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Spatial Segregation in Action? An Empirical Assessment of Population Concentration of Foreigners and Nationals in Italy, 2002–2018

Federico Benassi
University of Naples Federico II, Italy

Massimo Mucciardi
University of Messina, Italy

Maria Carella
University of Bari "Aldo Moro", Italy

Alessia Naccarato
University of Rome Tre, Italy

Luca Salvati
Sapienza University of Rome, Italy

Abstract

The spatial concentration of human populations is a dynamic attribute of demographic systems and a multifaceted research dimension intrinsically dependent on settlement patterns and diverging (individual) geographies. An extensive literature dealing with the quantitative assessment of this demographic aspect has proposed several methodologies and approaches, conceptualizing and operationalizing the

Corresponding Author:
Federico Benassi, Department of Political Sciences, University of Naples Federico II, Napoli, Italy.
Email: federico.benassi@unina.it

notions of "place" and "scale" in a different way. In this perspective, the present study investigates the spatial distribution of foreign and national populations residing in Italy for three years (2002, 2010, and 2018) adopting a mixed approach that integrates exploratory and confirmative statistical analyses of demographic indicators. The empirical results of this approach demonstrate that diverging interpretations of settlement patterns may result from the use of different methodologies, indicators, and observational scales. The study finally argues how future research on this topic should advocate for a better understanding of foreigners' settlement pattern as a place-specific process and insists on the importance of measures based on integrated (spatial and statistical) approaches.

Keywords
foreign population, spatial concentration, Italy

1. Introduction

Refined investigations of the spatial distribution and concentration of resident population were (and still are) a challenge for disciplines such as applied statistics, regional demography, geography, planning, and urban science (Duncan and Duncan 1955; Duncan 1957; Massey and Denton 1988). Since the pioneering contribution of Gini (1912, 1914, 1921), scholars have tested alternative approaches to the empirical measurement of population concentration over both time and space (Hoover 1941; Batty 1974; Long and Nucci 1997; Cohen 2021). Several indexes have been proposed, and the scientific debate about which of them works better was (and still is) particularly articulated (see, for instance, Arbia and Piras 2009; Rey and Smith 2013; Kopczewska 2017; Liu, Hua, and Liu 2018). In this perspective, novel contributions to modeling spatial concentration of populations that include multi-scale approaches have been recently proposed (Ayuda, Collantes, and Pinilla 2010; Bajat et al. 2011; Petrović, van Ham, and Manely 2018; Liu and Gu 2020).

Population concentration has also been regarded as a significant aspect of more general phenomena concerning migrants' residential segregation. Massey and Denton (1988) identified population concentration as one of the key dimensions of residential segregation, together with evenness, exposure, clustering, and centralization. The same applies to Reardon and O'Sullivan (2004) spatial approach to residential segregation. "Segregation" and "integration" identify two contrasting dimensions of the migrants' settlement process (Bolt, Özüekren, and Phillips 2010). Due to its implications in terms of social cohesion within host societies, the integration of migrants has become a central issue in both scientific and political debates (Arbaci 2019). As a consequence, measuring the residential concentration of migrants has also attracted increasing attention from a substantive point of view (e.g., Gavalas, Rontos, and

Salvati 2014; Di Feliciantonio et al. 2018; Ciommi, Chelli, and Salvati 2019; Benassi and Iglesias-Pascual 2023). The integration process for migrant populations can benefit from an explicit focus on "territorial embedded ness" explaining whether and how spatial contexts matter according to their performances (e.g., economic success or failure). Despite the relevance of this topic, there are, to the best of our knowledge, few empirical studies involving a diachronic analysis of the level of concentration of foreign population in Southern Europe, a region more recently involved in large migration flows than Northern and Western counterparts. These studies were largely based on "traditional" approaches and measures. Italy represents a specific example of the (rapidly increasing) immigration processes involving especially urban regions in Mediterranean Europe. The foreign population in Italy has grown intensively in the last 20 years — passing from more than 1.3 million in 2001 to more than four million in 2011, approaching at the beginning of 2018 nearly five million and representing almost 9 percent of the total population.[1] The spatial distribution of foreigners residing in Italy was demonstrated to be spatially dependent at both macro- and micro-levels (Tragaki and Rovolis 2014). In Northern Italy, a particularly dynamic macro-region in the country, there are more foreigners in both absolute and relative terms, compared with the other macro-regions of Italy, especially Southern Italy and the two main islands (Sicily and Sardinia), where unemployment rates are comparatively higher (Benassi and Naccarato 2018). Spatial heterogeneity is even greater when downscaling the analysis' level from regional to local dimensions — affecting together demographic dynamics (Reynaud et al. 2020) and residential segregation (Benassi et al. 2020).

Based on these premises, our study investigates the spatial concentration of foreigners in Italy from a theoretical and empirical point of view. First, following Arbia and Espa (1997), a specific (theoretical) reflection on the idea of spatial concentration of a given population is proposed. Second, alternative approaches measuring the spatial concentration of foreigners (and nationals) residing in Italy on three years (2002, 2010, and 2018) were tested for coherency. We adopted a mixed approach integrating different (concentration) measures proposed by Arbia and Espa (1997) with Geographically Weighted Regressions (GWRs) modeling the density of foreign population over space. Population density is assumed here as a local index of spatial concentration, a proxy of broader socioeconomic processes (e.g., reflecting economic agglomeration and the scale of social phenomena), while representing instead an intrinsic attribute of regional systems (e.g., delineating urban–rural, or metropolitan, gradients), and an indirect factor of population regulation — following the extensive literature on density-dependent population growth (e.g., Polinesi et al. 2020). The basic geographical units adopted here are the Italian

[1] It should be noted that these figures are even higher nowadays. Indeed, according to population continuous census data, the foreigners resident in Italy are 5,194 million at the beginning of 2022.

municipalities, a fine scale that has proved appropriate for understanding the high level of spatial heterogeneity characteristic of the Italian demographic system (Salvati et al. 2020). This investigation covers more than 15 years, during which important socioeconomic changes have occurred in Italy. While foreigners' density has grown significantly, the 2008 economic crisis has significantly influenced population distribution and local economies. With this perspective in mind, testing the latent evolution of residential concentration levels and patterns over time — and the main determinants of such changes before (2002), during (2010), and after (2018), economic crisis — is an intriguing task contributing to discussing and clarifying both theory and empirical aspects of the "population concentration" issue. We believe that this contribution may also be of interest to scholars not directly interested in the concentration/segregation processes of the foreign population in Italy. In fact, what we propose is not just a case study but an integrated study approach at a local scale that can be replicated in many other contexts. The approach is integrated because it combines the quantitative statistical aspect with the spatial geographic one both in relation to the global indices used and the regression models employed.

2. Foreigners, Population Density and Territorial Concentration

2.1. Spatial Distribution of Population and Demographic Density: Two Sides of the Same Coin?

Studying the spatial distribution of human populations is a fundamental step towards a refined understanding of multi-faceted socio-ecological interactions (Xu and Cohen 2019). Population density influences environments and resources' endowments being, in turn, affected by contextual variables such as ecological change and institutional (or structural) forces (de Sherbinin et al. 2007). As a result, demographic behaviors should be conceived and investigated as spatial processes related to settlement concentration in a specific place — where changes depend partly on the interconnected variables at various geographical scales. This approach enhances the value of a geographical perspective in capturing the broad variety of demographic dynamics and the relevance of the spatial context when trying to explain their linkages with socioeconomic processes (Voss 2007). Recent literature remains largely silent about the relationship between population density, taken as an ecological variable, and demographic behaviors. In this perspective, the spatial context was often treated as a neutral dimension, offering little causal explanation and few theoretical assets to any demographic aspect (Entwisle 2007). Questions about where and how the population is concentrated in specific places, and regarding the methods used to measure and relate the spatial concentration of population to other demographic phenomena, often remained unaddressed in this field of study (e.g., Ayuda, Collantes, and Pinilla 2010). Consequently, many population studies were

insufficiently equipped to evaluate the determinants and implications of the demographic patterns with respect to the space in which their dynamics and paths are incorporated (e.g., Bajat et al. 2011).

In line with these assumptions, our work brings together two approaches that remained largely independent in earlier studies, namely the spatial concentration of Italians (nationals), and the residential settlement patterns typical of foreigners. The two subjects share common grounds in a burgeoning field of studies that dates back to the 2000s and have investigated the spatial distribution of foreigners within the framework of residential segregation of minority groups in Europe (Musterd 2005; Arbaci 2007). A core tenet of these studies is that population and space should not be analyzed separately because they co-determine each other. In spite of the growing interest in the role of regions and urban areas in the integration process of migrants (Musterd 2003), recent literature on these topics lacks a coherent (theoretical and empirical) approach. Our work contributes to advancing a specific knowledge on the spatial concentration of foreigners in Italy, comparing the results of different quantitative methodologies and indicators.

2.2. Conceptualizing Settlement Patterns of Foreigners in Italy

Since the 1980s, Italy, in common with other Mediterranean European countries, has transformed into a country of immigration. The literature on the so-called "Southern European model of immigration" (King, Fielding, and Black 1997) identified different factors associated with increased immigration flows into such countries: (i) the permeability of their frontiers, (ii) the inherent disparities in wealth and unemployment levels, (iii) the increasing divide between aging populations in the destination countries and younger populations in the origin countries of migrants, and (iv) segmentation, flexibility and, sometimes, the informality of their labor markets (King 2001; Reyneri 2003). At the beginning of the 1990s, the presence of foreigners in Italy was relatively modest and characterized by a large share of undocumented and illegal migrants (Strozza 2004). During the 1990s, following the measures of regularization adopted on several occasions, international migration to Italy increased so much that at the beginning of 2001, the resident foreign population in the country amounted to over 1.3 million (2001 census data). Immigration to Italy has further intensified over the last 20 years: between 2001 and 2011, resident foreigners tripled due to net immigration of about 2.8 million people, increasing up to four million residents in 2011, and to almost five million people at the beginning of 2018. Italy is currently among the European countries with the highest number of foreign citizens. Over time, the areas of origin of immigrants have also changed: south-north migrations, or in general those from the lowest-income countries of both Asian and African continents, have been partly replaced with migrations on the east-west route from Eastern Europe and the Middle East (Carella and Pace 2001). This change in the origin of migratory flows was prompted by the radical

change in the political scenario that affected Europe between the end of the twentieth century and the beginning of the 2000s.

Studies on the spatial distribution of immigrants carried out between the end of the 1990s and the beginning of the 2000s examined the settlement models of the main groups of non-EU citizens residing in Italy according to three "territorial profiles" (Carella, Paterno, and Strozza 2004): (i) a "metropolitan" settlement profile, typical of large cities, especially Rome and Milan; (ii) a "border-neighbourhood" profile involving areas closest to the original countries of foreigners; and a residual, (iii) "widespread" settlement profile, found, although with different intensities, in all Italian regions. In the last 20 years, no substantial variations in settlement patterns of immigrants in Italy were detected (Blangiardo 2005). More recent literature has investigated the spatial (residential) patterns of selected foreign groups in some urban contexts, and the role played by foreigners in shaping their demographic dynamics (Strozza et al. 2016). Other studies have pointed out the residential segregation of foreign populations using multiple approaches at various geographical scales (Mucciardi, Altavilla, and Mazza 2017; Mazza, Gabrielli, and Strozza 2018), sometimes adopting a comparative perspective that went beyond the national boundaries (Benassi et al. 2020). Additionally, variations in the migration phenomenon have not only been quantitative. By contrast, the most significant changes involved the paths and conditions of the integration process for migrants. Immigration in Italy can no longer be considered a "recent" socioeconomic process, being instead in continuous evolution, and requiring investigation approaches that may benefit from an explicit conceptualization of the underlying role of space.

3. Spatial Concentration, Residential Segregation, and Immigrant Populations: An Overview and Some Reflections

Spatial concentration is an intrinsic feature in human populations at the base of multifaceted population geographies (Gibbs 1963; Korotayev 2006). Human being, albeit with a certain variability in relation to historical contexts and time periods, has, in fact, expressed the continuous need to interweave relations, exchanges, and interactions. Spatial distance acts as an obstacle to such interactions and thus, concentration in particular locations, for example, cities, becomes a fundamental fact in human (socioeconomic) evolution and a distinctive feature of his socio-demographic history (Sato and Yamamoto 2005). Population concentration in specific places is thus a factor explaining urbanization processes (Tisdale 1941; Jedwab and Vollrath 2015) and metropolitan development at large (Champion 2001). For instance, spatial concentration has been interpreted as a hegemonic trend at the base of fundamental historical processes, such as the industrial revolution in Europe (e.g., Egidi, Salvati, and Vinci 2020). However, urbanization remains — even today — a global phenomenon (Martì-Henneberg 2005), and, since the middle of the last century, for the first

time in human history, more than half of the world population came to live in urban centers (Zlotnik 2017).

Economic globalization and the consequent, albeit asymmetrical, globalization of migrations, reinforced the scientific interest in understanding apparent and latent drivers of long-term urban growth (Czaika and De Haas 2014) and the mechanisms underlying socioeconomic development in metropolitan regions (e.g., Benassi, Naccarato, and Salvati 2023). In this perspective, the spatial concentration of native and immigrant populations in specific locations, especially within cities and metropolitan regions, is therefore closely connected and extremely relevant from both functional and substantive points of view. This is particularly true with regard to immigrants with foreign citizenship who are often attracted to areas with a high concentration of (native) population, typically large (and mostly compact/dense) urban areas (Yap 1977; Skeldon 2017).

With regard to the different patterns of immigrants' settlement, a specific interest in the notion of spatial concentration fits into the more general framework of population geography. This is also because, as clarified in the seminal work of Massey and Denton (1988), the spatial concentration of the foreign (immigrant) population is one of the components of residential segregation. In general, the residential segregation of a minority group, be it an ethnic group or any population subgroup, involves the spatial separation of that minority group from another (usually majority) population group within a given geographical area (Kemper 1998). From the operational point of view, this phenomenon should be defined and quantified considering two concomitant aspects: the densification of the minority group in a few areas of the territory and their non-sharing with the majority group. With reference to immigration, residential segregation, and especially the spatial concentration of foreign populations, have both positive and negative aspects for the communities involved (Bolt 2009; Bolt, Özüekren, and Phillips 2010). The interpretations that have been provided over time with regard to residential segregation can be traced back to two main strands of thought: the "assimilationist model" advocated by the Chicago ecological school and the "ethnic status" model. For the Chicago school, the way immigrants distribute across the territory depends on the socioeconomic class to which they belong. In this view, residential segregation is seen as a physiological and natural phase of urban development, starting with the settlement of the new immigration group. In fact, this group occupies the lowest rungs of the economic/social ladder of the receiving territorial context, almost inevitably settling in the neighborhoods of its most degraded areas. In this phase, relations with the native population are limited and deprived of any organized inter-cultural communication. In time, the immigrant group can improve its social and economic position, and as the process of assimilation of the minority to the cultural and behavioral standards of the majority progresses, a new phase of residential mobility and a better distribution throughout the territory can take place. This view thus predicts a close relationship between spatial mobility and social mobility: large spatial distances reflect the existence of large social distances. More recently, this thesis has been revised by many authors

by approaching the segregation phenomenon no longer as a result of economic and social forces, but also as the result of practices and behaviors implemented by the majority social group in order to contain the growth of minorities within society (Massey 1990; Massey and Denton 2005).

Despite this fascinating interpretation, residential segregation can be envisaged from different points of view, and there is no unambiguous definition of what it means to be "segregated," although this operational difficulty can be less relevant from a territorial point of view. For the "ethnic status" model, on the other hand, territorial concentration and its persistence over time depend on a community's precise desire to preserve and maintain its identity. This would explain cases where there is a high degree of territorial concentration between groups that differ in terms of seniority of presence and socioeconomic status. According to scholars such as Barth (1969) and Maher (1994), the presence of relations or neighborhood contiguity between different groups does not necessarily lead to the assimilation of the minority group. Ethnicity can, however, channel the social life of its members and influence its territorial distribution. When a group exceeds a certain size, it may acquire autonomous forms of organization or institutions and may assume an attitude of social closure. For Boal (1976, 1981), "cultural distance" is a driver of spatial segregation of immigrants: the greater the cultural distance between members of the minority group and those of the majority group, the greater the difficulties in the integration process. While a very small cultural distance may reflect an evident dispersion across the territory, a high distance may lead to more extreme forms of territorial grouping.

Concentration in a given spatial context may result not only from voluntary strategies implemented by the immigrant community, but also be induced by forms of discrimination implemented by the native population (Massey 1990). Institutions can also put in place inductive discriminatory policies of spatial segregation, for instance through the welfare system, housing policies (Arbaci 2008), and school policies (Barberis and Violante 2017). It is precisely the element of voluntariness that fundamentally differentiates an ethnic "enclave" (which arises as an attitude of defense of group identity) from a "ghetto" (which is induced by discriminatory attitudes and behaviors, mostly from the surrounding [native] community). Research has documented the extreme heterogeneity of forms and modes of the spatial grouping of immigrant populations, which are difficult to catalog or enclose in a few conceptual categories (Vaughan and Arbaci 2011). Forms of territorial concentration derive from the combination of a plurality of factors of an extremely varied nature, ranging from the urban structure of the city, to the historical and geographical context of reference, to the demographic, social, economic, professional, and cultural characteristics of the populations involved (Arbaci 2007). This heterogeneity of contexts and situations also requires more complex indicators than those traditionally used in the classical literature if we are to measure spatial segregation in all its forms and dimensions.

With this perspective in mind, the positive and normative debate on the topical issue of the spatial distribution of immigrant populations in different geographical contexts has developed hand in hand with the history and evolution of international

migrations: in the United States, interest had already focused on the concentration/segregation of specific ethnic groups at the end of the nineteenth century; this has also been the case in other parts of the world since the mid-twentieth century. In the European context, the debate on this topic first developed in Northern Europe, when France, Great Britain, and the Netherlands began to experience the effects of decolonization and industrial development. Subsequently, the debate arose also in the countries of Mediterranean Europe, when they became the object of international migration flows, at least since the late-1970s (Bayona-Carrasco and Gil-Alonso 2012; Ciommi et al. 2018).

Our study fits into this broad strand of studies by attempting to develop an original approach, especially from a methodological point of view, and by proposing a reflection on the concept of spatial concentration of national and foreign population. In fact, our study measures the spatial concentration of native and foreign populations according to a dual approach: the statistical one, based on the concept of variability, and the spatial one, based on the concept of polarization. Since these two approaches were frequently kept distinct in the recent literature, our contribution can provide new empirical insights into the study of segregation processes and settlement geographies. Based on this rationale, our study proposes an empirical analysis that is diachronic and long-term in nature, providing a broad view of the processes underlying spatial concentration in the two populations. In this perspective, we delineated an explanatory, spatially explicit approach to the analysis of the local relationship between (foreign and native) population densities based on geographically weighted regressions. For these reasons we believe, in the light of the existing literature on the subject, that our study — driven by an eminently exploratory paradigm — can provide a novel and substantial contribution to population geography and migration studies.

4. Methodology

4.1. Data and Variables

Input data have been derived from the institutional website (www.istat.it) of the Italian National Institute of Statistics (Istat). The total municipal population in three sequential years (2002, 2010, and 2018) and shapefiles at the same geographical and temporal resolution were considered in our analysis. The adoption of a detailed elementary analysis' unit (such as municipalities) provides key information on both local heterogeneity and broader territorial divides. To overcome issues dealing with administrative boundaries' variation over time and source inconsistency, we used data from the intercensus reconstruction of population (2002–2018) provided by Istat on the basis of the last census' results. This dataset is fully coherent as a statistical source of information and as a geographical reference since it assures that municipal boundaries remain constant over time. Based on this reference, we computed selected indicators at the municipal level for 2002, 2010, and 2018.

Absolute values of Italian and foreign resident populations and population density (inhabitants/km^2), separately for foreigners and Italians, were the base of the subsequent analysis of the spatial concentration of population (Ciommi, Chelli, and Salvati 2019). The foreign population was defined using the criterion of citizenship: a person do not having Italian citizenship was considered as a "foreigner."

4.2. Methodology

Starting from the concept of population density — the simplest indicator of population concentration (Arbia and Espa 1997; Ascolani and Baldini 2007) — we provided a logical framework operationalizing the measurement of spatial concentration as, together, a statistical phenomenon (basically upon the concept of variability), and a geographical phenomenon (basically upon the concept of polarization). Following the approach of Arbia and Espa (1997), we adopted an exploratory, graphical approach suitable to integrate the "statistical" and the "geographical" dimension of population concentration: the *GI* scatterplot (where *G* and *I* stand for Gini's *G* and Moran's *I* indexes). We subsequently modeled the spatial variability in population density, adopting Geographically Weighted Regressions (Brunsdon, Fotheringham, and Charlton 1996, 1998). We used Quantum GIS to prepare geographical data and thematic maps and GeoDa for spatial autocorrelation analysis. Local regression models were computed using the software developed by Oshan et al. (2019).

4.2.1. A Spatially Explicit Analysis of Population Concentration. Population and space are the base of any process of residential concentration. Population density, hereafter D, is one of the first (and intuitive) measures of the spatial concentration of any population. Being derived from two key variables for each analysis' unit (i), the resident population in i (P_i) and the surface area of i (a_i), the population density of a given municipality (D_i) was computed as the ratio between P_i and a_i. D is, together, a spatially relevant and local-based indicator in population studies, dealing with both demographic dynamics and structure (Loftin and Ward 1983; Lutz, Testa, and Penn 2006; Goerlich and Mas 2008; Cohen, Xu, and Burnborg 2013). Despite its importance, population density presents some pitfalls that become evident when measuring the spatial concentration of a given population — especially when comparisons between two (or more) population groups should be carried out. The first issue is the quantification of the "standardization" term (i.e., the area of a given territorial unit) — which should refer to the only usable (i.e., net) surface. The definition of a "net" surface area for density calculation is not a straightforward and simple matter, and the whole area was used in the majority of cases. A second limitation is that the geographical definition of elementary units affects D, reducing its interpretation potential and comparative power. Moreover, mapping D presents some intrinsic problems in terms of class definition; finally, the statistical distribution of D is frequently asymmetric, preventing the use of standard techniques (Ascolani 2007). Despite these limitations, we too, in this empirical work, could not avoid using

population density. Unfortunately, in fact, at least for the Italian case, there is no statistically reliable information that allows us to have a more accurate measure of density that is, together, comparable over time and space. This is even more true when we make use of data in historical series or which, in any case, refer to past periods. On the other hand, this same measure, which as mentioned has obvious limitations, has recently been used in studies that refer to population dynamics in Italy and proved to work very well (Benassi and Naccarato 2019; De Lucia et al. 2020; Benassi and Carella 2022).

Gini (1912, 1914, 1921, 2005) was likely the first to propose a global index (G) based on the statistical concept of concentration in order to partially overcome these limitations and to capture the irregularity of the spatial distribution of real populations. From a statistical point of view, the concept of concentration is related to that of variability, while referring exclusively to transferable quantitative characteristics. With reference to a given population, the index is aimed at verifying how the amount of population is distributed across the elementary analysis' units, assessing whether it is equally distributed or concentrated in a small number of them. To this end, the normalized G index (the so-called "concentration ratio," also known as "concentration index," or "Gini's ratio," see Rogerson 2019) varies between 0 and 1, being closer to 1 with concentrated distributions (Ascolani 2007). The G index is calculated as:

$$G = \frac{\sum_{i=1}^{N-1} (p_i - q_i)}{\sum_{i=1}^{N-1} p_i}, \quad 0 \leq G \leq 1, \tag{1}$$

where (p_i) is the cumulative (relative) frequency (p_i), that is, the proportion constituted by the first municipality in a non-decreasing ordering over the total number of municipalities (N). Similarly, (q_i) is the cumulative (relative) frequency of the population resident in the first i-th municipality with respect to the total population $P(N)$. G neglects the territorial background of any concentration phenomenon, being a typically spatially implicit measure (Reardon and O'Sullivan 2004). Above all, it is unable to say anything about the geographical aspect of polarization (Arbia and Espa 1997), a concept that harks back to Tobler's (1970) first law of geography. To partially solve these drawbacks, Arbia and Espa (1997) proposed the use of Moran's (1948, 1950) global spatial autocorrelation index I:

$$I = \frac{n}{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_i (x_i - \bar{x})^2}, \quad -1.0 \leq I \leq +1.0, \tag{2}$$

I indicates whether and how much the spatial distribution of a variable is correlated with itself, given a neighborhood structure (i.e., a matrix of spatial weight). Positive values of the index suggest that similar values tend to polarize (i.e., to concentrate), and negative values indicate, on the contrary, that similar values tend to de-polarize (i.e., to repel each other). A value close to 0 indicates that the distribution of the observed variable is random or not affected by clustering. In equation (2), w_{ij} is a

spatial weight matrix that defines the neighborhood structure among the territorial units analyzed.

In our study, we use a contiguity spatial weight matrix, the so-called first-order "Queen" matrix. Based on this matrix, two territorial units (polygons) are neighbors if and only if they share a boundary or a vertex. In equation (2), x_i and x_j represent the observations (i.e., population density) related to *i*-th and *j*-th statistical units (municipality in our case), having $\bar{x}$ as variable's average. This type of matrix (Queen) has been extensively used in studies that applied spatial approaches to demographic phenomena; see, for instance, the contribution on spatial variability of fertility rate in Italy (Salvati et al. 2020) and the extensive work of Yang and colleagues about the geographical variation of mortality rates in the United States (Yang, Noah and Shoff 2015). Actually, we tested other two kinds of spatial weights matrixes, one based, like the Queen, on contiguity (Rook) and the other based on the distance (K-Nearest Neighbour [KNN]).[2] The results obtained indicate substantial robustness of the indicator and approach but nevertheless seem to indicate, at least to the best of our knowledge, a preference for the use of the Queen matrix.[3] Finally, it is important to underline that we used standardized rows in the computation of Moran's *I*. It is important to emphasize that, in the study of the territorial concentration of population, *G* is usually computed on population while *I* is referred to *D*. Arbia and Espa (1997) and Ascolani and Baldini (2007) have demonstrated that the use of Moran's *I* alone can be misleading when studying the territorial concentration of population. In fact, Moran's *I* delineate only one aspect of territorial concentration, basically polarization. To overcome these limitations, Arbia and Espa (1997) adopted a *GI* plot mixing both indicators — *G* and *I* — in order to capture simultaneously the statistical and geographical dimensions when measuring the territorial concentration of a given population. In essence, this approach allows us to diachronically evaluate the level of concentration in both statistical terms (i.e., measuring the distance from an ideal condition of uniformity) and geographical terms (i.e., in relation to the level of polarization). Being first proposed by Arbia and Espa (1997) for economic variables, this approach has found, up to now, few applications in population studies. To the best of our knowledge, no one until now has applied this approach to compare the territorial concentration of foreign and Italian citizens, with the exception of Ascolani and Baldini (2007), the only work referring to Italy and focusing on the total population.

[2] Rook contiguity matrix defines two territorial units as neighbors if they share a boundary. K-Nearest Neighbour (KNN) is a type of distance-based spatial weights and the closest "k" units will be included as neighbors. In our case, we established 47 municipalities as the number of nearest neighbours (NNs) in line with the results of the bandwidth identified in GWR model.

[3] Results are available from the authors upon (reasonable) request.

4.2.2. Spatial Effects Influencing Population Concentration. Demographic research is often based on individual data taken over a wide range of spatial scales, and therefore the corresponding variables, which involve correlated socioeconomic aspects, require a deep understanding of the influence of the background context (Mucciardi 2021). At the same time, scale is a fundamental concept in territorial analysis and, in particular, in spatial processes such as the territorial concentration of population and human settlements (Lloyd 2016). This is currently discussed in a considerable and diverse literature that investigates the role that geographical scale plays in social processes (Fotheringham, Yang, and Kang 2017; Yang et al. 2022a, 2022b). It is generally accepted that different processes operate at different spatial scales (Carlucci, Chelli, and Salvati 2018), and we often make a distinction between micro- and macro-levels, or between local and global processes but, in real-world scenarios, data are often generated from spatial processes operating at different spatial scales (Wolf, Oshan, and Fotheringham 2017). Local models such as Geographically Weighted Regressions (GWRs) capture process heterogeneity (Fotheringham, Brunsdon, and Charlton 2002, 2017). In this respect, GWRs may control spatial effects by distinguishing between factors that play a role over local and more global levels (Nakaya et al. 2005; Nakaya 2015). We use GWRs to model the spatial variation in density (inhabitants/km^2) of a foreign population and its evolution over time. More specifically, we run GWR models at the municipality scale assuming the density of foreigners' population as dependent on the density of Italian citizens. The idea is to understand whether there is a sort of spatial attraction (or repulsion) between the two populations, and where this relationship is stronger or weaker in identifying geographical patterns (Matthews and Yang 2012). In order to assess the influence that the geomorphological characteristics of a given territory can exert on the dependent variable, an additional predictor was introduced into the model: the average elevation (m) of each municipality (above sea level, taking the municipal centroid as a reference point). This is a proxy variable for the level of accessibility of Italian municipalities and, to a certain extent, their level of connection/isolation with neighboring contexts. This variable, which has been widely used in earlier studies on depopulation in Italy (e.g., Reynaud et al. 2020) was taken as time constant, and is particularly relevant in the Italian context, which is characterized by hilly and mountainous land covering more than 70 percent of the total country area.

5. Results

5.1. Spatial Concentration of Population

The level of territorial concentration of foreigners proved to be systematically higher than that of Italians (Figure 1, vertical axis), while decreasing over time (from 0.802 in 2002 to 0.797 in 2018) in spite of a weak increase characteristic of Italian citizens (between 0.712 and 0.714). At the country level, the decreasing territorial concentration of foreigners corresponded with an increase in their demographic dimension,

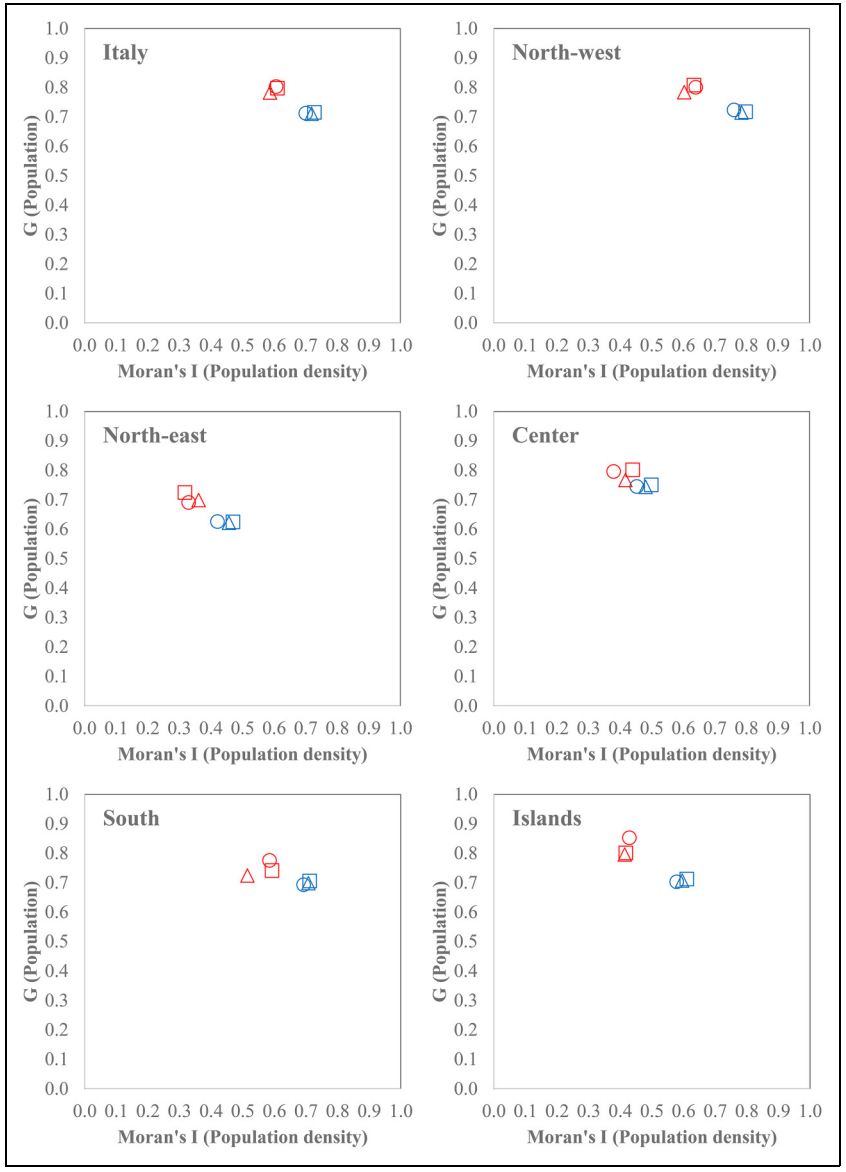

Figure 1. *GI* plot (red foreigners, blue Italians). 2002, 2010, and 2018(a).
(a) The circle represents 2002, the triangle 2010, and the square 2018.
Source: Our elaboration of Istat data.

with a moderate variability within each macro-region (Northern, Central, and Southern Italy). In particular from 2002 to 2018, foreign population residents in Italy increased from 1.3 million to 4.9 million people (+264 percent) while moderately higher figures for Southern Italy than Northern and Central Italy (241 percent, 264 percent, and 377 percent, respectively).

In both Northern and Central Italy, the spatial concentration of foreigners was stable over time, while decreasing in Southern Italy. Nevertheless, the highest territorial concentration of foreigners (0.852) was observed in the two main islands (Sardinia and Sicily) in the first year analyzed in this study (2002). Conversely, the highest level of concentration in 2018 was observed in North-Western Italy (0.807). The level of territorial concentration for the Italian population has remained relatively stable over time, with the highest level recorded in Central regions (likely because of the size effect of Rome, the capital city) and the lowest level found in North-Eastern regions.

The level of spatial polarization (Figure 1, horizontal axis) shows the reverse pattern. At both the country levels and in all macro-regions, foreigners were associated with lower levels of spatial polarization than Italians.[4] Contrary to *G*, the *I* index increased over time for both foreigners and Italians and at both country and subnational levels. The highest and lowest levels of *I* were recorded in North-Western and North-Eastern Italy, respectively. Nevertheless, a comparative inspection of *G* and *I* documents how foreigners and Italians have different trends for the two indicators. Foreigners show a high level of concentration and a lower level of polarization, that is, the variability in the distribution of foreigners in each municipality is lower than that of the Italians. Taken together, these results suggest how settlement models typical of the two populations do not converge over time.

Figure 2 shows the differences in the *G* index for each macro-region compared with the country level at each year. Foreigners and Italians show similar patterns only in North-Eastern Italy. In the rest of Italy, a relatively high heterogeneity between the two population groups was observed. Foreigners were more concentrated in the main islands than the other macro-regions for all the years, although the difference decreased from 2002 to 2018. Conversely, Italians were more concentrated in Central regions and, to a lesser extent, in North-Western Italy. An increasing concentration of foreigners was recorded between 2002 and 2018 in both North-Western and Central Italy.

[4] Comparison may be biased because *I* depends on *n* (number of observations), and this varies between different macro-areas. Nevertheless, the sample sizes in each macro-area are very large (i.e., number of municipalities in North-west, North-east, Center, South and Islands: 2,995; 1,388; 971; 1703; and 767, respectively). Therefore, we can argue that the null hypothesis of the absence of spatial correlation and the related statistical test can be compared as convergence to the normal curve is ensured (Griffith 2010). We computed in any case Z scores distribution for *I* and results seem to indicate that levels and dynamics of *I* and Z are coherent and quite homogenous.

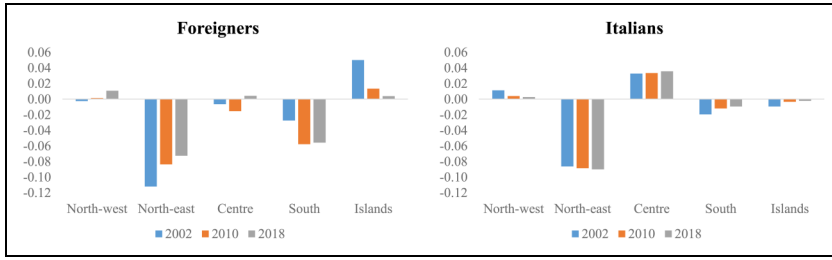

Figure 2. The distribution of the *G* index relative to Italians and foreigners in each macro-area with respect to Italy 2002, 2010, and 2018.
Source: Our elaboration on Istat data.

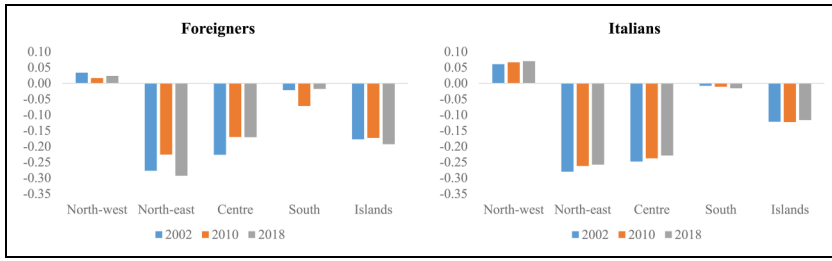

Figure 3. Moran's *I* for foreigners and Italians in each macro-area compared to the country area. 2002, 2010, and 2018.
Source: our elaboration on Istat data.

The two populations follow the same trajectories as far as spatial polarization is concerned. In fact, the level of polarization is higher in all the macro-regions compared with the national level for both populations and for each year. North-Western Italy was the only exception for both populations (Figure 3). On the basis of these results, looking at only one (statistical or geographical) dimension of territorial concentration would lead to partial (and potentially inconsistent) interpretations.

5.2. Local Regression Models

In the interpretation of the output of the models (global and local), it is important to bear in mind the variables (dependent and independents) have been standardized to a Z distribution so that $\mu = 0$ and $\sigma = 1$. The relationship between the population density of foreigners (dependent variable, Foreign Population Density, FPD) and predictors (Italian Population Density, IPD, and elevation) was investigated for local effects. We additionally estimated a (spatially implicit) global regression (OLS) serving as a benchmark for local models. The results are shown in Table 1 demonstrate that GWRs outperform OLS estimation (the Akaike's information criterion

Table 1. Results of OLS and GWR Models for the Dependent Variable FPD (2002, 2010, and 2018).

		GWR					
2002	OLS	Min	Median	Mean	Max	SD	Bandwidth[(b)]
Intercept[(a)]	0.000[n.s.]	−64.048	−0.023	0.068	25.179	2.21	47
IPD[(a)]	0.624***	−0.045	0.979	1.047	5.625	0.693	47
Elevation[(a)]	−0.076***	−54.395	−0.005	0.012	28.468	2.075	47

Abbreviations: OLS = Ordinary Least Squares; GWR = Geographically Weighted Regression; AICc = Akaike's information criterion with correction.
OLS model results: AICc = 18138.7; Adj-R^2 = .419; Moran $I_{\_OLS\_res}$ = 0.147***
GWR model results: AICc = 8864.0; Adj-R^2 = .841; Moran $I_{\_GWR\_res}$ = −0.000[n.s.].
Spatial kernel = adaptive bi-square; (*p < .05; **p < .01; ***p < .001; n.s.= not significant).
Criterion for optimal bandwidth: AICc.
[(a)]Monte Carlo significance test for spatial variability p < .001. Monte Carlo tests are based on 1,000 randomizations of the data.
[(b)]Number of municipalities (number of nearest neighbors for each location).

		GWR					
2010	OLS	Min	Median	Mean	Max	SD	Bandwidth[(b)]
Intercept[(a)]	0.000[n.s.]	−36.367	−0.011	−0.012	13.908	1.378	61
IPD[(a)]	0.640***	−0.010	1.134	1.120	4.445	0.673	61
Elevation[(a)]	−0.086***	−30.922	−0.007	−0.089	12.154	1.356	61

OLS model results: AICc = 17773.4; Adj-R^2 = .445; Moran $I_{\_OLS\_res}$ = 0.161***
GWR model results: AICc = 8685.6; Adj-R^2 = .862; Moran $I_{\_GWR\_res}$ = −0.000[n.s.].
Spatial kernel = adaptive bi-square; (*p < .05; **p < .01; ***p < .001; n.s.= not significant).
Criterion for optimal bandwidth: AICc.
[(a)]Monte Carlo significance test for spatial variability p < .001. Monte Carlo tests are based on 1,000 randomizations of the data.
[(b)]Number of municipalities (number of nearest neighbors for each location).

		GWR					
2018	OLS	Min	Median	Mean	Max	SD	Bandwidth[(b)]
Intercept[(a)]	0.000[n.s.]	−11.555	−0.026	−0.101	6.323	0.787	97
IPD[(a)]	0.690***	0.072	1.024	1.013	2.703	0.512	97
Elevation[(a)]	−0.054***	−12.539	−0.005	−0.149	5.314	0.838	97

Source: Our elaboration on Istat data.
Abbreviations: OLS = Ordinary Least Squares; GWR = Geographically Weighted Regression; AICc = Akaike's information criterion with correction.
OLS model results: AICc = 16985.8; Adj-R^2 = .498; Moran $I_{\_OLS\_res}$ = 0.109***
GWR model results: AICc = 9363.3; Adj-R^2 = 0.822; Moran $I_{\_GWR\_res}$ = 0.002[n.s.].
Spatial kernel = adaptive bi-square; (*p < .05; **p < .01; ***p < .001; n.s.= not significant).
Criterion for optimal bandwidth: AICc.
[(a)]Monte Carlo significance test for spatial variability p < .001. Monte Carlo tests are based on 1,000 randomizations of the data.
[(b)]Number of municipalities (number of nearest neighbors for each location).

with correction [AICc] of the first model is lower than that of the OLS model) for all years. The adjusted R^2 was systematically higher in GWR compared to OLS models (ranging between 0.4 and 0.5 for OLS and between 0.8 and 0.9 for GWR). A significant spatial autocorrelation of regression residuals was systematically observed for OLS models and was found insignificant for GWRs. Global models delineate a positive relationship between the density of foreigners and Italians. This effect increased markedly over time, being the highest in 2018. The relationship between the density of foreigners and elevation is, on the contrary, negative although quite low and stable over time (0.07, 0.08, and 0.05). With regard to the first predictor, IPD, the same trend of the global coefficients was observed with the local ones derived from GWR. This means that the Italian population density gains importance when modeling the population density of foreigners from 2010 to 2018, likely indicating the existence of a sort of density-dependent process (Polinesi et al. 2020).

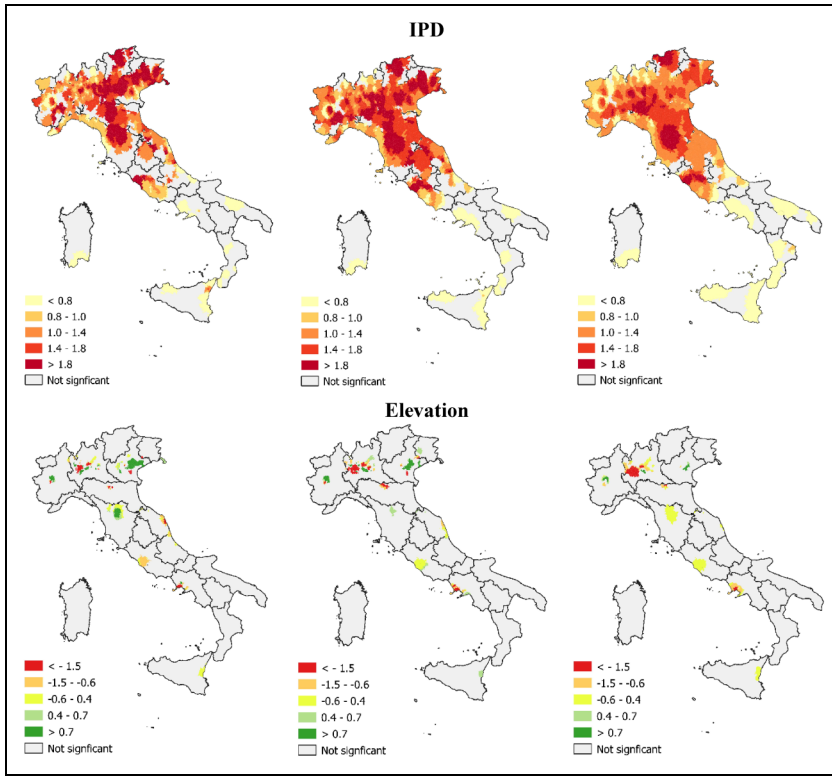

Figure 4. Maps illustrating the spatial distribution of local regression coefficients (municipal level, GWR models in Table 1), 2002 (left), 2010 (middle), and 2018 (right). Palette values indicate the absolute coefficient value when the estimate is significant ($p < .05$), otherwise the coefficient's value is reported as not significant.
Source: Our elaboration on Istat data.

As far as the bandwidth estimation in GWR, following Sachdeva and Fotheringham (2020), spatial weighting kernels can be defined as "fixed" or "adaptive." Fixed kernels have the same rate of distance-decay for all locations whereas adaptive kernels have different rates of distance-decay depending on the density of data points in the vicinity of the regression point. Depending on the choice of the kernel, the bandwidth is typically defined as either the distance at which weights fall below a certain value (fixed) or the number of nearest neighbors from the regression point which receive a non-zero weight in the local regressions (adaptive). Adaptive bi-square kernel is more favorable when dealing, such as in our case, with non-uniform spatial distributions of observations (i.e., centroids of each municipality in the present study). Moreover, it is also able to better handle irregularly shaped study areas (Oshan et al. 2019). These are the two basic reasons why we chose this type of spatial weighting kernels. In the case of the adaptive kernel, the bandwidth represents the number of nearest neighbors from the regression point which receive a non-zero weight in the local regressions (i.e., the ones which are considered as neighbors to i). Following Sachdeva and Fotheringham (2020), the optimal bandwidth selection is a trade-off between bias and variance. In particular, the selection of the bandwidth parameter is based on statistical optimization criteria like Akaike Information Criteria (Fotheringham, Brunsdon, and Charlton 2002; Yu et al. 2020). The bandwidth parameter is an indicator of the spatial scale over which the processes under observation operate. In our case, the procedure identifies a relatively small (optimal) bandwidth in 2002, 47 municipalities, which indicates local processes that vary significantly across Italy. Nevertheless, this number increases over time: 61 in 2010 and 97 in 2018 indicating a process of regionalization (Yang et al. 2022a, 2022b).

Figure 4 shows the geographical distribution of the local parameters estimations in 2002, 2010, and 2018. With reference to IPD, local effects are statistically insignificant almost everywhere in Italy, especially in Central and Northern Italy. In Southern Italy, local estimations were statistically significant within the metropolitan regions of Cagliari (Sardinia), Palermo, Messina, and Catania (Sicily), Reggio Calabria (Calabria), Naples (Campania), and Bari (Apulia). These spatial patterns were basically time-invariant, increasing the net effects everywhere, and indicating how the territorial concentration of foreigners is essentially influenced by urbanization in Southern Italy. This phenomenon is partly valid also in the rest of Italy, although with a less clear spatial pattern. The net impact of the Rome metropolitan area was quite clear while, at least in part, counterbalanced with a "coastal" effect on the east border of Italy — from Abruzzo to Emilia Romagna. Stronger effects, however, were registered in both 2010 and in 2018 across the major urban structure of Italy, moving from Florence to Bologna and Milan, and all over the so-called Po Plain (from Turin to Venice). The effects in the Veneto region were also intense. These patterns became clearer in 2018. Negative (or slightly positive) impacts in 2018 were observed in Southern Italy. Competition for space in this part of Italy affects foreigners and Italians in different ways since these two populations tend to

assume different spatial configurations as a possible response to the recession — producing deeper changes in more fragile local contexts. Local regression coefficients for elevation follow a quite peculiar spatial distribution, with statistically significant local effects being localized in specific areas of the country. Additionally, while the global estimates are negative, this is not always true for local estimates, reaching highly positive values in some specific locations (as we can see from the map and the values of the "Max" parameter in Table 1). The negative estimates (red polygons) initially concerned the municipality of Milan and its peripheral crown (2002), expanding over the next two observation years, and involving in turn other metropolitan cities such as Naples and, to a lesser extent, Rome. It would therefore seem that in these cities, where the foreign presence is comparatively high, the low elevation correlates with lower values of the density of foreigners.

6. Discussion and Conclusions

One of the main concerns in the literature regarding human population distribution is the discussion of the surrounding patterns and the factors that determine their concentration (Mucciardi 2021). In this article, we have developed a reflection that embraces alternative approaches in conceptualizing the spatial engagement of any process of population settlement (Colombo and Sciortino 2004). More specifically, we have explored the spatio-temporal evolution of the territorial concentration of foreigners in Italy, adopting an original approach based on the integration of statistical and geographical analysis (Salvati 2014). Our results emphasize the importance of multiple approaches when measuring the territorial concentration of foreigners and comparing it with the concentration of nationals (Ascolani and Baldini 2007).

The concentration of foreigners over space, as measured by Gini index, decreased between 2002 and 2018, and faced a more stable concentration of the Italian population. On a national scale, an increase in the foreign population corresponded to a decrease in its territorial concentration, with a relatively high level of heterogeneity among regions (Strozza et al. 2016). From a geographical point of view, the reverse trend was observed in terms of demographic polarization (Tragaki and Rovolis 2014). So, if we interpret territorial concentration as a "pure" spatial process (e.g., Goerlich and Mas 2008), we should conclude that in the case of Italy — and in all macro-regions of the country — the level of concentration was increasing over time for both Italians and foreigners. Spatial heterogeneity can be related to the fact that Northern Italy is more attractive for international migration because it is more dynamic from an economic point of view (Fratesi and Percoco 2014). Conversely, foreigners' density was less intense in the rest of the country (Reyneri 2003).

Another issue was related to the urban structure since Northern Italy is characterized by a polycentric system with high levels of connection between cities such as Milan, Turin, Genoa, Venice, and Bologna (Ciommi et al. 2018). In Southern Italy, urban structures are relatively mono-centric, with some big cities, Naples above all, dominating the metropolitan hierarchy and rather disconnected from the

remaining urban nuclei. Central Italy assumed an intermediate position, with some contexts (Tuscany) being oriented to polycentrism and other contexts (Latium) being clearly mono-centric (Burgalassi 2010; Salvati 2014; Ganciu et al. 2018). These results demonstrate the importance of using the two concepts of territorial concentration (statistic and geographical) simultaneously (Musterd 2005).

Alongside the first finding, the relationship between the population densities of foreigners and Italians confirms the importance of the local scale for understanding the mechanism of density-dependent processes of population regulation in Italy (e.g., Polinesi et al. 2020). In urban areas, in both Southern and Northern Italy, the population densities of foreigners are positively correlated with those of Italians (Basile et al. 2018). However, this relationship was strictly dependent on local contexts, being statistically significant in metropolitan Italy only, and suggests the different use of space by national and foreign citizens in strictly rural and intermediate areas. Dual use of Italian space (urban versus rural) could be detrimental to social cohesion (Salvati and Carlucci 2016). Considering the economic dimension suggests that the residential geography of the foreigners is labor-oriented (Carlucci et al. 2018). Similarly, to other countries in both Southern and Western Europe (Goerlich and Mas 2008; Fratesi and Percoco 2014; Lloyd 2016), this implies that if we want to have a more balanced population distribution and lower levels of spatial concentration of foreigners, we should reduce the economic gap and the inherent social divide between different parts of the country.

It is important to draw attention to two main limitations of this contribution, which, however, may represent a stimulus for future research developments. The analysis conducted refers to the foreign population as a whole. However, as widely demonstrated in several studies carried out in Italy at different geographical scales (Strozza et al. 2016; Benassi, Lipizzi, and Strozza 2019), settlement patterns vary greatly in relation to citizenship. Some communities, typically those from Eastern Europe (EU and non-EU), tend in fact to have rather widespread settlement patterns. These communities are contrasted by others that are characterized by adopting concentrated settlement patterns, such as some communities in North Africa and Asia, or of the clustered dispersed type, the Chinese community. What we see in this contribution is therefore a kind of average behavior that, as mentioned, is the result of settlement patterns that are also very different and articulated. If, therefore, on the one hand, the results should be read with some caution, on the other hand, they allow us to appreciate certain aspects that would otherwise be difficult to observe due to the high fragmentation of the foreign population in terms of individual communities.

A second major limitation lies in the effects of the citizenship acquisition process on settlement geographies and, therefore, on the level of concentration of both "new" Italians and foreigners. Indeed, in the past decade, the acquisition of Italian citizenship raised significantly: at the beginning of 2020, it is estimated about 1.5 million Italian residents who were not at birth (Barbiano di Belgiojoso and Ortensi 2022; Strozza, Conti, and Tucci 2021). It is reasonable to assume that this collective has a specific geographical distribution over the Italian territory so that, for instance,

the new Italians in Central-Northern Italy, comparatively more numerous than in the South, can play a role in foreign population dynamics.

One of the possible future developments of the study could be to assess how the phenomenon of new Italian citizens (acquisition of Italian citizenship by foreign immigrants) has affected the process of foreign population concentration, especially in the last decade. In fact, it would be interesting to assess whether new Italian citizens have a settlement pattern different from the average one of foreigners and in which territories this diversity, if any, manifests itself in a more relevant way. These findings provide valuable information on the processes of adaptation to the host society from a territorial point of view.

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ORCID iD


Federico Benassi https://orcid.org/0000-0002-8861-9996

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