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Analyzing migration phenomena with spatial autocorrelation techniques

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Abstract In less than one century, Italy has tested a strong intensification of immigration changing from a country originating great migration flows to a country which is the destination of migration flows. The aim of this paper is to examine foreign immigration in Italy distinguishing according to nationality of foreigners. The spatial dimension of migration flows has been analyzed in this paper using Spatial Autocorrelation techniques and more particularly Local Indicators of Spatial Association in order to analyze the highest values of a foreigner group considering the relationship with the surrounding municipalities.

INTRODUCTION

During each political pre-electoral debate in Europe and in USA, one of the most discussed topics is migration phenomena and related policies. Foreigners' presence coupled with a careful integration of people with different demographic and social characteristics, cultural backgrounds, experiences and expectations may represent a great opportunity for destination areas of migration.

In order to avoid that such opportunities become threats, a continuous observation of the phenomenon is fundamental for programming measures and interventions suitable for an effective integration of immigrants and their families. Migration has always been a natural process which produces other significant transformations in the environment as well as in everyday life, in economic systems, cultures, religions etc. Presence of foreigners is not easily detectable, because it is a particularly complex and rapidly evolving phenomenon. Modern migrations are mainly characterized by two components, comparable in terms of absolute value: internal migration where part of the population moves within the country; external migration where part of the population reaches the country coming from another state.

This work is completely concentrated on external component of migration towards Italy, distinguishing according nationalities of foreigners. An analysis of migration phenomenon in Italy which considers both the internal and the external components, without distinguishing between them, has been developed by Scardaccione *et al.* (2010). Spatial autocorrelation techniques have been used in this paper to analyze migration flows. These methods consider the intensity of a phenomenon inside a municipality, measuring at the same time the degree of influence over its surrounding municipalities. More particularly, for each foreigner nationality, Local Indicator of Spatial Association has been adopted in order to discover the highest values of the phenomenon coupled with the highest level of similarity with its neighbouring municipalities.

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SPATIAL AUTOCORRELATION TECHNIQUES

Geographical objects are generally described by means of two different information categories: spatial location and related properties. In data analysis there is a huge literature concerning methods which separately compute attributes from spatial components.

The most interesting property of spatial autocorrelation is the capability to analyze at the same time locational and attribute information (Goodchild, 1986). Consequently, spatial autocorrelation can be considered as a very effective technique in analyzing spatial distribution of objects assessing at the same time the degree of influence of neighbour objects. This concept is well synthesized in the first law of geography defined by Waldo Tobler (1970) "All things are related, but nearby things are more related than distant things". Adopting Goodchild (1986) approach, Lee and Wong (2001) defined spatial autocorrelation as follows:

$$SAC = \frac{\sum_{i=1}^N \sum_{j=1}^N c_{ij} w_{ij}}{\sum_{i=1}^N \sum_{j=1}^N w_{ij}} \quad (1)$$

Where:

N is the number of objects;

i and j are two different objects;

c_{ij} is a degree of similarity of attributes i and j;

w_{ij} is a degree of similarity of location i and j;

defining x_i as the value of object i attribute; if $c_{ij} = (x_i - x_j)^2$, Geary C Ratio (1954) can be defined as follows:

$$C = \frac{(N-1)(\sum_i \sum_j w_{ij} (x_i - x_j)^2)}{2(\sum_i \sum_j w_{ij}) \sum_i (x_i - \bar{x})^2} \quad (2)$$

If $c_{ij} = (x_i - \bar{x})(x_j - \bar{x})$, Moran Index I (1948) can be defined as follows:

$$I = \frac{N \sum_i \sum_j w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\sum_i \sum_j w_{ij} \sum_i (x_i - \bar{x})^2} \quad (3)$$

These two indices are very similar, mainly differing in the cross-product term in the numerator, which in Moran is calculated using deviations from the mean, while in Geary is directly computed.

These two indices are global indicators of spatial autocorrelation. They provide an indication about the presence of autocorrelation. The precise location of elevated values of autocorrelation is provided by

Local Indicators of Spatial Association. One of the most adopted indices of local autocorrelation is LISA-Local Indicator of Spatial Association developed by Anselin (1988, 1995), considered as a local Moran index. The sum of all local indices is proportional to the value of Moran one:

$$\sum_i I_i = \gamma * I.$$

The index is calculated as follows:

$$I_i = \frac{(x_i - \bar{x})}{S_x^2} \sum_{j=1}^N (w_{ij}(x_j - \bar{x})) \tag{4}$$

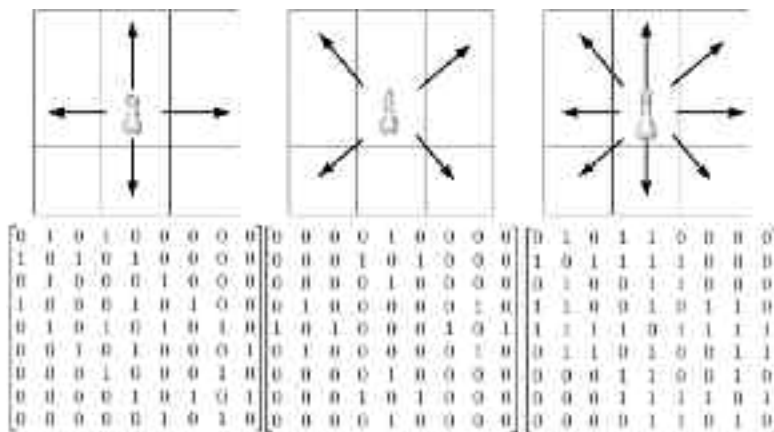
It allows, for each location, to assess the similarity of each observation with its surrounding elements. Five scenarios emerge:

- locations with high values of the phenomenon and high level of similarity with its surroundings (high-high H-H), defined as **hot spots**;
- locations with low values of the phenomenon and low level of similarity with its surroundings (low-low L-L), defined as **cold spots**;
- locations with high values of the phenomenon and low level of similarity with its surroundings (high-low H-L), defined as potentially **spatial outliers**;
- locations with low values of the phenomenon and high level of similarity with its surroundings (low-high L-H), defined as potentially **spatial outliers**;
- locations completely lacking of significant autocorrelations.

LISA (Local Indicator of Spatial Association) provides an effective measure of the degree of relative spatial association between each territorial unit and its surrounding elements, allowing highlighting type of spatial concentration for the detection of spatial clusters.

In equations 1, 2, 3, 4 the only term not well formalized is w_{ij} related to neighbourhood property. The most adopted approach in formalizing this property is spatial weights matrix, w_{ij} are elements of a matrix considered as spatial weights, equal to 1 if i and j are neighbours, equal to 0 in the case of self-neighbour or if i and j are not neighbours. This approach is based on the concept of contiguity, where elements share a common border of non-zero length. It is important to give a more detailed definition of contiguity and more particularly what does a border of non-zero length exactly mean. Adopting chess game metaphor (O’ Sullivan and Unwin, 2002), contiguity can be considered as allowed by paths of rook, bishop and queen (Figure1).

Figure 1 Spatial weights matrix and the metaphor chess game



ITALIAN SPATIAL DISTRIBUTION OF FOREIGN IMMIGRATION

In recent years Italy has tested a strong intensification of immigration. The biggest cities and metropolitan areas are major attraction centres for immigrants and even if less than in the past this phenomenon is mainly concentrated in Northern part of Italy.

Despite today immigration phenomenon is seen as a crucial problem for the large number of immigrants who daily arrive on the Southern coast of the country, the dimension of the phenomenon is rather concerning movements from Italian regions where the economic crisis is more evident to those where there is more job offer.

In the past, migratory phenomenon in Italy was mainly characterized by abandonment of the nation to reach North and South America. Subsequently, migration originated in southern Italy and it was mainly directed to Switzerland and Germany.

Considering internal migration, an exodus directed to big industrial centres of northern Italy occurred after the Second World War, when a lot of people left Southern Italy countryside to reach the big industrial cities of the North in search of a job.

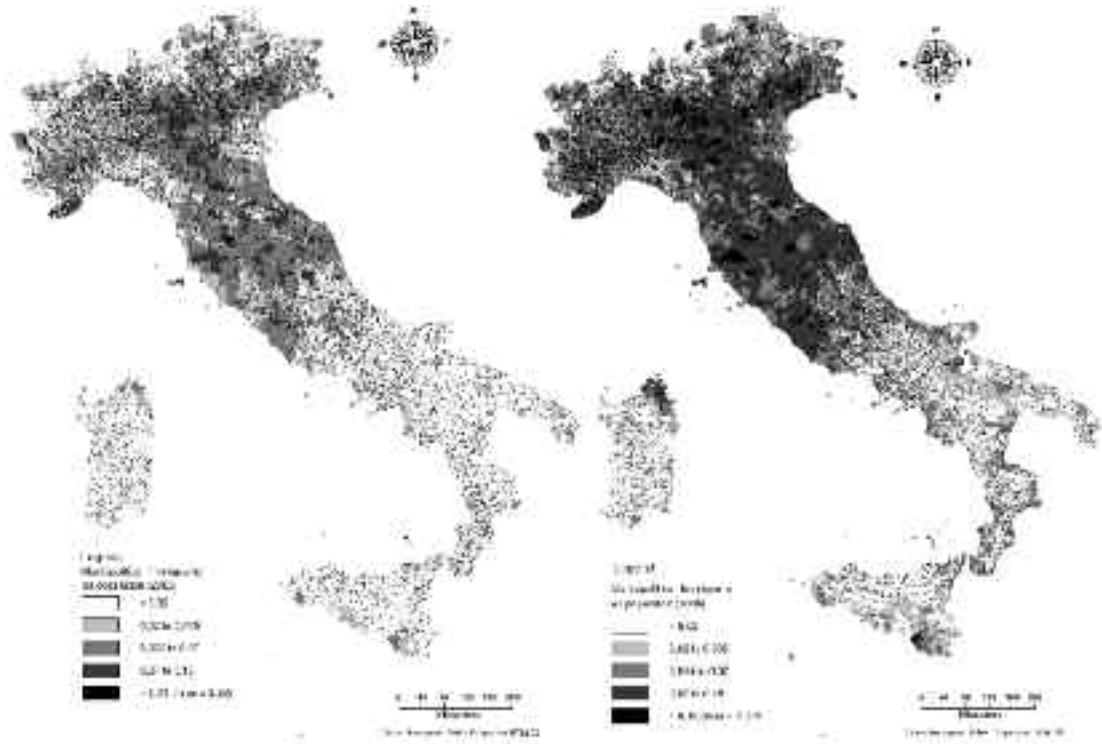
Population growth observed recently in Italy is strongly determined by the foreign component. For this reason this paper is completely concentrated on this aspect. Data concerning foreign residents at municipality scale have been analyzed for years 2003 and 2009 using official data of Italian Institute of Statistics (ISTAT).

We considered 2003 because on 30 July 2002 Italian parliament approved a new law concerning immigration discipline and rules on conditions of foreigners. Consequently, a strong increase of residence permits has been registered in 2002, due to the regularization of foreign people having working permits.

In fact, in 2003, working permits increased of about 355 thousand units for men and approximately 295 thousand units for women. While in subsequent years, the increase of residence permits was almost exclusively due to family reunification. We considered 2009 because it is the last year of available data on foreign origin at municipality scale.

The analysis over data concerning foreign migration in Italy provided interesting results in terms of the pattern drawn by their spatial distribution in Italian municipalities. As a general note, we can recall that Italy has experienced a dramatic increase in percentage of foreign population living in its territory, since the value more than doubled in less than a decade, from 3.5% at the beginning of the century to the current 7% of foreign population over the total. This value of course represents the average and local variations can be noticed in all administrative unit levels, these being regions, provinces and municipalities, as those analyzed here.

Figure 2 Foreign residents in Italy. Percentage of foreign residents over population in Italy in 2003 and 2009
(Source: our elaboration from Italian Institute of Statistics - Istat)



If we observe general data and compare the two years considered - 2003 and 2009 - we can notice that foreign residents more than doubled, from fairly 2 million people in 2003 to 4.2 million people in 2009. Such an increase of more than 2.2 million people was led by few national groups, since ten nationalities count for 73% of total immigrants in Italy in 2009 and a total of 20 nationalities explain the most of immigration process covering 88% of foreign residents.

In the top ten positions, in terms of absolute numbers – as well as absolute increase – we can find countries like Romania, Albania, Morocco, People’s Republic of China, Ukraine, Philippine Islands, India, Poland, Moldova and Tunisia. In particular Romania, Albania, Morocco and China lead the way.

Especially Romanians represent the first most numerous group which has experienced the most dramatic increase. A partial reason of such an increase can be possibly found in Romania accessing EU in 2004, which allowed an easier movement of people between the two States and therefore people to relocate to Italy.

Table 1 Foreign residents in Italy, 2003 - 2009 comparison and absolute increases of single groups (absolute and percentage values). (Source: our elaboration from Italian Institute of Statistics – Istat)

Countries	Population 2003	Population 2009	Percentage increase	Percentage increase
Romania	177812	887763	399,27%	709951
Albania	270383	466684	72,60%	196301
Morocco	253362	431529	70,32%	178167
China	86738	188352	117,15%	101614
Ukraine	57971	174129	200,37%	116158
Philippine	72372	123584	70,76%	51212
India	0	105863		105863
Poland	40314	105608	161,96%	65294
Moldova	24645	105600	328,48%	80955
Tunisia	68630	103678	51,07%	35048
Macedonia	51208	92847	81,31%	41639
Peru	43009	87747	104,02%	44738
Ecuador	33506	85940	156,49%	52434
Egypt	40583	82064	102,21%	41481
Sri Lanka	39231	75343	92,05%	36112
Bangladesh	0	73965		73965
Senegal	46478	72618	56,24%	26140
Former-Yugoslavia	51708	57877	11,93%	6169
Nigeria	26383	48674	84,49%	22291
Total foreigners	1990159	4235059	112,80%	2244900
Total population	56890331	60320749	6,03%	3430418

Data show also that “historical” groups as Albanians continue to choose Italy as a destination for migration, as well as other groups coming from north African countries, like Morocco, Tunisia, Egypt and Senegal. A most recent phenomenon is related to the immigration from South East Asia, particularly from China, India and Bangladesh, not to forget Philippine Islands, already “settled” as a foreign group in Italy.

Italy represents a destination also for nationals from industrialized countries, as the rest of EU and USA. The number of people from these latter countries involved is not as high as those related to the countries already mentioned, but in any case they are interesting to understand some spatial patterns, as it will be more evident when observing local cases.

LOCAL INDICATORS OF SPATIAL ASSOCIATION INDEX: RESULTS AND COMMENTS

Data analysis at 2003

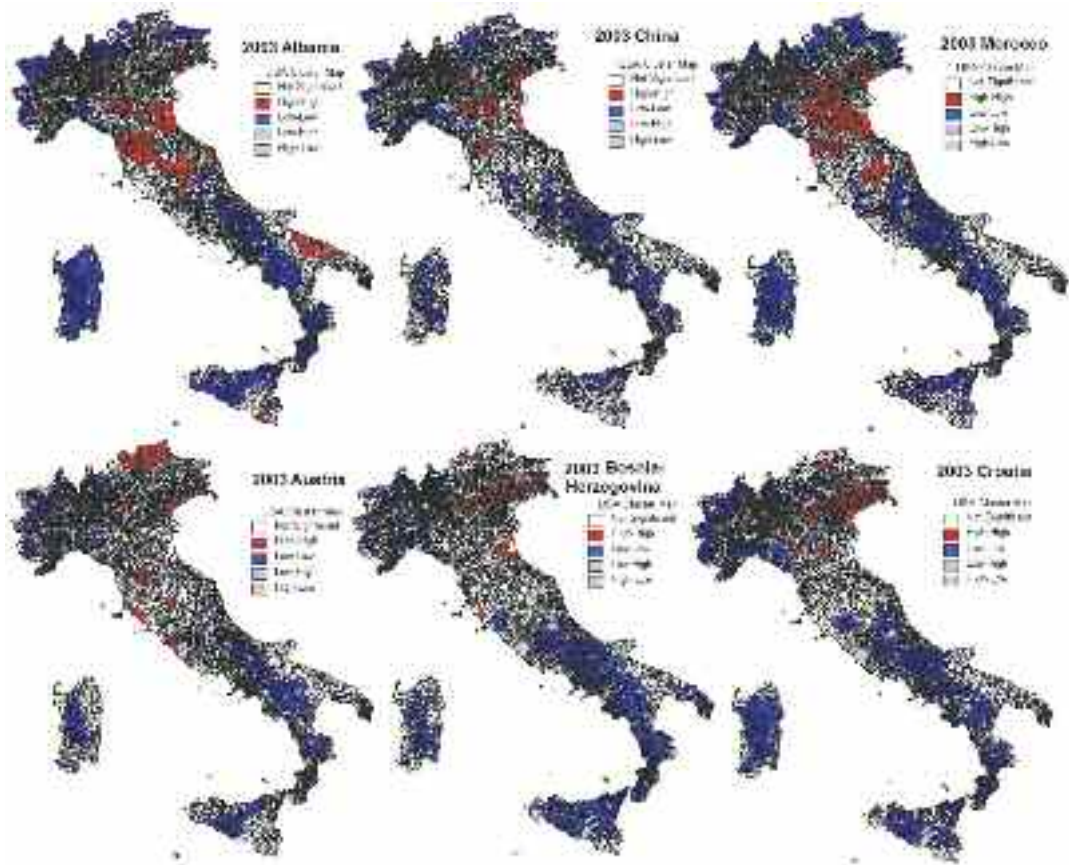
The application of LISA allows detecting clusters in a spatial distribution at local level; in this case the analysis was computed considering foreign population in Italian municipalities. The analysis was applied on some of the national groups.

Considering data at 2003, the Chinese group shows clusters particularly in some major metropolitan urban areas, as Milan and Rome and their hinterlands. Also, the phenomenon is interesting in its

presence in Tuscany, between the provinces of Florence and Prato, as well as in the area crossing the three regions of Veneto, Lombardy and Emilia Romagna. In this latter region, there is a cluster of municipalities connecting urban areas of Parma, Reggio Emilia and Modena. In Veneto a cluster can be noticed around the city of Venice in the municipalities located in the mainland.

A preference for location clustered in Northern – Central Italian regions seems to be noticed also in case of people from Morocco. We can fairly notice a single cluster of municipalities whose vertices can be observed in the areas around the cities of Venice and Milan and covering the area including Veneto, Lombardy and most of Emilia Romagna regions. Clusters can be also observed in northern Tuscany and in Umbria regions, as well as on the Adriatic Coast in Marche region.

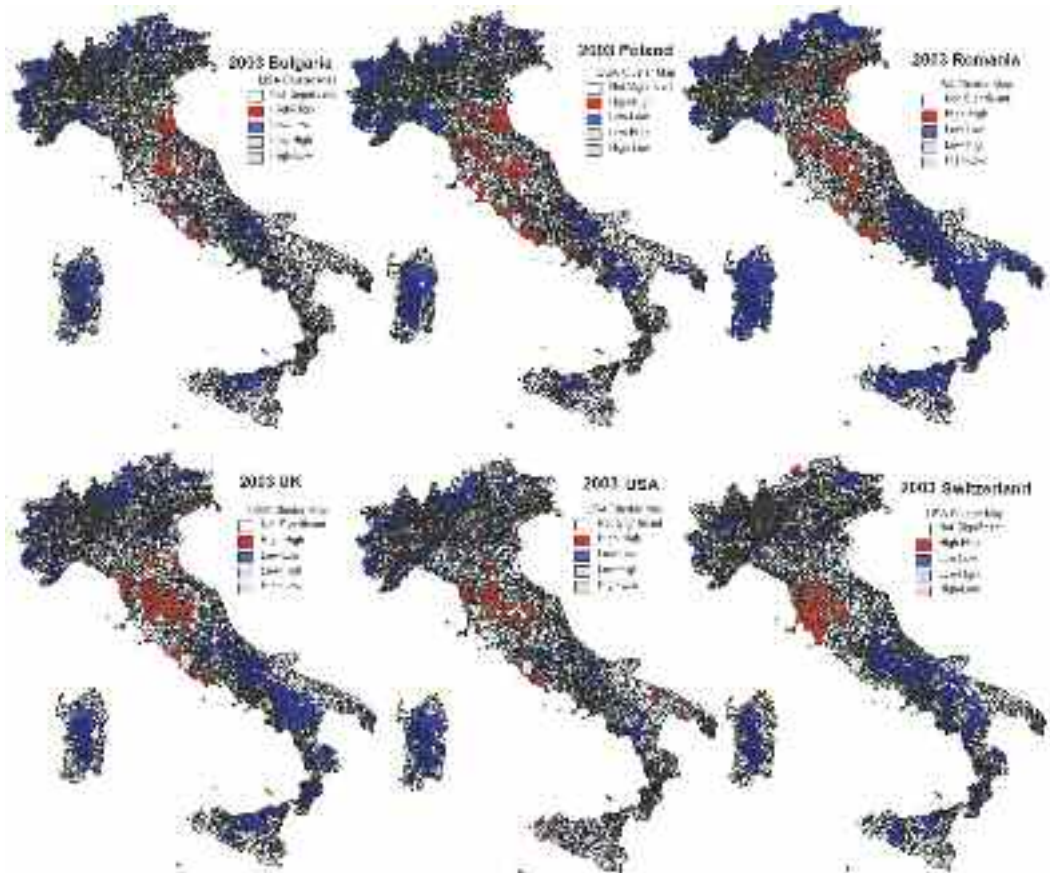
Figure 3 LISA cluster map 2003. (Source: our elaboration with GeoDa on ISTAT data)



“New” migrants from Poland and Bulgaria seem to prefer central Italian locations, being mainly clustered in Emilia Romagna, Tuscany and Lazio regions, here also preferring some urban and periurban locations (i.e., Rome and its hinterland). Former Yugoslavian states, as Yugoslavia (in 2003 grouping Serbia and Kosovo), Bosnia-Herzegovina and Croatia are present with groups mainly clustered in North-eastern Italy, starting from the North-eastern border between Italy and Slovenia and spreading westwards to Verona area and also (Croatians) clustering in the city of Milan. Tunisian people are mainly concentrated in Emilia Romagna region, as well as in Milan area and in some Southern Italian locations, such as Naples area, Puglia region and Sicily (this latter possibly motivated by its geographical proximity to Tunisia and the integration of migrants in activities concentrated on fishery and agriculture). With reference to the groups from

industrialized countries, the algorithm used seems to be useful in highlighting some hot spots that can be quite easily explained. Neighbouring Austrian people cluster in Alto Adige province in Northern Italy, located at the State Border with Austria, and presenting a strong Austrian-speaking community. Also, their presence is noticed in part of Friuli Venezia Giulia Region, here also close to the State Border, as well as in municipalities along the coastline. Such areas are renowned as tourist locations for Austrian people and, in some cases, once belonged to Austro-Hungarian Empire. Their presence can also be noticed in municipalities neighbouring important urban areas, as Venice, Verona, Milan, Florence and Rome. Switzerland, UK and USA show also interesting settling pattern in Italian municipalities. For Swiss people some similar comments as for Austrian can be drawn, as the fact that clusters can be found in Lombardy and Alto Adige areas close to the State Border. Apart for that characteristic, all these groups tend to prefer also urban areas as Milan, Venice, Rome and Florence and particularly Tuscany as a region (among all, the “Chiantishire”), this latter therefore not to be considered just as a tourist destination, but also as a relocation site for these nationals.

Figure 4 LISA cluster map 2003 (Source: our elaboration with GeoDa on ISTAT data)



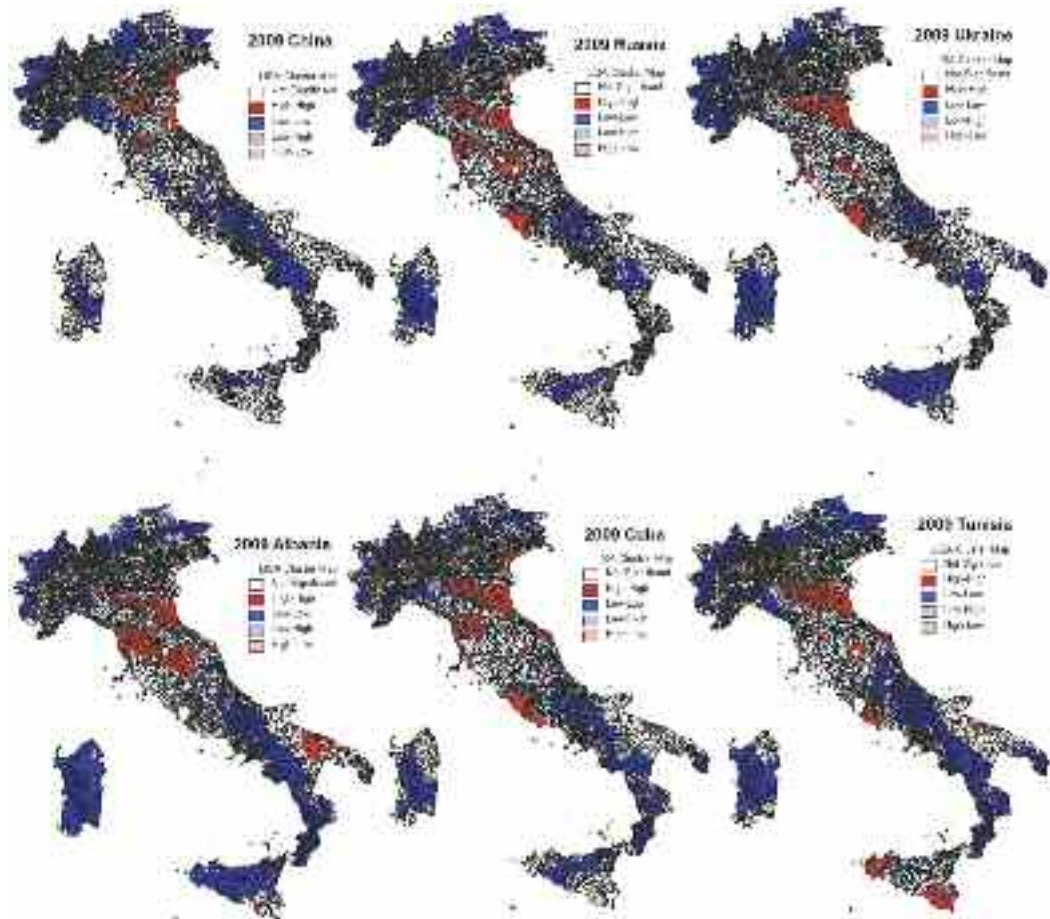
Some interesting patterns can be also noticed concerning USA people, as some clusters can be noticed close to important military installations, as Aviano and Sigonella Air Force Bases, respectively located in Friuli Venezia Giulia Region, close to Pordenone and in Sicily, in Catania province. Some general conclusions can be drawn considering the different nationals. Foreign immigration appears as a phenomenon mainly characterizing Northern and Central Italy, in quantitative terms and with reference of its spatial distribution.

Southern Italy and Islands appear less characterized by immigration (Gentileschi, 2007), although, of course, important figures can be observed here (one for all, the presence of Tunisians in Sicily and Albanian people both in Sicily and Puglia). Large urban areas tend to attract immigrants. This is visible both considering cities (i.e., Milan) and municipalities neighbouring urban areas (i.e., municipalities surrounding cities like Rome, Naples, Florence, Venice, Verona, etc.). Industrialized areas attract also immigrants, both in terms of ‘traditionally’ industrialized areas and also in the small-medium enterprises districts. This is visible particularly in North-eastern, North-west (Milan area) and Northern-Central Italy (Emilia Romagna and Tuscany Regions).

Data analysis at 2009

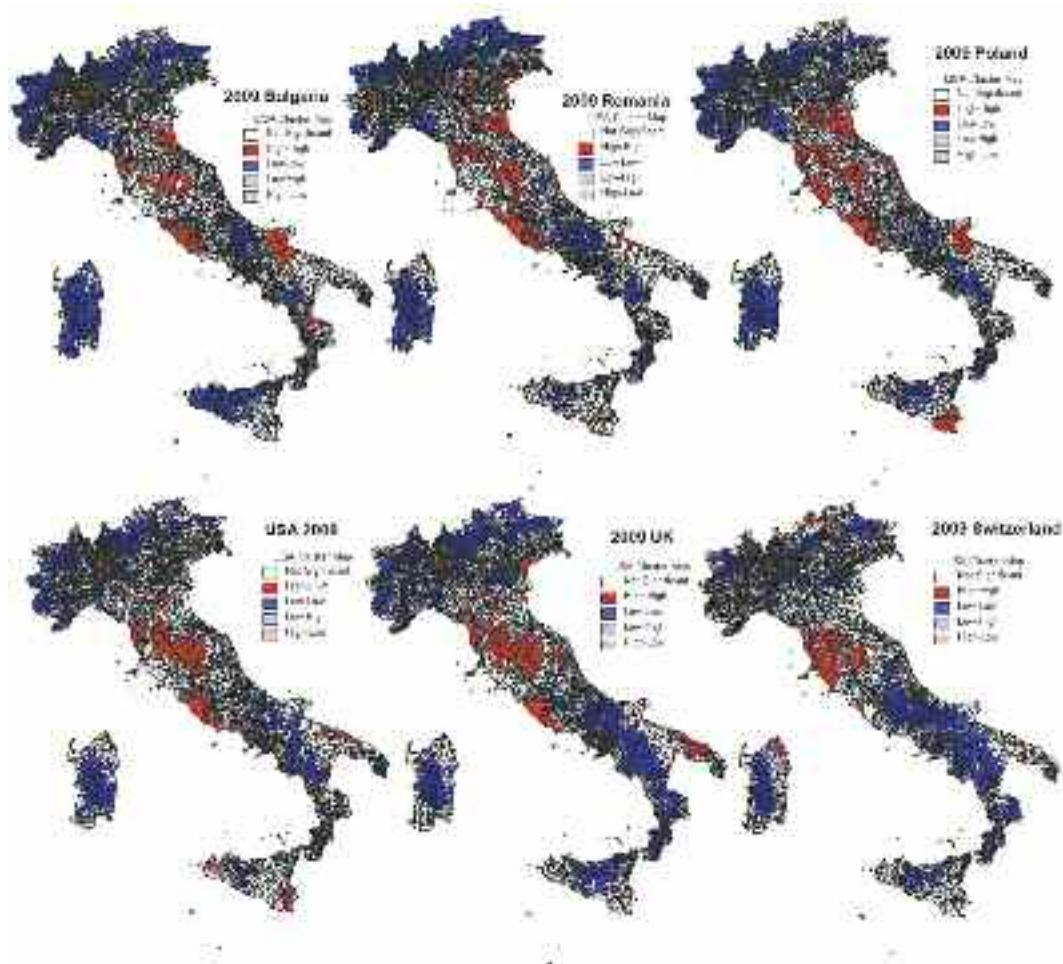
The analysis of 2009 data can provide us with some information concerning the variation occurred in the years and new patterns of settlements. We highlight here some major changes in some of the groups examined. As a general remark, all groups analysed seem to maintain their spatial organization in the years, although clusters generally enlarge and new locations appear. In particular Bulgarian people reinforce their presence around the Italian Capital Rome, while a new cluster appears in Puglia region, centred in the city of Foggia and in its neighbouring municipalities. This seems to be due to activities of Bulgarian people in agricultural activities. Also the press reports as irregular immigration from Bulgaria is being increasing in the area. Polish people confirm the same immigration pattern of 2003, although enlarging their clusters, reinforcing their presence in Lazio (especially Rome), and ‘heading south’, locating in Puglia region in Foggia area, as well as Bulgarian people, and also in Southern Sicily.

Figure 5 LISA cluster map 2009 (Source: our elaboration with GeoDa on ISTAT data)



Industrialized countries, UK and US confirm their spatial distribution, with new locations in Puglia and Lazio regions, particularly in the municipalities of Rome and neighbouring ones, and British people, in particular, tend also to move eastwards from the traditional location in Tuscany (“Chianti-shire”) to locate also in Umbria and Marche Regions. Similar patterns as those noticed can be detected for Switzerland. Here also people tend to settle in Tuscany and in neighbouring regions (Umbria and Marche) but also to experiment a ‘spatial diffusion’ towards the North-eastern coast of Sardinia. Here also some general conclusions can be drawn. In general terms the considerations done with reference to 2003 can be confirmed, particularly in terms of North-South differences and polarization of migrants in (big) urban and industrialized areas (Valussi, 1978; Cristaldi, 2011). However, some interesting patterns seem to arise, as we can spot a trend of “internal movements” of migrants, since clusters seem to grow in their dimensions and also to appear, with reference to some groups, in areas once not experimenting the phenomenon, in particular some other groups, part from Albanian and Tunisian people, settling in Southern Italy (i.e., Bulgarian and Polish people in Puglia, Campania and Calabria Regions).

Figure 6 LISA cluster map 2009 (Source: our elaboration with GeoDa on ISTAT data)



CONCLUSIONS

The research carried out in this paper relied on the application of some spatial statistical techniques to immigration phenomena, focusing on the Italian case. In particular, we applied LISA algorithms to foreign residents in Italy, related to municipalities and diversified in terms of their nationality of origin. As we run LISA methods on some of the major groups currently living in Italy, we were able to detect clusters in their spatial distribution, not limiting us to examine immigration in terms of their percentage weight, but also, and more importantly, in terms of spatial aggregation of foreign groups over the territory.

We could therefore observe some interesting clusters and trends, valid for immigration in wide terms and also in terms of national differences. In particular, we discovered some of the major characters of immigration in the two years, 2003 and 2009: in general terms it is a phenomenon especially characterizing Northern regions, cities – metropolitan areas and industrial districts and areas. Different nationals show differences in migration and settlement patterns. These can be explained by means of migration chains, geographical proximity and economic specialization in the country of origin that is proposed as expertise in the country/site of destination. Changes occurred in less than a decade, demonstrating a trend in internal movements inside Italy, visible in terms of enlargement of single nation clusters and creation of new ones, different from the original ones. It meant also suburbanization, since presence of foreign people in suburban municipalities around major cities and metropolitan areas increased. Also, Southern and insular Italy became areas of settlement for some migrant groups, if not with very large numbers, with interesting composition. In terms of heterogeneity, we noticed that the “weight” – in percentage terms – of foreign population is in most of the cases characterized by an increase in number of nations in single municipalities, as well as of people. This means that in general, at least with reference to single municipalities, we do not observe ghettoization processes with dominance of single foreign groups – here we cannot say nothing related to dynamics within a municipality.

These same conclusions, of course, are compatible with other levels of data analysis and knowledge of the phenomenon. However, we must stress that the methods applied here were quite precise in highlighting some of the characters of immigration phenomenon that could be just imagined or hypothesized by means of other more traditional methods. It must be also stressed that this method can be interesting coupled with more qualitative local analysis. Indeed, it proved to be interesting in highlighting clusters and therefore local cases of some interest, therefore helping scholars to more precisely aim and deepen their research.

References

- Anselin, L. (1995), *Local Indicators of Spatial Association-LISA*, *Geographical Analysis* 27, pp. 93-115.
- Anselin, L. (1988), *Spatial Econometrics: Methods and Models* (Kluwer Academic, Boston - MA).
- Cristaldi, F. (2011), *Immigrazione e territorio. Lo spazio con/diviso* (Patron editore, Bologna).
- Geary, R. (1954), *The contiguity ratio and statistical mapping*, *The Incorporated Statistician* 5.
- Gentileschi, M. G. (a cura di) (2007), *Geografie dell'immigrazione. Stranieri in Sardegna* (Pàtron editore, Bologna).
- Goodchild, M. F. (1986), *Spatial Autocorrelation*, *Catmog* 47 (Geo Books, Norwich).
- ISTAT – Italian Institute of Statistics, various years <http://demo.istat.it>
- Lee, J., Wong, D. W. S. (2001), *Statistical analysis with ArcView GIS*, (John Wiley and Sons, New York).
- Moran, P. (1948), *The interpretation of statistical maps*, *Journal of the Royal Statistical Society* 10.
- O'Sullivan, D., Unwin, D. J. (2002), *Geographic Information Analysis* (John Wiley and Sons, New York).
- Scardaccione, S., Scorza, F., Las Casas, G., Murgante, B. (2010), *Spatial Autocorrelation Analysis for the Evaluation of Migration Flows: The Italian Case*, *Lecture Notes in Computer Science*, 6016, (Springer-Verlag, Berlin), pp. 62–76.
- Tobler, W. R. (1970), *A computer movie simulating urban growth in the Detroit region*. *Economic Geography*, 46(2) pp. 234 - 240.
- Valussi, G. (a cura di) (1978), *Italiani in movimento*, *Atti del convegno di studi sui Fenomeni Migratori in Italia*, Piancavallo, 28-30 aprile 1978 (GEAP, Pordenone).