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Neighbourhood effects and determinants of population changes in Italy: A spatial perspective

Federico Benassi[1], ***Annalisa Busetta***[2], ***Gerardo Gallo***[3], ***and Manuela Stranges***[4,*]

Abstract

Population trends in Italy are strongly spatially differentiated, with some municipalities showing a systematic loss of population, and others showing an equally continuous demographic increase. Here, we focus our attention on the spatial dimension of population change, looking at how different socio-economic and demographic dimensions affect population changes, as well as their spatial effects. After performing a preliminary descriptive analysis of the trends of population growth and decline in Italy over the last 40 years and the relevant demographic components, we used a spatial Durbin model (SDM) to investigate the potential existence of a diffusion process and the determinants of the average annual growth rate between 2011 and 2019 at the municipal level. The spatial dimension and local heterogeneities in Italy were found to be highly relevant in the analysis of population decline. Moreover, we examined the relationship between demographic, social and economic factors and the demographic growth/decline of municipalities in the subsequent 10 years. Among the different covariates included in the model, the demographic composition of the population, the female activity rate, the youth employment rate and the presence/absence of a school proved to be strongly related to population growth and decline in Italian municipalities.

Keywords: Italy; spatial Durbin model; spatial demography; local analysis; municipalities

[1]University of Naples Federico II, Department of Political Sciences, Naples, Italy

[2]University of Palermo, Department of Economics, Business and Statistics, Palermo, Italy

[3]Italian National Institute of Statistics (ISTAT), Department for Statistical Production, Directorate of Population Statistics, Social Surveys and Permanent Population Census, Rome, Italy

[4]University of Calabria, Department of Economics, Statistics and Finance "Giovanni Anania", Arcavacata di Rende (CS), Italy

[*]Correspondence to: Manuela Stranges, manuela.stranges@unical.it

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1 Introduction

In 2007, Reher stated that a decline in population would be the 'key social issue of the twenty-first century' (p. 189). Indeed, the fear of population decline is as old as states themselves, because it has always been considered both a symptom and a cause of failure and weakness (Coleman and Rowthorn, 2011). Most European countries are experiencing demographic decline, especially in their rural territories (Copus et al., 2011), i.e., in the so-called 'shrinking regions' (Espon, 2017; Hospers, 2011). The demographic and territorial landscapes of Italy are shaped by such regions, which should be taken into account when considering the effects of these shrinking places (Del Panta and Detti, 2019). In this paper, we employ the concept of the spatial diffusion process (i.e., spatial contagion) based upon the concept of the first law of geography: namely, that 'everything is related to everything else, but near things are more related than distant things' (Tobler, 1970). This law can be considered the theoretical background to all spatial diffusion process theories (Benassi and Iglesias-Pascual, 2022).

After providing a brief description of the evolution of the average annual growth rates of Italian municipalities from 1981 to 2019, we apply a spatial Durbin model (SDM) to explore how different demographic and socio-economic dimensions are related to each municipality's population growth and decline over the years 2011–2019, considering the direct and the indirect spatial effects of the dependent and independent variables. Our contribution seeks to improve our knowledge of the process of population growth and decline in Italian municipalities by applying a pure spatial analysis approach at a very fine scale. To the best of our knowledge, the SDM has not been previously used to explore population changes in Italy. Other works have used a spatial approach to explore population change in Italy, but the method we apply is original, because it allows for the measurement of the direct and indirect spatial effects (spatially lagged) of the dependent and independent variables on the demographic growth of the population at the municipal level. Thus, our approach may help to clarify the spatial link between all of the variables included in the model.

Italy appears to be characterised by a dual spatial demographic system in which some territorial contexts—typically the large urban centres and their surrounding areas, especially those located in the north of the country—still attract populations from other Italian contexts (internal migration) as well as from abroad (international migration), resulting in systematic demographic growth (Benassi et al., 2019; Strozza et al., 2016); while other territorial contexts, including an increasing number of medium-sized and small municipalities that are located far from the large urban centres and/or that have a low level of accessibility—typically located in southern Italy, and very often in mountainous or inland areas—are characterised by a systematic loss of population due to a negative natural balance and a zero or, as is the case in most of these municipalities, a negative migration balance (Benassi et al., 2021, 2023; Reynaud et al., 2020).

Thus, in Italy, the concept of spatial diffusion is highly relevant (Morrill et al., 1988). According to this concept, the diffusion through space of a given behaviour (demographic decline for example) can occur by contagion (Doignon et al., 2021; Iglesias-Pascual et al., 2022; Morrill et al., 1988; Saint-Julien, 2007). Understanding the spatial dynamics of population growth and decline in Italy is important because both processes have strong policy implications with a wide range of potential consequences (Elshof et al., 2014) that need to be carefully considered by governments. Most rich countries are facing population decline and ageing, albeit with strong heterogeneities between geographical domains within each country.[1] While these countries will have to cope with low fertility and population ageing, the policies aimed at addressing these challenges are still evolving, and often lack a spatial dimension (Ezeh et al., 2012). Daugirdas and Pociute-Sereikiene (2018), focusing on Lithuania, have underlined that depopulation can lead to a decline in social networks and a growing number of social problems, including the social and territorial exclusion of residents and a lack of investment in the peripheral areas. Additionally, population decline is often accompanied by the structural ageing of the population, which has significant consequences for economic growth (Nagarajan et al., 2016). Reynaud et al. (2020), focusing on Italy, have demonstrated that the depopulation process, measured at the municipal level by a simultaneous equation system, is deeply affected by territorial factors, which are often overlooked in analyses of the spatial linkages between depopulation and the local context. In particular, previous results have shown that territorial factors—and especially altitude—greatly affected depopulation rates at the local scale, and that municipalities with a declining population at a given time were more likely to also experience depopulation in the subsequent decade. In their conclusion, the authors called for more refined spatial analysis of the depopulation process in Italy. Thus, our work can contribute to the literature on depopulation by helping to shed light on the peculiarities of the phenomenon within Italy by analysing which factors are related to population decline using a spatial approach that aims to improve our understanding of the spatial patterns of both the dependent and the independent variables.

The remainder of this paper is structured as follows. In Section 2, we review the prominent literature about population decline/growth in Europe and Italy and the determinants of these trends, while in Section 3 we describe our research objective, the data used and the methods applied. In Section 4, we provide descriptive findings on the demographic dynamics of Italy over the last 40 years, which can be useful for framing the current Italian situation. In Section 5, we present the empirical results of the spatial model. Finally, in the last section, we discuss the results and draw some conclusions based on our findings.

[1] For an analysis of the regional convergence in the process of population ageing across Europe, see Kashnitsky et al. (2017).

2 Literature review

2.1 Heterogeneities in population growth and decline in Europe and in Italy

As the number of rich countries and regions across the world that report a decline in population is growing, over the past decade, both scholars and public policymakers have become increasingly interested in this issue. Both population growth and decline have strong policy implications. Population decline can have a very wide range of consequences (Elshof et al., 2014). Europe is currently experiencing a phase of population decline, which will, according to the latest projections (United Nations, 2022, medium variant), lead to a decrease in the population size of over 21% (157 million inhabitants) by 2100. However, the level of population decline is not uniform across territories (i.e., it is spatially biased), as there are noteworthy differences in the rates and the directions of population change both between countries and between regions and small areas within each country. These diverging trends are expected to continue into the future, which will likely exacerbate current regional and national demographic inequalities (Newsham and Rowe, 2022), thereby reinforcing the idea that dual spatial demographic contexts are detrimental to the construction of a cohesive society (Lobao and Saenz, 2002). All demographic phenomena in Europe, including fertility, are highly heterogeneous at the subnational level. Klüsener et al. (2013a) have investigated the role of states and regions in shaping spatial patterns of nonmarital fertility in Europe since 1960 using a dataset of 497 European subnational regions and smaller countries, and found that the role of states relative to the role of regions declined in the latest period examined (between 1990 and 2007). Among the possible explanations for these changes are increased supranational integration, such as within the European Union; and decentralisation within states leading to increases in variation in subnational contextual conditions.

In the literature, analyses of the patterns of growth and depopulation typically distinguish between rural and urban contexts, as these phenomena tend to be driven by different factors in each of these two contexts. There may be a mutual relationship between urban and rural dynamics, as the decrease in population often leads to migration to urban areas and a parallel exodus from rural areas (Christiaans, 2017), most studies have concentrated exclusively on rural (Kuczabski and Michalski, 2013; Pužulis and Kūle, 2016; Wojewódzka-Wiewiórska, 2019) or urban decline (Haase et al., 2016; Wolff and Wiechmann, 2018). Kabisch and Haase (2011) examined urban population trends in 21st century Europe, and found that the urban agglomerations they studied had not reached a single evolutionary stage of urban development. In particular, the authors observed that thus far in the 21st century, urban revival or reurbanisation has led to population increases in the inner parts of cities, despite ongoing suburbanisation trends; and that, albeit to a smaller extent, a process of desurbanisation has been occurring. Additionally, they found an increase of agglomerations in the urbanisation stage, which has led to an obvious trend towards reurbanisation and urbanisation occurring in parallel. The persistence of a sharp rural–urban dichotomy in research on population decline compounds the problem of a lack of large-scale studies on the topic, as most of the previous research on this issue has consisted of small-scale case studies that provided highly specific accounts of localised population declines (Newsham and Rowe, 2022). Although the urban–rural pattern (in which the urban areas gain population due to people leaving rural areas) is dominant, some studies have noted that not all rural areas are declining at the same pace (Bryden and Munro, 2000). Rizzo (2016), focusing on southern Italy, found that there are some rural areas that have been able to maintain slow population growth. Many of these territories, which have been labelled 'Territori Lenti' (slow territories) (Lanciarini, 2005; Lanzani, 2005), have grown due to large investments in the agritourism sector. Similarly, Collantes et al. (2014), focusing on Spain, found that mass immigration to rural areas before 2008 has contributed considerably to a deceleration of depopulation in these places. Indeed, in some rural areas, immigration flows have actually reversed the previous population trends after decades of steady decline. An important aspect of rural depopulation that policymakers are increasingly taking into account is that moving behaviours are selective (Elshof et al., 2014). It has, for example, been shown that young adults, especially the more talented ones, are more likely than other population groups to leave their area of origin to pursue education or employment opportunities (Rees et al., 1997; Zelinsky, 1971).

Currently, given the spread of communication technologies and the process of space shrinkage (Kirsch, 1995), we believe that scholars should move beyond a focus on urban and rural contexts when studying depopulation. As Reynaud et al. (2020) has emphasised, certain geographical variables of municipalities (e.g., the altitude and the distance from the sea) are crucial in influencing (in negative terms) demographic dynamics, and cannot be easily changed by technological improvements. For this reason, our analysis refers to all Italian municipalities, but considers their spatial attributes by using a spatial weight matrix (i.e., defining a spatial neighbourhood structure). In doing so, we seek to answer the question of whether it makes sense to speak about the existence of a process of spatial diffusion of demographic growth and decline among Italian municipalities.

Within the European context, Italy has always been characterised by demographic and socio-economic territorial divisions. These differences are so deeply rooted that Bagnasco (1977) coined the term 'Tre Italie' to explain the diverging economic development of the Italian macro regions (north, centre and south). Understanding these differences is also important when considering demographic behaviours in relation to both fertility and mortality on the one hand, and migration on the other. In an analysis of the demography of Italian regions, Bonaguidi (1985) found substantial differences in the demographic characteristics of the central and the northern areas of Italy and the southern areas of the country (Dunford, 2002).

Regarding depopulation processes, previous studies conducted at the municipal level in Italy have shown that some municipalities have 'more dynamic' situations, whereas others are characterised by demographic malaise, and are thus becoming smaller and more peripheral (Golini et al., 2000; Reynaud et al., 2020). These processes can lead to a sort of vicious circle of (demographic) marginality that is, to some extent, auto-propulsive and spatially dependent. Benassi et al. (2023) studied the evolution of municipalities in Italy by analysing their levels of growth/decline in four subsequent periods of time over the last 40 years (1981–2019). They found that the number of municipalities that experienced a light or an intense process of demographic decline increased over time through the dynamics of spatial contagion. The authors also calculated the value of global Moran's *I* (1948), and found a positive global spatial correlation in all four periods considered (similar positive or negative values for the average growth rates tended to be spatially clustered). They also showed that the index increased from 0.401 in 1981–1991 to 0.436 in 2011–2019. Based on the local version of the Moran's *I* index (Anselin, 1995), Benassi et al. (2023) also classified each municipality according to their growth rate and the growth rate of the surrounding municipalities, and found an acceleration of spatial clustering. More specifically, they observed that in the last period they considered (2011–2019), the urban and the metropolitan spatial plots expanded, especially in the centre–north, while the areas where municipalities had low growth rates were surrounded by areas where municipalities were distributed more widely, but were circumscribed by precise geographical logics: e.g., the inland territories of Sardinia and Sicily, the Apennine ridge, and the inland areas of Liguria and Emilia near the Apennines and Alpine border areas.

2.2 The determinants of population growth and decline

Most previous studies on population decline concentrated on the levels of depopulation or on the consequences of the process, while failing to acknowledge the process through which decline unfolds (Newsham and Rowe, 2022) and the determinants of that process. Regardless of the territorial scale at which population decline is observed, it is clear that it can be caused by a wide variety of factors (Elshof et al., 2014). Population decline is, indeed, a complex phenomenon that is influenced by a range of political, economic and social factors (Haase et al., 2016). Because of this complexity, population decline can be difficult to predict (Ubarevičiene et al., 2016).

From a strictly demographic point of view, natural decline and negative net migration are the two main factors that lead to population decline. These two trends are intertwined, and, as is well known, each can hasten the other. One of the most frequently studied factors that can contribute to an uneven process of population change is the population age structure (Ubarevičiene et al., 2016). The age distribution of a population reflects many other aspects relevant to its growth or decline, such as its labour market potential and its reproduction capacity. The ageing of rural populations and rapid declines in population size in rural areas are frequently caused by the selective migration of particular age groups (Burholt and Dobbs, 2012; Walford and Kurek, 2008). In a recent contribution on migration, Bagavos (2022) found that the presence of a foreign-born population attenuated population decline trends in eastern and southern European countries, and that it was a driver of population growth in a very limited number of countries. More importantly, Bagavos showed that in western European and Nordic countries, the presence of a foreign-born population turned the expected process of population decline into population growth. The author concluded that the foreign-born population has helped to drive overall population change and growth in Europe, and that this effect is mainly attributable to net migration, rather than to natural change in the migrant population.

In addition to demographic dynamics and structures, economic factors also play a very important role in population decline. Economic decline is often a precursor to population decline, but both processes can become part of a vicious circle (Ubarevičienė and van Ham, 2017) that leads to a downward spiral of the local economy characterised by a decline in tax revenues, service provision and social infrastructure, and the abandonment of homes and factories (Elshof et al., 2014). In the debate about the link between patterns of growth in rural and urban territories discussed in the previous subsection, it clearly emerges that urban areas are often more attractive because they offer more social and economic opportunities and provide more services for families and individuals than rural areas. Younger age groups are more prevalent in inner-city neighbourhoods, which typically have more sustainable economic and cultural conditions (Ubarevičiene et al., 2016).

Generally speaking, the socio-economic conditions of the different areas are important drivers of the inflow or the outflow of people. According to the neoclassical economic model, most internal migration is a response to job and educational opportunities (Ní Laoire, 2000; Stockdale, 2004). Average salaries, the educational level of the population, the size and the structure of the labour market, the unemployment rate, the number of businesses per capita, the level of foreign investment, and family dynamics or a desire to live in a better environment are the main specific factors identified in the literature as drivers of internal migration (Biagi et al., 2011; Niedomysl, 2008, 2011; Nivalainen, 2004; Schmidt, 2011; Tammaru and Sjöberg, 1999; Ubarevičienė and van Ham, 2017; Westlund and Pichler, 2013).

Among the other social factors related to population decline, some studies have specifically investigated the impact of the proximity of primary schools on the depopulation of inland areas, and have reported contradictory results. Although theoretical considerations suggest that rural school closures will lead to local population decline, most studies have found that school closures have no statistically significant effects or only small effects on population. In an early US study, Johnson (1978) examined four elementary school closures in the Seattle school district, and found ‘virtually no evidence of community deterioration associated with the closure decisions’ (p. 357). Amcoff’s (2012) analyses of 236 rural school closures in Sweden during the 1990–2004 period were based on migration data recorded in the areas around each school. He concluded that there were ‘no statistically significant effects of the closing of rural schools [. . .] on the migration patterns in the schools’ surroundings’ (p. 58). Elshof et al. (2015) analysed population register data from 553 rural villages in the north of the Netherlands during the 1996–2011 period to determine the impact of the absence or the closures of primary schools in rural villages on the in- and outflows of families with children. They concluded that 'villages without a primary school, and villages that have experienced the closure of a primary school, have similar influx, but larger outward flows of families with children compared with villages with a primary school' (p. 625). By contrast, Barakat (2015), studying the province of Saxony in East Germany for the 1994–2007 period, found little evidence of a relevant effect of primary school closures on local population decline, and concluded that expectations of a dramatic impact of school closures on out-migration lack a theoretical foundation.

A recent study by Kroismayr (2019) explored the demographic, economic and social trends in Austrian municipalities in which at least one primary school was closed between 2001 and 2014. Kroismayr investigated the importance of distinguishing between municipalities that had lost their last school and those that still had a school. Surprisingly, he showed that 'the municipalities which closed their last school were not as badly affected as the concept of the downward spiral would imply, as in our sample the municipalities with one remaining school suffered a much greater loss in the number of families and births'. Thus, he concluded that the presence of a school was of negligible importance. He also showed that the municipalities adopted different coping strategies, and that in most cases, the decline in population was caused by out-migration, rather than by a decline in birth numbers. In particular, he maintained that the populations of inland rural areas were very settled, especially in places where a higher share of the population was working in agriculture. He attributed this pattern to people working in agriculture being less mobile (being reluctant to leave the rural area) and to having more than the average number of children. The study concluded that the depopulation trend may have been even more pronounced in the municipalities in which the share of the population working in agriculture was not high.

Recently, two different studies found that school closures had a statistically significant population effect. In particular, Lehtonen (2021) found a clear negative population effect of rural school closures. His results came from analyses of population data of the areas surrounding (within 5–10 km) municipalities in Finland where 518 schools were closed between 2011 and 2018. Along the same lines, a study by Sørensen et al. (2021) focused on the effects of rural school closures in 2011 on population levels in municipalities in Denmark in the 10 years after the school closures. They concluded that the school closures had a negative effect on the populations of local communities. The authors sought to explain why their results contradicted those of the previous literature by noting that whereas most of the other quantitative studies considered municipalities as the unit of analysis, their analysis considered the communities surrounding the school (Lehtonen, 2021; Sørensen et al., 2021), and used a longer time span (Sørensen et al., 2021).

3 Research objectives, data and methods

Our literature review has provided some key insights: first, that demographic phenomena in Europe are characterised by strong heterogeneities; second, that the traditional urban–rural divide in population growth or decline must be revised, as not all rural areas are declining at the same pace, and trends can vary across neighbouring municipalities even within urban areas; and, third, that individualised factors can affect the growth and the decline of the populations of different territories.

In line with these findings, we first describe the annual growth rates of Italian municipalities from 1981 to 2019 to reveal the existence of territorial heterogeneities at a municipal level, and to determine whether urban and rural areas display consistent patterns. We then concentrate on our main research objective, which is to individualise the demographic, social and economic factors related to the growth and the decline of population at the municipal level. To realise this objective while considering the spatial dimension, we apply the SDM (Elhorst, 2014).[2]

The SDM is the model that is most compatible with the concept of (spatial) diffusion processes, because it implies that the neighbourhood structure has an influence that is not simply assumed, but that can actually be estimated. It is important to clarify that these spatial lag models are designed to produce indirect evidence of diffusion in cross-sectional data (as in our case). This type of model has recently been used in other demographic studies that investigated the geographical variation in fertility and international migration in Spain (Sabater and Graham, 2019); the diffusion patterns of fertility in Italy at the sub-regional level (Benassi and Carella, 2022; Vitali and Billari, 2017); and the geographical variation of mortality rates in the United States (Yang et al., 2015).

The quantitative analysis was carried out on a dependent variable and a set of covariates. The variables were computed at the local (municipality) scale. The dependent variable was the annual growth rate (‰) of the population for the 2011–2019 period. The covariates referred to 2011 values.

For the computation of the dependent variable, we used population data from the 2011 Population and Housing Census and the 2019 pre-census data from population

[2] For the sake of brevity, we present here only the results of this model, although we actually estimated four different models: ordinary least squares (OLS), a spatial error model (SEM), spatial autoregressive models (SAR) and a spatial Durbin model (SDM). The classical OLS was estimated only in order to have a benchmark model, as it allowed us to evaluate the coefficients, but it did not account for any spatial effect. Between the three spatial models we estimated (SEM, SAR and SDM), we opted for the SDM because, as is explained in the text, it was the best from a formal and a substantive point of view at describing the spatial diffusion process of population growth and decline in Italy, as it allowed us to include the lagged values of the covariates. In comparing the four methods, we can see that even though the results of the different models clearly differed, there were no noteworthy variations in the signs of relationship of the covariates. We also computed some fitting indices, such as the Akaike Information Criterion (AIC) (Akaike, 1973, 1974), and the SDM proved to be the model that best fit our data. All of the results of the other three methods are available from the authors upon reasonable request.

registers. We chose to use data from pre-census population registers instead of data from the permanent census or the revised population registers for reasons of internal coherence. It is important to note that the permanent Italian census data represent a temporal break in the series of population census data, as they mark the first time in Italian history that census data have been collected without using a traditional approach. All of the data, including the geographical data (shape files), were downloaded from the Istat website. In the SDM, the regression coefficients are decomposed into direct and indirect (spatial spillovers) effects (Golgher and Voss, 2016). The direct effect 'represents the expected average change across all observations for the dependent variable in a particular region due to an increase of one unit for a specific explanatory variable in this region' (p. 185); while the indirect effect 'represents the changes in the dependent variable of a particular region arising from a one-unit increase in an explanatory variable in another region' (p. 185).

The SDM improves on other spatial models, such as the spatial autoregressive model (SAR), by including not only a spatial lagging of the dependent variable, which captures the effect of spatial contagion of y on itself, but also a spatial lagging of all of the independent variables. In our case, the spatial lagging of the explanatory variables was added so that the characteristics of neighbouring municipalities could have an influence on the annual growth rate of each municipality under analysis. Thus, the SDM allowed for the annual growth rates of the neighbouring municipalities, in addition to their structural characteristics, to determine the growth rate of a municipality. Following Yang et al. (2015), a generic SDM can be written as:

$$y = \rho W_y + \alpha l_n + X\beta + WX\theta + \varepsilon, \quad \varepsilon \sim N(0, \sigma^2 I_n) \tag{1}$$

where y denotes an $n \times 1$ vector of the dependent variable; W is the spatial weight matrix; W_y represents the spatial lagged variable (endogenous interaction relationship); and ρ denotes the effect of W_y, which is known as the spatial autoregressive coefficient. l_n indicates an $n \times 1$ vector of those variables associated with the intercept parameter α. X represents an nxk matrix of k explanatory variables, which are related to the parameter β. WX reflects the spatial lagged explanatory variables (exogenous interaction relationships), and θ denotes a $kx1$ vector of the effects of WX. The error term, ε, follows a normal distribution with a mean of 0 and a variance $\sigma^2 I_n$, where I_n is an nxn identity matrix. The model had been estimated by the maximum likelihood estimation method (Anselin and Rey, 2010).

More specifically, we used a SDM in which the dependent variable (the annual average growth rate of each municipality in the last period, 2011–2019) was placed in relation both to the same 'spatially lagged' variable y (Anselin, 2001; Matthews and Parker, 2013) and a set of covariates measured in 2011 and their spatially lagged values. The independent variables included in the model were linked to four conceptual dimensions associated with depopulation, each of which included a certain number of variables:

(1) demographic aspects: the variables considered in this dimension are the 'percentage of the population under 6 years old' (%), the 'percentage of the population over 75 years old' (%) and the 'percentage of foreign people' (%);

(2) socio-economic mobility: the variables considered in this dimension are the 'percentage of youth living alone' (%), the 'study/work mobility' (measured as the percentage ratio between the resident population who commute daily from their usual residence to their place of work or study and the resident population aged up to 64 years), the 'female activity rate' (%) and the 'youth (15–29 years old) employment rate' (%);
(3) schooling: for this dimension, we considered the 'presence/absence of primary school'; and
(4) economic-productive context: the variables considered in this dimension are the 'share of employees in the agricultural sector' (%) and the 'share of employees in the industrial sector' (%).

All of the variables included in the model stemmed from the Population and Housing Census of 2011, except the data on the absence/presence of schools, which came from the Ministry of Education and Scientific Research.[3] All of the independent variables were measured in 2011. On this last point, the temporal reference of the variables, it should be emphasised that the explanatory variables refer to 2011 (i.e., the beginning of the observation period), while the dependent variable, which is the average rate of change of the resident population, refers to the 2011–2019 period. This approach allowed us, from a technical point of view, to keep endogeneity issues under control. Moreover, from a substantive point of view, this approach enabled us to adopt a (pseudo) causal perspective (i.e., what happened in 2011–2019 depended to a certain extent on what was observed in 2011). A crucial aspect of spatial analysis is the determination of the relevant neighbourhood of a given area: i.e., the spatial units—in our case, the municipalities—surrounding a given data point (area) that would be considered as influencing the observation at that data point. Indeed, these neighbouring areas are spatial units that interact in a meaningful way. This interaction could relate, for example, to spatial spillovers and externalities (Lansley and Cheshire, 2016).

Before arriving at the final model, we tested the effects of many demographic and socio-economic factors. The number of covariates was then set to the minimum that allowed us to control for problems of multicollinearity. As the multicollinearity condition number was lower than 30 in all of the models applied, we can assume that the level of multicollinearity was negligible (Anselin and Rey, 2014). In all of the spatial analyses proposed here, the spatial weight matrix was obtained as a 'Queen' contiguity matrix of the first order: two municipalities (i, j) were considered neighbours ($W_{ij} = 1$) if and only if they shared a boundary or a vertex geographically. This is the simplest way to approach the concept of neighbourhood. In particular, in this kind of spatial weight matrix, the concept of contiguity is used. We chose this type of spatial weighting matrix for several reasons. First, the use of this matrix is very common, and it is often adopted when statistical units refer to a local scale

[3] These data stem from the Archive of public schools (2019), provided by the Ministry of Education and Scientific Research to Istat. The data we used in the model refer to the year 2011.

(Benassi and Carella, 2022; Iglesias-Pascual et al., 2022; Salvati et al., 2020; Yang et al., 2015). Moreover, contrary to other approaches to spatial weighting, such as the K-Nearest Neighbour (K-NN), we did not have to decide on an arbitrary number of neighbouring municipalities. It should be noted that this kind of spatial weighing matrix is the same as that applied in two previous studies on the same topic (e.g., Benassi et al., 2021; Benassi and Carella, 2022), which can be considered the progenitors of this paper. Therefore, using the same spatial matrix guarantees the coherence and the comparability of the results of these studies. The regression models were estimated using R studio following the procedure in Mendez (2020).

4 Descriptive findings: The demographic dynamics of Italy in the last 40 years from the regional to the local scale

As was shown in the literature review, Italy—in contrast to other European countries—has long been characterised by demographic and socio-economic territorial divisions, and by relevant heterogeneities between territories. Some data on these heterogeneities are shown in Figure 1, in which we avoided the divisions typically drawn between the three macro regions (north, centre and south), and instead used the more detailed partitions currently used in the official statistics to shed light on the differences between the north-east and the north-west within the 'north' macro region, and between the islands and other southern regions within the 'south' macro region.

We can clearly see that in the past, the higher comparative levels of growth in the north and the centre were due to the combination of natural growth and a positive migration balance. Nevertheless, higher natural increase values were recorded in the south and the islands. The tendency towards a decrease in the natural growth rate produced a different effect in each macro region, and a similar pattern can be observed for the internal migration rate. As a consequence, we can see that some macro regions (typically in the north) were less demographically distressed. Especially in recent years, this was also due to international migration flows, mostly to the north of Italy (Benassi and Naccarato, 2018). We do not have long time series data on international migration flows. Nevertheless, we can state that for Italy as a whole in 2019, the migratory balance with foreign countries was positive and equal to 153,273. Migration intensity was relatively high in the north-west (56,068), the centre (42,924) and the north-east (32,826); and was relatively low in the south (17,513), and especially in the islands (3,924).

Obviously, the geographical scale is crucial for detecting the spatial heterogeneity and the dependence patterns of demographic processes. Indeed, the local scale (municipal level) should be adopted to ensure a better understanding of population spatial heterogeneity and spatiotemporal variability, as has been demonstrated by some recent studies on Italian demography conducted at the territorial level (Caltabiano et al., 2019; Salvati et al., 2020). In Benassi et al. (2023), we showed the distribution of the municipalities in Italy by the levels of growth/decline in four subsequent periods of time covering the last 40 years (1981–2019). The number of municipalities that have experienced either a light (annual growth rate per 1000 between ≥ −8.0 and ≤ −2.0) or an intense (≤ −8.0) demographic decline has increased over time. Using this classification, we counted the number of municipalities in each specific condition to evaluate the changes over time (Table 1). We found that the share of municipalities that experienced an intense demographic decline increased progressively from 1981 (18.7%) to 2019 (25.7%).

Figure 1:
Demographic trends and dynamics in Italy and macro geographic areas: overview on some indicators 1951–2014

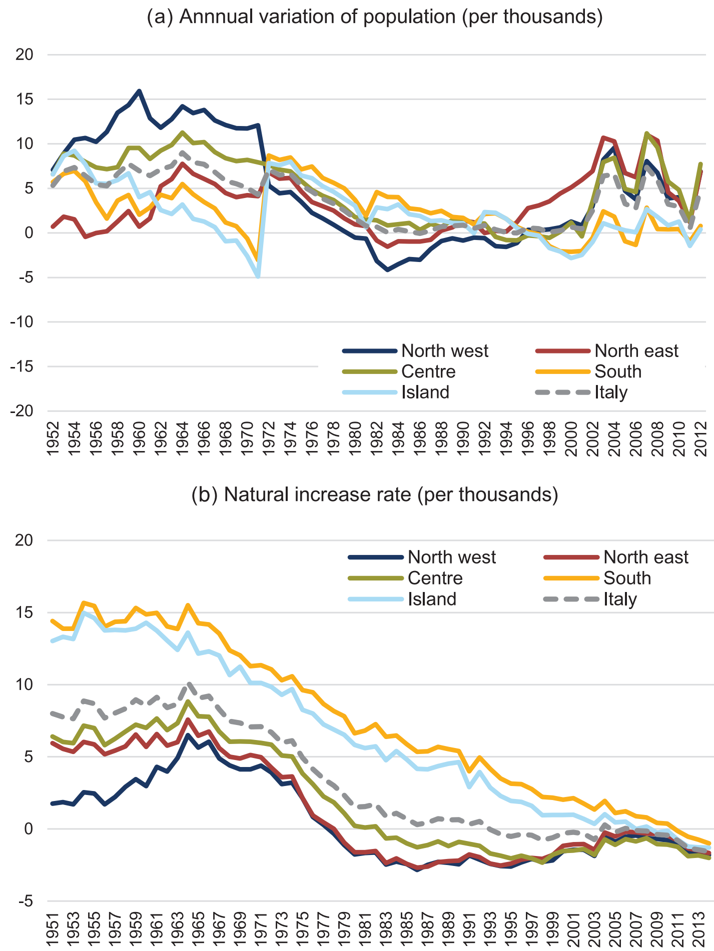
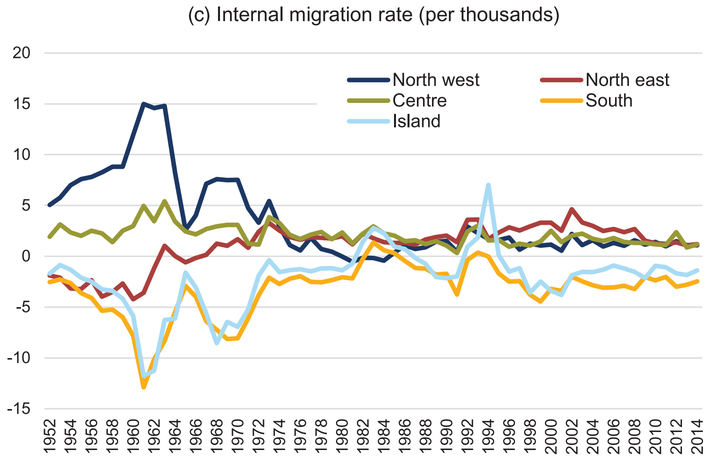


Figure 1:
Continued



Source: our elaboration based on Istat data 'Serie storiche' (https://seriestoriche.istat.it/); for (a), source: Table 2.3.2; for (b), source: Table 2.4.1; for (c), source: Table 2.12.

In the last period, 2011–2019, around 50% of the municipalities belonged to these two categories, and about 6% belonged to the intense decline group.

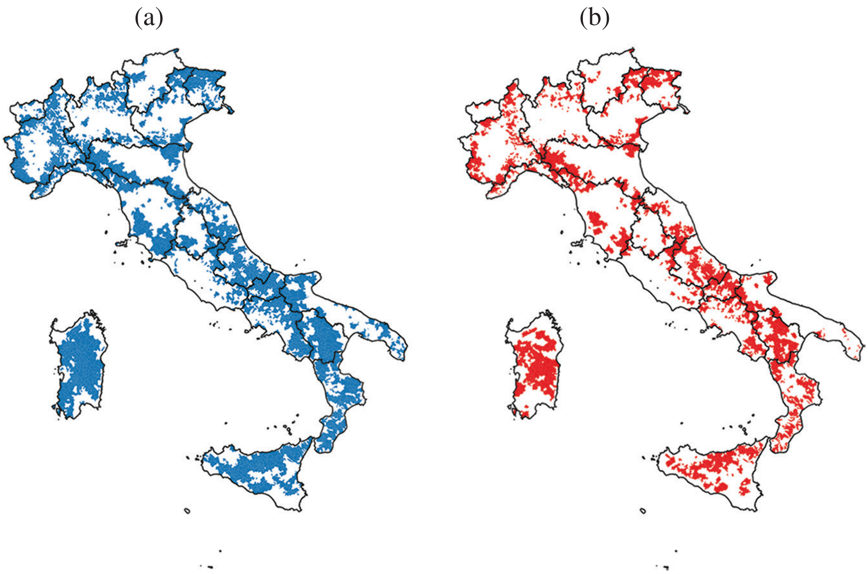
The consequences of those dynamics are summarised in Figure 2(a) and (b), which show the spatial distribution of municipalities in a condition of prevalent or systematic demographic decline, respectively. In the left panel of Figure 2(a), the spatial distribution of municipalities in a condition of prevalent demographic decline is shown; this condition occurred in 3,245 Italian municipalities (41% of the total). The geography of this group of municipalities is clearly spatially dependent, and

Table 1:
Percentage of municipalities by categories of demographic growth/decline

Categories of demographic growth/decline	1981–1991	1991–2001	2001–2011	2011–2019
Intense demographic decline	18.7	17.0	14.7	25.7
Light demographic decline	20.3	20.4	17.5	28.5
Stagnation	18.8	18.4	16.0	20.2
Light demographic growth	22.8	22.8	22.5	18.4
Intense demographic growth	19.5	21.3	29.3	7.3
Total	**100.0**	**100.0**	**100.0**	**100.0**

Source: Our elaboration based on Istat data. For the years 1981–2011, the data are from census sources. For 2019, the data are from a demographic (pre census) source revised by Istat (https://demo.istat.it/).

Figure 2:
Municipalities in a condition of prevalent (a) or systematic (b) demographic decline, 1981–2019



Source: our elaboration based on Istat data. For the years 1981–2011, the data are from census sources. For 2019, the data are from a demographic (pre-census) source revised by Istat (https://demo.istat.it/).
(a) A municipality is classified as being in a condition of prevalent demographic decline if its average annual growth rate was negative at least three to four times in the 1981–2019 period.
(b) A municipality is defined as experiencing 'systematic population decline' if it had negative annual growth rate values in all four periods.

forms clear spatial patterns. Most of the municipalities in this group are located across the mountain range of the Apennines from the north to the south; in the Alpine areas across the Italian national border in the north-east and the north-west; in the inland areas located further from the sea; and in large parts of the two bigger islands of Italy (in this case, especially in the inland areas). It is interesting to note that the proximity of such municipalities played a role in population decline, and that depopulation affected local contexts from the north to the south of Italy. In the right panel (Figure 2(b)), we show the spatial distribution of the municipalities in a condition of systematic population decline based on the average annual growth rate during the 1981–2019 period. This condition occurred in 1,884 municipalities (23.8% of all municipalities), which means that the risk of a municipality that has already lost population (three times out of four) experiencing additional systematic population losses was quite high, at 58.0%. The distribution of municipalities in this condition creates spatial patterns that are even clearer than before, which can be called the geography of population loss and decline.

From the data reported in Table 1 and the maps in Figures 2(a) and (b), the relevance of space in defining the temporal dynamics of population growth at the local level seems quite clear. Depopulation is an intrinsic spatial process, especially when referring to territorial units (municipalities in our case) that are not independent of each other (Voss, 2007). Indeed, the first law of geography seems to be an important tool for investigating depopulation processes, and should not be ignored in empirical analysis.

5 Empirical findings

We modelled the variation in population that occurred in each municipality in the last period of analysis (2011–2019) using a set of demographic, social and economic covariates. As we already mentioned in the estimation process, we controlled for the role of space, and, in particular, for the spatial proximity of territorial units (i.e., municipalities) using both dependent and independent variables. Table 2 shows the results of the SDM used to evaluate which factors were related to the demographic growth or decline of Italian municipalities, considering both direct and indirect spatial effects.[4] The first important result is that the lag coefficient (Rho) was positive (0.3004) and statistically significant, which indicates that the variation in population was significantly affected by the value it assumed in the neighbouring municipalities. The value and the significance of this coefficient confirmed the spatial nature of the phenomenon, and indirectly indicated the existence of a spatial diffusion process.

Among the covariates included in the model, we could observe that the demographic dimension was significantly and consistently associated with population variation: the age structure was among the main forerunners of population growth/decline. In particular, the percentage of children up to six years of age was positively associated with the change in population between 2011 and 2019, and thus with a demographic increase. Both the direct and the indirect average effects were positive. This means that both the direct and the indirect (spillover) effects tended to boost demographic growth, all conditions being equal. By contrast, a high percentage of elderly people aged 75 years or older was negatively associated with both direct and indirect negative effects. This means that territories in which the percentage of older people was comparatively high tended to be spatially clustered, which, in turn, accelerated the pace of demographic decline (negative effect on demographic growth rates). The effect of the percentage of foreigners was quite interesting. The average direct effect was not statistically significant. However, the average indirect or spillover effect (i.e., the effect of the neighbourhood municipalities on the observed municipality *i*) was positive, which suggests that it had a positive impact on demographic growth.

[4] We estimated a reduced form of the SDM model not including variables related to the demographic dimension. The idea was to test the existence of a possible mediating' effect. Results are quite stable compared to the full model (available from the authors upon reasonable request).

Table 2:
Results of a spatial Durbin model on the average annual growth rates in the 2011–2019 period

					Effects		
Variable	**Coefficient**	**Std. error**	***z*-values**	***p*-values**	**ADE**	**AIE**	**ATE**
Intercept	−2.0537	0.7736	−2.6549	0.0079			
% under 6 years old	0.7226	0.0775	9.3266	0.0000	0.7601	0.8882	1.6483
% over 75 years old	−0.6376	0.0244	−26.1392	0.0000	−0.6449	−0.1730	−0.8179
% foreigners	0.0035	0.0026	1.3582	0.1744	0.0043	0.0196	0.0239
% youth living alone	0.1265	0.0192	6.5897	0.0000	0.1238	−0.0655	0.0582
Study/work mobility	−0.0418	0.0089	−4.7216	0.0000	−0.0416	0.0052	−0.0364
Female activity rate	0.1745	0.0142	12.2543	0.0000	0.1754	0.0196	0.1950
Youth (15–29) employment rate	0.0385	0.0112	3.4296	0.0006	0.0375	−0.0243	0.0132
% workers in agriculture sector	−0.1169	0.0136	−8.5719	0.0000	−0.1201	−0.0743	−0.1944
% workers in industry	−0.0895	0.0123	−7.2808	0.0000	−0.0937	−0.0995	−0.1933
Primary school	0.8612	0.2407	3.5775	0.0003	0.8113	−1.1821	−0.3707
Lag % under 6 years old	*0.4306*	*0.1244*	*3.4616*	*0.0005*			
Lag % over 75 years old	*0.0654*	*0.0381*	*1.7152*	*0.0863*			
Lag % foreign people	*0.0132*	*0.0034*	*3.8670*	*0.0001*			
Lag % youth living alone	*−0.0858*	*0.0314*	*−2.7363*	*0.0062*			
Lag study/work mobility	*0.0163*	*0.0126*	*1.2945*	*0.1955*			
Lag female activity rate	*−0.0381*	*0.0227*	*−1.6825*	*0.0925*			
Lag youth (15–29) employment rate	*−0.0293*	*0.0164*	*−1.7872*	*0.0739*			
Lag % workers in agriculture sector	*−0.0191*	*0.0182*	*−1.0467*	*0.2952*			
Lag % workers in industry	*−0.0457*	*0.0164*	*−2.7821*	*0.0054*			
Lag primary school	*−1.1206*	*0.4520*	*−2.4795*	*0.0132*			
Lag. coefficient (Rho)	*0.3004*			*0.0000*			

Log likelihood: −25395.6
Akaike info criterion: 50837.0
LM test for residual autocorrelation test value: 18.781, p-value: 0.0000

Note: ADE = average direct effect; AIE = average indirect effect; ATE = average total effect.
All effects are statistically significant at $p < 0.05$, except those underlined.

The social dimension also played an important role. The share of young people living alone was significantly associated with an increase in population. The direct effect was positive, while the indirect effect was not statistically significant. This means that while an increase in the percentage of youth living alone in a municipality was positively associated with population growth in the municipality, this was not the case for the neighbouring municipalities. Additionally, mobility played an important role: the ability to reach places of study or of work in a reasonable time was certainly one of the factors that slowed down the depopulation of a territory. At the municipal level, the direct effect of the percentage of the population who moved to reach places of study or work in 2011 was, as expected, negatively associated with the variation in the following years, while the indirect effect was not significant. This means that municipalities where the share of the workforce and/or of students who remained within the city was low (and levels of commuting outside of the municipality were therefore high) were at greater risk of depopulation.

Turning to the employment covariates, we found that both the female activity rate and the youth employment rate were significantly associated with an increase in the population in the last period, with a positive and significant direct effect and no significant indirect effect. The variables concerning the economic-productive environment were also relevant. The percentage of workers in both the agriculture sector and industry were negatively associated with an increase in the population during the last period with both direct and indirect effects. This finding raises important questions about the transformation of the economic structure of Italy, and, in particular, about the industrial and agricultural crisis in the southern part of Italy in recent years.

The presence or the absence of schools emerged as both a cause and a consequence of the decline or the growth of the population of a municipality. All other things being equal, the presence of a primary school in a municipality in 2011 was positively linked to an increase in the population in subsequent years. Interestingly, the direct effect was positive, while the indirect effect was negative. This means that the presence of a primary school in the municipality in 2011 was positively related to population growth in subsequent years, while the presence of a primary school in the neighbouring municipalities in 2011 was negatively related to population growth in the next period. Given the Italian ministerial requirements[5] for the creation of classes, it is the lack of children or a reduction in the number of children residing in the municipality that leads to the closure of primary schools and the movement of families with children to neighbouring municipalities where a school is present. As this vicious circle feeds itself, it appears that making it possible for families to send their children to school is essential to stemming the depopulation of small municipalities, especially in inland areas of the country.

The results of the statistically significant spatial lagged covariates included in the SDM confirmed the spatial nature of the phenomenon, and indicated the existence of a spatial diffusion process (i.e., the effects of spatially lagged covariates on the dependent variables were almost always statistically significant). This means that the variation in population was significantly affected by the value the covariate assumed in the neighbouring municipalities. Specifically, the lagged version of the variables related to the percentage of residents under six years of age and to the percentage of foreign-born residents showed a positive correlation with the dependent variable. This means that a municipality that had neighbours in which the percentages of the population who were young children or foreign-born were higher tended to have a positive demographic growth rate. By contrast, the lagged version of the percentage of young people living alone, the percentage of workers in industry and the presence of a primary school were all negatively correlated with the dependent variable. The explanation for this finding is straightforward: in most cases, a municipality that

5 The requirements for the creation of classes call for a minimum of 15 pupils for primary schools and of 18 pupils for low secondary schools, but both minimums were reduced to 10 pupils for mountainous municipalities and small islands.

had neighbours with higher shares of youth living alone, workers in industry and a primary school was a context of origin for the out-migration of young people, migrant workers and families who settled in the municipalities that had these characteristics. Thus, from these results, the importance of space, and particularly of the concept of being near in space—i.e., the first law of geography—clearly emerges.

6 Discussion and conclusions

In this paper, we analysed the diffusion process for population growth or decline in Italy at the municipal level. Italy, like many other European countries, is characterised by a high degree of territorial heterogeneity, with some areas experiencing population growth, and many others facing population decline. After reviewing the literature on population growth and decline in Italy and analysing the annual growth rates of Italian municipalities from 1981 to 2019, which showed that there was a positive spatial autocorrelation between the municipalities, we used a SDM to investigate which demographic, social and economic factors were related to this pattern of growth/decline at the municipal level. The analysis of the determinants/predictors of the average annual growth rate over the last 10 years at the municipal level showed that the spatial dimension had a strong effect. Moreover, our results confirmed that the demographic composition of the population was strongly related to the dynamics of the subsequent years. It should be recalled that this relationship is mutual, as the interdependencies between the causes and the effects are not linear (Großmann et al., 2013). For instance, in municipalities where the number of young women was higher, the fertility level tended to be higher; and, conversely, in municipalities where fertility (and immigration) was higher, the percentage of residents aged 6+ also tended to be higher in subsequent years, while the percentage of residents aged 75+ tended to be lower.

Also relevant is the contribution of the socio-economic dimension by individuals whose faster—or at least less slow—transition to adulthood is a crucial factor in population growth. Thus, we confirmed that leaving the family of origin is an important transition phase that provides the foundation necessary for family formation (and for the other stages of transition to adulthood), and is therefore an important driver of population growth through fertility (Billari and Kohler, 2004).

Concerning the employment covariates, we found that both the female activity rate and the youth employment rate were significantly associated with an increase in the population in the subsequent period, with positive and significant direct effects and no significant indirect effects. This result is related to the debate on the positive relationship between female participation in the labour market and fertility at the macro level. Although research findings still do not completely agree on the sign of the relationship between female labour force participation and fertility at the micro and the macro levels, they all agree on the importance of economic factors (Alderotti, 2022; Busetta and Giambalvo, 2014; Innocenti et al., 2021; Tocchioni, 2018). The studies by Brewster and Rindfuss (2000), Rindfuss et al. (2003) and

Engelhardt and Prskawetz (2004) were the first to debate the relationship between female participation in the labour market and fertility at the macro level, as well as the changing correlation between the two variables over space and time at the national level. Focusing on regional differences, Busetta and Giambalvo (2014) examined the impact of women's participation in the labour market on the probability of having a first child at both the macro and the micro levels, and found contrasting results at the two levels. More recently, Innocenti et al. (2021) investigated the association between 'economic complexity' (measured using many different economic indicators) and fertility at the province level. They found that fertility was higher in provinces characterised by higher levels of economic complexity.

Among the different covariates we considered, the presence/absence of a school proved to be most strongly related to population growth and decline. We showed that, other things being equal, the presence of a local primary school in a municipality in 2011 had a direct positive impact on the demographic development in the municipality in the subsequent years, whereas the presence of a primary school in the neighbour municipalities was negatively related to population growth in the municipality. The remarkable direct, indirect and lagged coefficient for the presence of primary schools seems to suggest that this factor is extremely relevant for the survival of Italian municipalities. Even if it ignored the timing of the eventual school closure, our model clearly showed that the presence of a school was crucial to the survival of a municipality. These results are in line with recent findings showing that school closures have a negative effect on population growth (see, e.g., Lehtonen, 2021 and Sørensen et al., 2021). The presence of schools, as well as the availability of child care (Klüsener et al., 2013b), are also related to the fertility decisions of couples, which—as was discussed—are important drivers of population growth. Thus, our results seem to show that in Italy, primary schools not only perform educational and other social functions in the community, they also provide a crucial territorial presidium for municipalities seeking to retain population and increase economic activity.

With this paper, we have contributed to the literature on the causes and the consequences of depopulation in two ways. First, we have added to the spatial dimension of the analysis of population decline and local heterogeneities in Italy by providing strong evidence that space matters in defining population growth and decline, and by underlining the importance of considering spatial demography when studying such processes (Voss, 2007). Second, we provided a contribution to the debate on the demographic, social and economic factors associated with population growth/decline by explicitly considering the spatial dimension.

Our results corroborate the existence of strong and essential spatial dimensions of population decline, which should, therefore, be considered in depopulation studies. A further potential development of this work is to estimate the contribution of foreign-born populations to population growth or decline in different territories. We know that the presence of foreigners may slow population decline due to both migration itself (direct effect) and the contributions of the foreign-born population to natural change (indirect effect), as it is well known that foreigners typically have higher fertility rates than natives. From this perspective, a spatial regression model in which the dependent variable is the average annual growth rate of the total population of the i-th municipality, and the explanatory variables are the growth rates of foreign and Italian populations for the same municipality, plus a spatial lag effect, would allow for the evaluation of the net effects that changes in the rates of Italians and foreigners have on the total rate of change, while keeping in check the spatial effect of y on itself (which will still be measured to see whether an element of spatial influence of y on itself remains).

In accordance with Ezeh et al. (2012), we consider further research into the patterns of population growth and decline to be essential, because demographic policies can affect other social systems and social groups, as well as fertility decisions and trends. From this point of view, further modelling improvements are also necessary. Our analysis used global spatial regression models, which, despite representing an improvement on classical ordinary least squares (OLS), did not allow the local spatial variability of parameters to be brought under control and investigated. This is, however, a very relevant aspect that we propose to explore further in future contributions. In particular, it seems necessary to test the use of particular local regression models in which the scale (i.e., the 'bandwidth') is not constant—the so-called multiscale geographically weighted regression model (MGWR; Fotheringham et al., 2022; Oshan et al., 2019). These models will help us to better understand the different metrics at which the explanatory variables act by highlighting local and supra-local effects, as well as by enabling us to map local patterns (Matthews and Yang, 2012; Yang et al., 2022).

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ORCID iDs

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

Annalisa Busetta https://orcid.org/0000-0002-5588-7433

Gerardo Gallo https://orcid.org/0000-0002-6659-6164

Manuela Stranges https://orcid.org/0000-0002-7419-427X

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