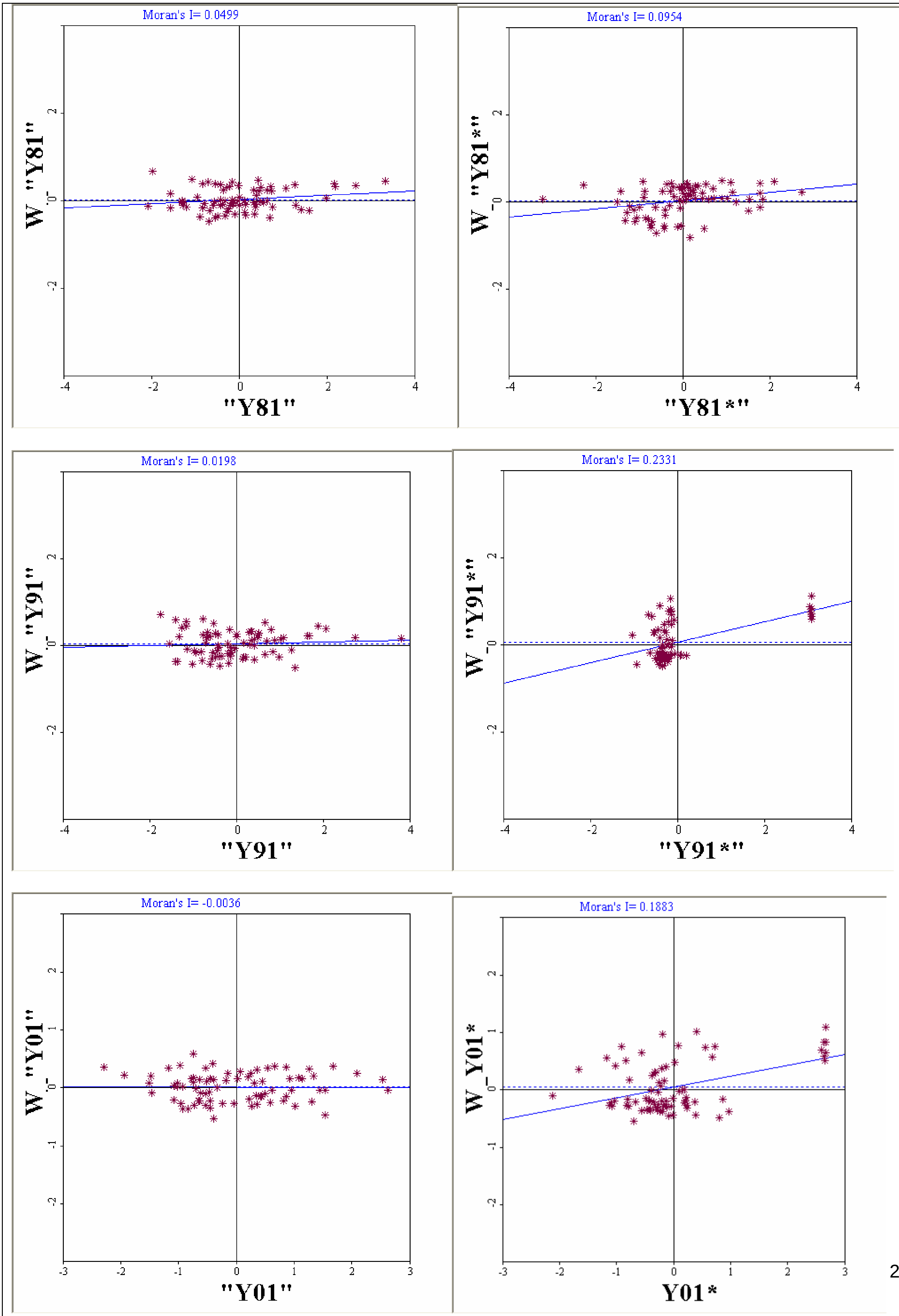
Tab.2. Moran index related to traditional and Spatial Agglomeration measures γ_{MS} and γ^S_{MS} (contiguity matrix)

		I_1981	*I_1991*	*I_2001*
γ_{MS}	**1° order Contiguity (Queen)**	0.0031	0.0548	0.0513
	2° order Contiguity (Queen)	0.0499	0.0198	-0.0036
	3° order Contiguity (Queen)	0.019	0.0312	-0.0171
γ^S_{MS}	**1° order Contiguity (Queen)**	0.0895	0.2559	0.2777
	2° order Contiguity (Queen)	0.0954	0.2331	0.1883
	3° order Contiguity (Queen)	0.0237	0.0823	0.0669

In both cases (Moran applied on γ_{MS} and γ^S_{MS}, respectively) we can see a very low autocorrelation. However, we want point out there is higher autocorrelation when the index is referred to the spatial lagged agglomeration measures.
On figure 6 we report the Moran scatterplots assessed on the 2^{th} order contiguity matrices.
A Moran scatterplot allows visualizing four types of local spatial association between an observation and its neighbours, each of them being localized in a quadrant of the scatterplot.
Graphs are sorted by column, in the first column the Moran scatterplots are related to the traditional indicator of agglomeration in the Sicilian LLSs for the latest three Censuses.

In particular, in the right column we can see the scatterplots related to agglomeration spatial indices always for the same areas.
Even if autocorrelation results are always near to 0, in this second group of measures ($I_{\gamma}{}^{S}{}_{MS}$) we obtain larger slopes. Most points are situated in I (HH) and III (LL) quadrants revealing a positive spatial autocorrelation, that is spatial clustering of similar values

Fig.6 Moran related to I_{MS} with contiguity matrix 2^{th} order


Moran's I= 0.0499
W_"Y81"
"Y81"
Moran's I= 0.0954
W_"Y81*"
"Y81*"
Moran's I= 0.0198
W_"Y91"
"Y91"
Moran's I= 0.2331
W_"Y91*"
"Y91*"
Moran's I= -0.0036
W_"Y01"
"Y01"
Moran's I= 0.1883
W_Y01*
Y01*

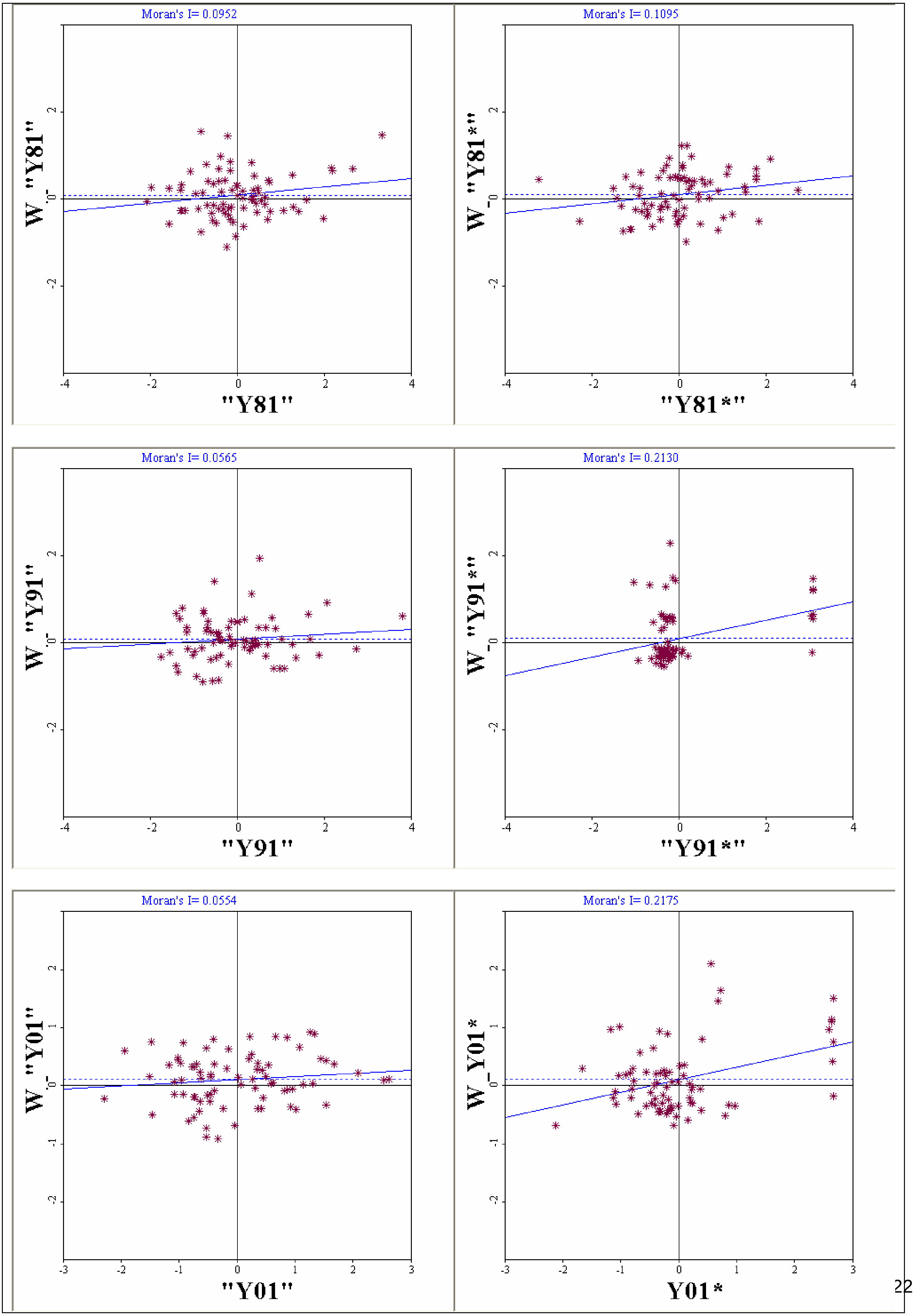
Then we recalculated the Moran index and the scatterplot considering a different concept of neighbourhood, based on the distance not on the contiguity.
Particularly, we considered the principle K-Nearest neighbours. Specifically two sites S_i and S_j are said to be neighbour if the distance between them is less than a threshold set in advance (whatever the threshold is selected): $d_{ij} \leq \min d_{ik} \ \forall k$.
This criterion ensures each observation have exactly the same number of neighbours.
Through Moran index calculated with reference to the two types of agglomeration measures, we obtained the values shown in table 3.

Tab.3_ Moran index related to traditional and Spatial Agglomeration measures γ_{MS} and γ^{S}_{MS} (distance matrix)

		I_1981	***I_1991***	***I_2001***
γ_{MS}	**Arch Distance K nearest K=4**	0.0952	0.0565	0.0554
	Arch Distance K nearest K=5	0.0968	0.0673	0.0094
	Arch Distance K nearest K=6	0.0352	0.0357	-0.0099
γ^{S}_{MS}	**Arch Distance K nearest K=4**	0.1095	0.213	0.2175
	Arch Distance K nearest K=5	0.1115	0.1514	0.1721
	K nearest K=6	0.0996	0.1918	0.1899

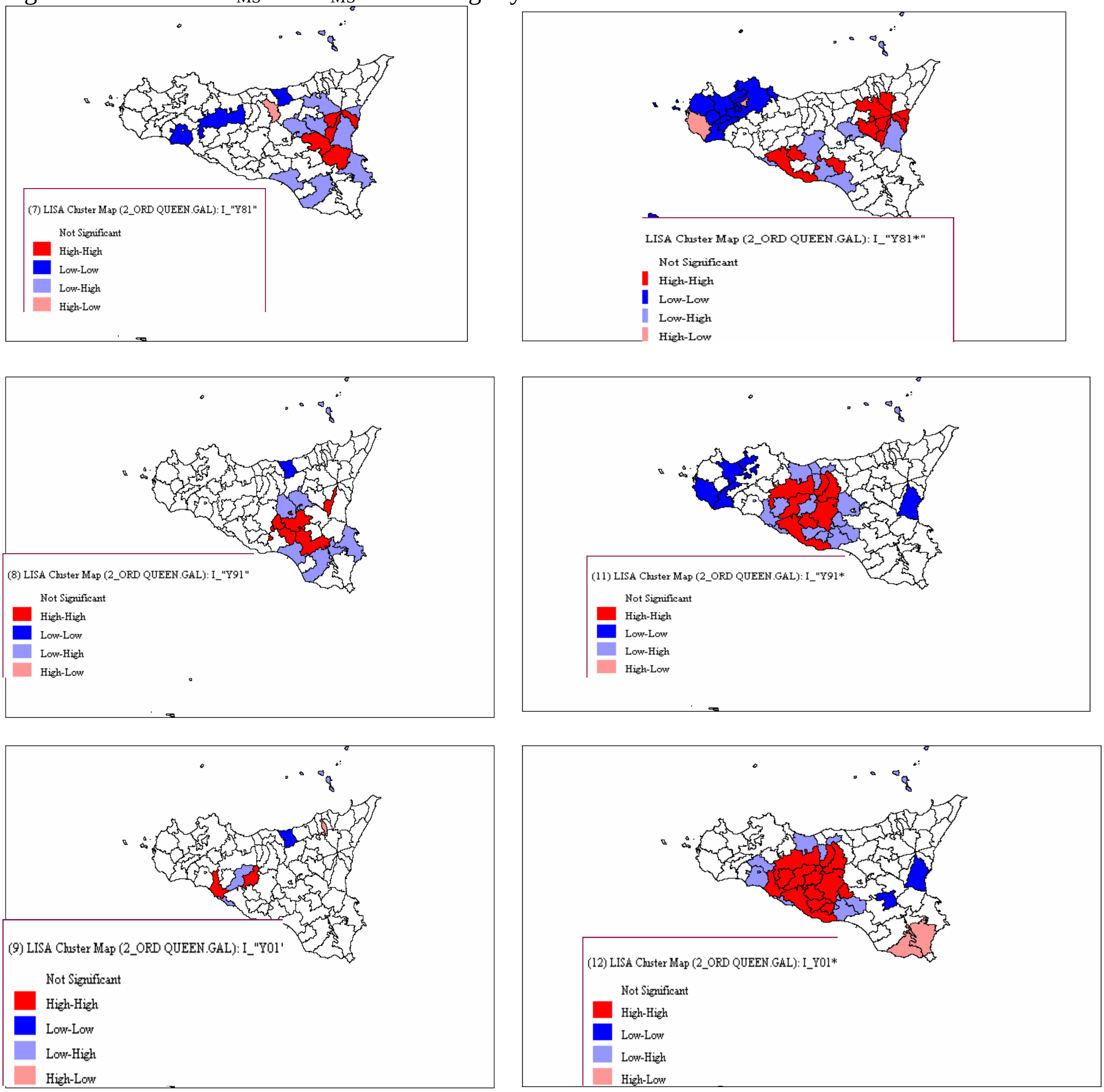
Moran index values are now higher than those ones obtained by means the contiguity matrix but the difference between the two typologies of index (γ_{MS} and γ^{S}_{MS}) holds over, supporting the better performance of spatial version of the indices.
In confirmation of these results, from Moran scatterplot (fig. 7) the presence of positive autocorrelation is evident only for the modified indices.

Fig.7. Moran related to I_{MS} and I^{S}_{MS} with distance matrix k nearest 4


Moran's I= 0.0952
W_"Y81"
"Y81"
Moran's I= 0.1095
W_"Y81*"
"Y81*"
Moran's I= 0.0565
W_"Y91"
"Y91"
Moran's I= 0.2130
W_"Y91*"
"Y91*"
Moran's I= 0.0554
W_"Y01"
"Y01"
Moran's I= 0.2175
W_Y01*
Y01*

Since Moran scatterplots don't allow assessing the statistical significance of spatial associations, Local Indicators of Spatial Associations (LISA) statistics will also be computed, considering both contiguity matrices and distance-based matrices.
In the LISA graphs, fig 8, (we report only LISA calculated on the second order matrix for sake of brevity) we have strong proofs of positive autocorrelation.
Particularly, from the local Moran index applied to the new measure is easy to single out the agglomeration cluster, in which LLSs with a high agglomeration value are surrounded by LLSs with high values. In the same way it happens for the LLSs with low values. Also the results from the application of LISA on new measures sustain our hypothesis of agglomeration forces "between" areas, not observable by the standard agglomerations measures.

Fig 8. Lisa related to I_{MS} and I^{S}_{MS} with contiguity matrix 2^{th} order order



7)_Concluding Remarks

The spatial discontinuities, as outcome of the uneven growth path - notably in the less developed regions - have constituted the object of many analyses based on statistical units at a disaggregate territorial level by means of suitable socio-economic indicators.
Many elements affecting the ways of manifestation of the regional development can be found in the complex interaction processes within (and between) the geographical partitions, enhanced by the proximity of the operators involved.
In this paper we have presented an overview of the literature in the scope of the agglomeration. Specifically, we took account of the desirable characteristics for the class of indicators used to evaluate the amount and the effects of the spatial dependence among agglomerative factors.
Subsequently, we have singled out the Maurel and Sédillot index (1999), the classical agglomeration measure meeting nearly all the expected requirements, highlighting its key qualities. In fact, it controls for differences in the size distribution of plants and thus provides a measure of the localization beyond the only concentration of the employment; besides, it allows for comparisons between industries. We have also considered the limits of this measure, the main of which is making a point only of the forces operating inside each area irrespective of contiguity effects.
After changing the scope of the index, that is referring the measure to the area instead of the sector of activity, we have tried to estimate the agglomeration phenomenon in neighbouring regions.
To this aim we inserted a spatial lag operator into the measure obtaining a weighted average of the neighbouring agglomeration values the way of a raw standardized contiguity matrix.
To test the performance of our index we wanted to look into some aspects of the local realities of a region (Sicily) showing evident characters of backwardness in comparison with other regions of Italy.
The empirical analysis was carried out having recourse to the data of latest three Censuses. We focused on the evolution of employment depending on two causes: the action of the agglomerative forces inside each territorial unit and the effects of the interdependence phenomena among adjacent areas.
Consequently, we chose referring to the Sicilian Local Labour Systems as they represent a highly disaggregated grid useful to verify the existence of spatial autocorrelation processes somehow typifying the regional development path.
LLSs are locations in which places of work and residence come together, made up of two or more municipalities and have no relations with administrative zones.
Once the necessary comparisons were made, also through graphical tools, we can maintain that our index performs better than the original formulation of the Maurel and Sédillot index. Actually, we can see on the maps that agglomeration is not clearly visible through standard indicators whereas, from the most informative measures delayed spatially, an agglomeration cluster emerges with ease.
We also investigated the presence of spatial dependence by both types of indicators, obtaining a positive result through the new measures of spatial agglomeration. This can be caused by spatial externalities, or spill-over effects: particularly, what is observed at one point is determined in part by what happens elsewhere in the system.
Indeed, the analysis conducted by means of the new indexes allows to assess the presence of a substantive spatial dependence, namely the agglomeration of a single area is affected by the characteristics of the neighbourhood and by the agglomeration processes in the neighbouring areas.

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