

Spatial Autocorrelation of Alternative Infrastructural Indicators

L'autocorrelazione Spaziale di Indicatori Infrastrutturali Alternativi

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Riassunto: Obiettivo del lavoro qui presentato è di verificare l'intensità dell'autocorrelazione spaziale – ossia dell'influenza della contiguità territoriale – sul livello di infrastrutturazione delle diverse aree del paese. Tale verifica viene svolta con riferimento: i) a due diversi approcci di stima della dotazione infrastrutturale: l'approccio della dotazione fisica e quello dell'inventario permanente (Mazziotta, 2005); ii) a due misure di autocorrelazione spaziale: l'indice di Moran (Moran, 1950, Cliff e Ord, 1973) per la misura dell'autocorrelazione spaziale complessiva e l'indice messo a punto da Anselin (1995) per misurare il contributo all'autocorrelazione di ciascuna area considerata. I risultati confermano anche da questo punto di vista il miglior adattamento dell'approccio basato sulla dotazione fisica.

Keywords: spatial autocorrelation, infrastructure endowment indexes.

1. Introduction

Regional growth analysis often uses infrastructure endowment to explain regional development. In the literature, there are different methods to quantify public capital based on past investment or on data about infrastructure endowment. The aim of the paper is to use spatial autocorrelation across infrastructure indexes to assess the performance and quality of each infrastructure index. We expect that a good infrastructure index captures the spatial network characterizing infrastructure endowment. In this case the level of spatial autocorrelation across infrastructure endowments in Italian territorial areas should be significant and remarkable. The paper evaluates spatial autocorrelation for four different indexes. We estimate the global autocorrelation index (I), defined by Moran (1950), to investigate the presence of spatial patterns for the whole area. We also evaluate local spatial statistics to quantify the extent of local dependency and homogeneity. The local Moran Index (Anselin, 1995) quantifies how close is infrastructure endowments in a given area with respect to the infrastructure endowments in the neighbouring areas. The results of the spatial autocorrelation analysis show significant spatial patterns in the distribution of infrastructure endowment only for indicators expressed in physical terms. The unbiasedness of physical indicators with respect to the different efficiency of the public capital expenditure on the national territory can explain the results.

2. Spatial autocorrelation estimates of infrastructural index

Spatial autocorrelation is a property of spatial data that exists whenever there is a systematic pattern in the values recorded at different locations in an area. In particular, where high values of a variable at one location are associated with high values at neighbouring localities, the spatial autocorrelation is positive; where high values correspond to low values in the adjacent localities, the spatial autocorrelation is negative. One of the most important spatial autocorrelation indexes was introduced by Moran (1950); this index is analogous to the usual correlation coefficient. Its values approximately range from 1 (strong positive spatial autocorrelation) to -1 (strong negative spatial autocorrelation). The choice of weights w_{ij} between neighbours is a crucial step in the analysis; there are many ways to assign neighbour weight, and the choice depends on the type of spatial application and on the research question. In this work we use two methods: 1) w_{ij} is the spatial weight measure of contiguity and is defined as 1 if the location i is contiguous to the location j and 0 otherwise; 2) we calculate the distances between each location with its contiguous locations; we take, for each locations, the maximum distance so we have, in the case of provinces, 95 distances and we calculate the average of these 95 (m) w_{ij} is defined as 1 if the distance of location i is shorter than m from location j and 0 otherwise. While Moran global test permits us to test for spatial patterns over the whole study area, a significant spatial correlation related to smaller sub-area could be hidden in the total area. This is the case of large territorial grid and the analysis is carried out over areas where the assumption of spatial homogeneity is not realistic. In literature several local indicator of spatial association are proposed. Both distance statistics (Cliff and Ord, 1973) and the local indicator of spatial association derived by Anselin (1995) resemble passing a moving window across the data, and examining dependence within the chosen region for the site on which the window is centred. This approach allows to identify non-homogeneities in relationships between location across the study area, to select local outliers and to improve the definition of spatial development processes, giving information on the best territorial level in order to analyse spatial change. A very popular indicator is the Local Moran's Index, that is a local spatial autocorrelation statistics based on the Moran's I statistics. It was developed by Anselin (1995) as a Local Indicator of Spatial Association, or LISA statistics. Anselin defines LISA statistics as having the following two properties: (i) the LISA for each observation expresses the extent of significant spatial clustering of similar values around that observation, and (ii) the sum of LISAs for all observations is proportional to a global indicator of spatial association, like Moran's (global) I. The analytical expression of local Moran's I, as proposed by Anselin (1995), is the following:

$$I_i = \frac{(x_i - \bar{x})}{S^2} \sum_{j=1}^N w_{ij}(d)(x_j - \bar{x}), \quad j \neq i \quad (1)$$

Where x_i is the value of variable X in the area i , $\bar{x}$ is the arithmetic mean of X, n is the number of observation and N is the number of observations included in the contiguity area of i ; w_{ij} is the element of the symmetric contiguity matrix $[w_{ij}]$, equal to 1 if the

area j is distant less than the value d from the area i , and equal to 0 in all other cases. S , introduced as standardization factor, is equal to:

$$S^2 = \frac{\sum_{j \neq i=1}^N x_j^2}{N-1} - \bar{x}^2 \quad (2)$$

Analysis of Local Moran's I is very similar to that of global Moran's I . Values of I_i that exceed $E(I_i)$ indicate positive local spatial autocorrelation across areas, considered contiguous by a distance criteria (in our analysis by a given distance between the centroids of the considered areas), in which similar values, either high values or low values are spatially clustered around point i . High positive values of Local Moran's I can be also due to the strong impact of some specific point on the global Moran's I . Values of I_i below $E(I_i)$ indicate negative spatial autocorrelation where neighbouring values are dissimilar to the value at point i . A normally distributed Z statistics (two-tailed) can be calculated to determine significance. The analysis of local spatial autocorrelation in public infrastructure across Italian provinces has been carried out by the use of local Moran's I . Provinces are considered contiguous when the distance between the two centroids is lower or equal than the maximum distance across all centroids, equal to 94,2 kilometers.

3. Results and conclusions

The paper shows two results (Table 1): 1) the existence of spatial autocorrelation and its variability between territorial areas; 2) the variability of Moran's I in the four different indexes used to estimate the stock of public capital.

Table 1: Global Moran's I for different public capital indicators, by areas and methodological approaches

Regions	Indicators of public capital*			
	A	B	C	D
Large areas (4)	0,11	-0,07	-0,54	-0,30
Regions (20)	0,64	0,12	-0,20	-0,26
Provinces (<i>adjacence</i>)	0,66	0,25	0,03	-
Provinces (<i>distance</i>)	0,64	0,22	0,07	-

* A and B: indicators based on the physical approach; C and D: indicators based on the monetary approach. For more details, see Mazziotta (2005).

The results confirm that the level of spatial autocorrelation increases when the territorial scale is more detailed. This is true for all indexes. Moreover, there are important differences between the physical approach and the monetary approach to the public capital evaluation. The regional and provincial results show that Moran's I has a positive values in the physical approach (A and B), suggesting the presence of spatial homogeneity in the endowment of physical public capital, and it has a negative values

in the monetary approach, confirming the territorial dispersion of public capital expenditure. The Moran's I, estimated using the distances matrix, confirms substantially the results estimated with the traditional contiguity matrix. It is well known that the level of spatial autocorrelation is strictly linked to the choice of the territorial grid (Arbia, 1986). On the other side, the coherence of the results obtained using different spatial grid suggest the robustness of our analysis. The results of local spatial autocorrelation of infrastructure indexes show that there is an high heterogeneity in spatial autocorrelation across Italian provinces. Considering the index A, it is possible to identify 3 large areas including clusters of provinces with a high endowments of infrastructure, localized in the Centre-north (Alessandria, Milano, Pavia, Cremona, Verona, Gorizia, Trieste, Piacenza, Parma, Reggio Emilia, Modena, Bologna, Ferrara, Ravenna, Forlì), and, on the other side, 3 areas including cluster with a low endowments of infrastructure, in the Southern Italy (Campobasso, Isernia, Caserta, Benevento, Napoli, Avellino, Salerno, Foggia, Taranto, Potenza, Cosenza, Catanzaro, Agrigento, Caltanissetta, Enna, Ragusa). The index B identifies a lower number of provinces with significant local spatial autocorrelation, mainly located in the centre-north (Novara, Varese, Milano, Rovigo, La Spezia, Piacenza, Livorno) with the exception of four provinces (Potenza, Agrigento, Caltanissetta, Enna). The index C has a value of Moran global test near zero and so the decomposition in local value identifies only 3 provinces (Gorizia, Trieste, Pordenone). A possible interpretation of the results is that the presence of physical infrastructure is more even on the territory, whereas the expenditure presents a more concentrated pattern. This is the case if some non territorial disaggregated expenditures are imputed to the main province in a region, or to the main city in a province. A different case is represented by the infrastructure presented in few provinces (like airports or harbours), that have, on the other side, a limited weight on the global infrastructure index. Actually, other kinds of infrastructure are naturally spread out on different provinces and therefore they generate spatial autocorrelation. For instance, several network infrastructure, as high speed road, electricity, energy, railways, even if they are more concentrated in some areas, tends to expand by contiguity. These considerations and our result therefore suggest that the expenditure approach presents a higher approximation in the estimation of the stock of public capital with respect to the method based on the physical identification. Similar conclusions are obtained in some specific analyses on the infrastructure indicators where indicators based on physical endowment approach show better performance and higher quality than indicators based on public expenditure.

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