A SPATIAL ANALYSIS OF THE INFLUENCE OF THE FOREIGN POPULATION ON AGEING IN ITALY

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Abstract. Italy is experiencing an intense demographic aging process, mostly driven by a declining fertility and increasing longevity. The presence of the foreign population is often mentioned as a potential counterbalancing factor, but its actual impact on the age structure remains a matter of debate. This paper aims to explore whether, how and to what extent the effect of the foreign population on demographic aging varies over a territory. Unlike previous studies focusing on national-level effects, this analysis looks at municipal variations over time, offering a more detailed understanding of how foreign presence influences local aging processes. The analysis is based on municipal-level data provided by Istat and covers the period 2002–2022. The dependent variable is the proportion of the elderly population (65+) in relation to the total resident population. The analysis is conducted using Ordinary Least Squares (OLS) and Geographically Weighted Regression (GWR) models to investigate the factors influencing demographic ageing across Italian municipalities. The main explanatory variables include the proportion of foreign citizens (hereafter referred to as foreigners) in the population, the median age of the foreign population, and demographic behaviours such as the Crude Birth Rate of foreign women and the Internal Migration Rate of foreign citizens. The models also control for other demographic factors, including life expectancy for women and men, the Crude Birth Rate of Italian women, and the Internal Migration Rate of Italian citizens. The analysis shows that the impact of the foreign population on demographic ageing varies significantly across municipalities and over time, highlighting spatial and temporal heterogeneity in these effects.

1. Introduction

Population ageing represents one of the most significant demographic shifts currently affecting Europe, wide-ranging implications for welfare systems, labour markets, and social cohesion (Bloom and McKinnon, 2014). Italy has experienced a significant rise in its population's median age over the past few decades, becoming one of the world's oldest countries. However, this demographic shift has not been uniform across the country: patterns of ageing vary significantly at the local level, reflecting differences in fertility, mortality, and the dynamics of both internal and international migration (García-Pereiro, 2018; Backman and Karlsson, 2024).

While the role of declining fertility and increasing life expectancy in driving population ageing has been widely studied, the contribution of international migration, particularly the presence of foreign residents in shaping local ageing

patterns has received comparatively less attention. We have investigated the spatial dimension of ageing in Italy, focusing on the impact of foreign residents on local age structures in the years 2002 and 2022. Using annual demographic data from the Italian National Institute of Statistics (Istat) and spatial regression models, we have assessed whether, and to what extent, the presence of foreign residents has mitigated population ageing in Italian municipalities. Specifically, we have explored both general trends and spatial heterogeneity of this relationship using Ordinary Least Squares (OLS) and Geographically Weighted Regression (GWR) models. These insights are crucial for informing spatially sensitive demographic and migration policies.

2. Literature

In recent decades, demographic literature has increasingly focused on the role of international migration in shaping the evolution of population dynamics, particularly in relation to ageing processes and changes in age structure. In contexts marked by negative natural growth, such as Italy, immigration has gradually acquired a rebalancing function, contributing not only to overall population growth but also to slowing the pace of ageing (Gesano and Strozza, 2011).

The demographic impact of the foreign component manifests itself through the size and age composition of migratory flows, so-called direct effect (Di Giulio *et al.*, 2012). It is widely recognised that international migrants commonly arrive in their destination countries at a relatively young age and join age groups that are frequently undersized in contexts of advanced population ageing (Backman and Karlsson, 2024). Consequently, they contribute -at least in the short to medium term - to a partial reshaping of the demographic structure (Collantes *et al.*, 2014). Nevertheless, the effectiveness of this rebalancing effect is limited by several factors. First, the total volume of migration flows remains modest when compared to the size of the resident population, reducing their long-term impact on the age structure (Fihel *et al.*, 2018). Second, once settled in the host country, migrant populations themselves undergo ageing processes, like the native population (Bermingham, 2001).

In addition to structural effects, the foreign component of the population influences local demographic dynamics through its demographic behaviour. As demonstrated in existing literature, the fertility of foreign women is particularly relevant in contexts with very low fertility (Bagavos, 2022; Paterno, 2011). Births to foreign mothers account for a significant percentage of the total, contributing to mitigating the birth rate deficit (Gesano and Strozza, 2019). Immigrant women, who mainly arrive at childbearing age, show higher fertility rates than their native counterparts, at least in the early stages of migration process (Sobotka, 2008; Gabrielli *et al.*, 2007). However, more recent studies have reported a progressive

convergence in reproductive behaviour between native and immigrant women, due to cultural, economic and structural factors, resulting in a reduced compensatory effect attributable to foreign fertility (García-Pereiro and Paterno, 2024). Moreover, internal migration patterns of foreign populations further shape the demographic structure of territories. These movements contribute to the spatial redistribution of the population, counteracting ageing in some areas and intensifying demographic pressure in others (Casacchia *et al.*, 2022).

Then the effectiveness of migration in mitigating ageing is not uniform across the country, but varies significantly depending on the geographical distribution of foreigners (Busetta *et al.*, 2025). The innovation exhibited by cities has been demonstrated to exert influence on their attractiveness, thus resulting in a concentration of young foreigners in areas characterised by greater socio-economic opportunities (Kanbur and Rapoport, 2005; Fratesi and Riggi, 2007).

Italy exhibits distinct territorial polarisation, characterised by a higher concentration of foreign populations in the northern regions, which are recognised for their economic and employment opportunities, and a significantly lower presence in the southern and island regions (Benassi and Naccarato, 2018; Strozza *et al.*, 2016). This territorial heterogeneity suggests that their contribution to containing ageing should not be investigated exclusively at the national level, but rather through an analysis that considers the sub-national scale (Pratschke and Benassi, 2024).

In this context, incorporating the spatial information provides the basis of a methodologically sound approach for exploring the relationship between migration dynamics and demographic transformations.

According to these theoretical premises, this study aims to investigate two specific research questions:

RQ1: How do the demographic structure (age and sex) and behaviours (birth rates and internal mobility) of foreigners influence the percentage of the over-65 population at the municipal level?

RQ2: How have these relationships evolved over time?

3. Data and methodology

The study is based on demographic data, which comprises the age structure of all 7,896 Italian municipalities, as provided by the Italian National Institute of Statistics (Istat) through the DemoIstat database, covering the period 2002–2022.

It should be noted that the Istat data only include only the registered resident population. Therefore, individuals with residence permits who are not registered, as well as visa overstayers, are excluded. As these groups tend to be younger than long-

term residents, their absence may result in a slight overestimation of population ageing.

The dependent variable is the percentage of the population aged 65 and over (%65+), which is used as a measure of demographic ageing at the local level. To analyse the possible contribution of the structure and demographic dynamics of the foreign population in mitigating this phenomenon, the following independent variables of interest are included: percentage of foreign population in total (%FP); median age of the foreign population (MAFP); crude birth rate of foreign women (CBRF); and internal migration rate of the foreign population (IMRF). In addition, several control variables are introduced to account for structural ageing factors independent of foreign presence. Those are: crude birth rate of Italian women (CBRI); internal migration rate of the Italian population (IMRI); and life expectancy at birth for men (LEM) and women (LEW).

As shown in Table 1, Italian municipalities underwent significant demographic changes between 2002 and 2022. The proportion of foreign nationals has increased significantly during this period, with their mean age rising from 31 to 38, suggesting that foreign residents have been staying longer in the same municipalities. Internal migration decreased, particularly among foreigners, thereby reversing the positive migration balance observed in 2002. Concurrently, birth rates declined for both Italians and foreigners, with the latter experiencing a more pronounced decline. Most strikingly, the proportion of older adults tripled, confirming ageing as a widespread structural trend. Although life expectancy continued to improve, its slower pace has exacerbated the challenges associated with population ageing.

Table 1 - *Demographic indicators of Italian municipalities for the years 2002 and 2022.*

	2002			2022		
Variable	**Mean**	**SD**	**Median**	**Mean**	**SD**	**Median**
IMRI	0.98	16.16	0.00	0.37	11.38	0.00
IMRF	68.25	320.33	22.33	-0.89	107.21	0.00
%FP	2.24	2.04	1.72	6.72	4.34	5.95
MAFP	30.97	8.55	31.00	38.07	6.35	37.00
CBRI	36.56	13.58	36.36	31.64	15.60	31.33
CBRF	54.76	85.22	23.74	30.90	44.07	24.20
%65+	8.85	2.89	8.36	26.14	5.36	25.57
LEW	83.03	0.79	83.10	84.75	0.80	84.80

Data show an increase in population ageing, an ageing foreign population that has become more established in the country, and a decline in internal mobility and birth rates. All of these factors highlight the need for new territorial and social strategies to address the challenges posed by an ageing population.

The analysis aims to determine whether and to what extent the characteristics of the foreign population influence the proportion of people over 65 across different Italian municipalities. To this end, a two-stage methodological approach is adopted. First, ordinary least squares (OLS) regression models are estimated for two reference years - 2002 and 2022 - to assess the average impact of the explanatory variables on demographic ageing. This approach assumes that the relationships between variables remained constant throughout the national territory, thus enabling general trends and variations over time to be identified. In the second phase, Geographically Weighted Regression (GWR) is applied to capture the spatial heterogeneity of the estimated coefficients.

This reinforces the usefulness of GWR in identifying differentiated territorial configurations, which are fundamental to the development of targeted, place-based policies. Therefore, to evaluate the models' performance and explanatory capacity, the results of OLS and GWR are compared using the coefficient determination index (R^2) and the adjusted Akaike information criterion (AICc) for each of the analysed years. The spatial autocorrelation of the residuals is also calculated using Moran's index to verify the model's ability to capture the spatial structure of the phenomenon. Specifically, we assessed whether GWR can reduce residual spatial autocorrelation more effectively than OLS, thereby demonstrating superior representation of local variations.

4. Results

The analysis of the results is divided into two main stages. First, the OLS models for the two analysed years (2002 and 2022) are examined in general terms. Second, the spatial dynamics revealed by Geographically Weighted Regression (GWR) are explored. Table 2 shows the standardised coefficients obtained from OLS models for the years 2002 and 2022.

Table 2 - *Estimated coefficients and significance levels from OLS models for 2002 and 2022.*

Variable	2002	Sig.	2022	Sig.
MAFP	-0.0305	**	0.2659	***
LEW	-0.2127	***	0.1236	***
LEM	0.1997	***	-0.2332	***
CBRI	-0.2247	***	-0.1581	***
CBRF	-0.0859	***	-0.0572	***
%FP	-0.0035	ns	-0.0485	***
IMRI	-0.1008	***	0.0571	***
IMRF	0.0946	***	-0.0336	**

*Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$; ns = not significant.*

The dependent variable in both models is the percentage of the population aged 65 and over out of the total resident population, used as a measure of demographic ageing. This provides an effective, albeit concise, overview of how the factors influencing population ageing have evolved. Some elements emerge with particular clarity.

Firstly, the median age of the foreign population (MAFP) has increased over time. While it had a negative and moderate effect in 2002, it became positive and increasingly significant in 2022, reflecting the ageing process of the foreign population. The birth rate of Italian women (CBRI) has remained consistent over time, with a negative and highly significant coefficient in both years. This confirms that higher birth rates are associated with a smaller proportion of the elderly population. However, the intensity of the effect slightly decreased in 2022, in line with the general decline in fertility.

The foreign birth rate (CBRF) also has a negative effect and is decreasing over time, suggesting progressive convergence of reproductive behaviours of foreign and Italian women. This decline may also be partially explained by structural changes in female migration flows, with an increasing number of women arriving in Italy beyond childbearing age, often from Eastern European countries (García-Pereiro and Paterno, 2024).

Changes in internal migration flows are also interesting. In 2002, the internal mobility of foreigners (IMRF) had a positive effect, which is consistent with the presence of families that had already settled down. However, in 2022, the coefficient reversed and became negative, indicating a higher proportion of young people in these flows. Similarly, the internal mobility of Italians (IMRI) has undergone a reversal over time, shifting from a strongly negative value in 2002 to a positive one in 2022. This reflects a change in the age composition of internal migration flows, with older age groups becoming increasingly involved, in contrast to the initial prevalence of younger individuals.

Finally, the percentage of foreigners in the total population (FP%) had no significant effect on ageing in 2002, when foreign presence was still marginal. However, in 2022, the effect became negative, indicating that a higher foreign presence is associated with a lower proportion of older people. Nevertheless, the intensity of this effect has decreased over time, suggesting that the demographic composition of the foreign population is increasingly similar to that of the Italian population.

Overall, the results of the OLS model show that the role of the foreign population and migration flows in demographic ageing has evolved from simple, well-defined dynamics to more complex and less distinct effects. The OLS models demonstrate aggregate trends, but explain only a small proportion of the variance (adjusted R^2 between 10% and 15%), which suggests that there is significant variability at a local

level that the global approach fails to fully capture. This highlights the need for an analysis that considers territorial differences, such as that offered by GWR.

Applying Geographically Weighted Regression (GWR) overcomes the limitations of Ordinary Least Squares (OLS) by providing a more detailed and territorially differentiated analysis of the factors influencing population ageing. Figures 1 and 2 show local GWR coefficients for 2002 and 2022, respectively: a) median age of the foreign population; b) internal migration rate of foreigners; c) crude birth rate of foreign women. Figure 2 also includes d) the share of foreigners, which was not significant in 2002.

These maps highlight the presence of spatial variability and reinforce the importance of adopting a geographically explicit perspective.

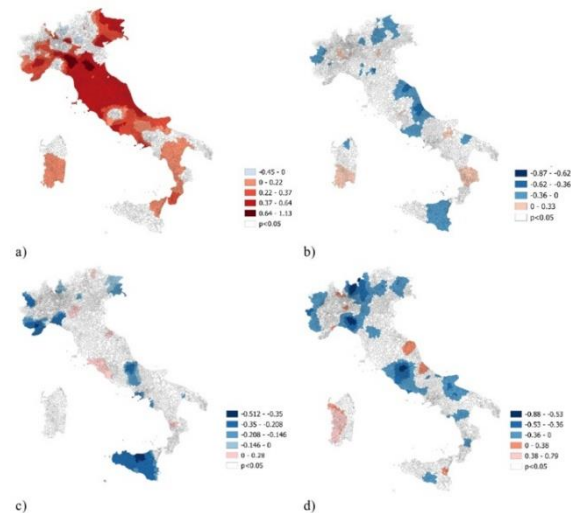**Figure 1** *Spatial distribution of GWR coefficients (2002).*
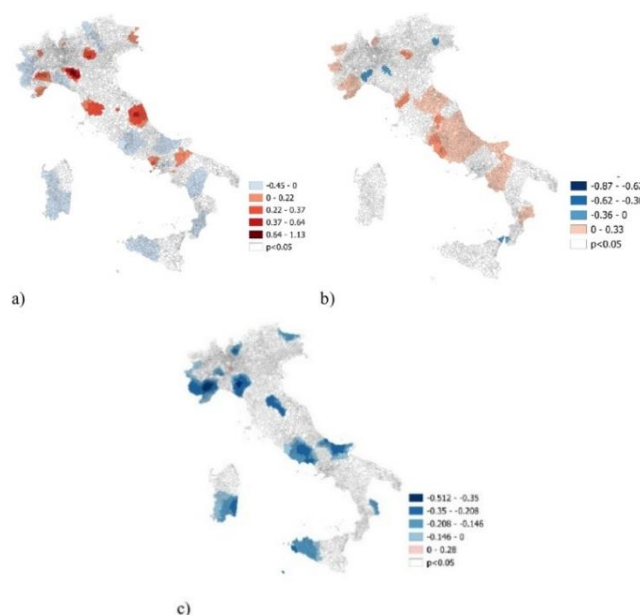
Note: Maps show local effects of: a) the median age of the foreign population; b) the internal migration rate of foreigners; c) the crude birth rate of foreign women.

One important result concerns the internal mobility of foreign citizens (IMRF). In 2002, the local coefficient associated with this variable was positive in some areas of central and northern Italy, indicating that foreign citizens also moved towards municipalities with elderly populations. This suggests that, at that early stage, mobility was not exclusively driven by youthful demographic trends, but could also have been influenced by work-related factors, family networks, or other attractive features of a given area. By 2022, however, this effect had significantly decreased or disappeared in many areas, often becoming statistically

insignificant. This trend reflects greater stabilisation of foreign settlements and less age-selective mobility.

Figure 2 *Spatial distribution of GWR coefficients (2022).*

Note: Maps show local effects of: a) the median age of the foreign population; b) the internal migration rate of foreigners; c) the crude birth rate of foreign women; and d) the share of foreigners.

Overall, the results demonstrate that the effects of explanatory variables are not consistent across space but vary significantly depending on local contexts.

The percentage of the foreign population in the total (%FP) showed significant changes over time. While its effect was negligible in 2002, by 2022 it was negatively associated with ageing in many areas of the North and Centre. This suggests that a higher share of the foreign population is associated with a lower percentage of residents aged 65 and over. However, in some areas of the South and the Islands, positive effects have emerged, indicating either the ageing of the resident foreign population or the recent arrival of younger groups.

In 2002, the birth rate of foreign women (CBRF) had a slightly rejuvenating effect, concentrated in certain areas of the Centre and North of the country. By 2022, however, positive effects on ageing had emerged in several areas, indicating a decline in fertility and increasing convergence towards Italian reproductive patterns.

The median age of the foreign population (MAFP) exhibited a weak and uneven effect in 2002, but by 2022, a clear positive correlation had emerged in many areas of the North, Centre, and South. This indicates a growing involvement of the foreign population in ageing processes, which is consistent with greater settlement stability and a change in its demographic composition.

Compared to the OLS, the GWR significantly improves performance, explaining over 50% of the variability in ageing (compared to 10-15% for the OLS) and demonstrating lower AICc values, which indicates better predictive ability. GWR also reduces spatial autocorrelation in the residuals more effectively than the OLS, picking up local differences that the OLS cannot detect.

5. Conclusions

The analysis provides a detailed and dynamic overview of the demographic factors influencing Italy's ageing population at a municipal level. It highlights the important and changing role of foreign populations in different areas over time.

In response to research question (RQ1), the analysis reveals that the demographic dynamics of the foreign population have a differential impact on the growth of the over-65 population at municipal level. Heterogeneous spatial effects are highlighted: in the central and northern regions, the higher fertility of foreign women and youth migration flows contributes to slowing down the ageing process. In contrast, in southern regions and inland areas the demographic impact of foreigners is often limited or even associated with more pronounced ageing.

In response to RQ2, the temporal evolution shows strong and persistent spatial differentiation, with some areas maintaining a 'rejuvenating' effect of the foreign population, while others gradually converge towards ageing dynamics, even among foreigners. Geographically weighted regression (GWR) has enabled these spatial and temporal transformations to be captured, which are not detectable by global models such as OLS. This confirms that the role of the foreign population in demographic ageing is complex and evolving.

The integrated OLS-GWR approach provides a more nuanced understanding of Italian demographic dynamics, emphasising the importance of geographically differentiated policies to effectively address population ageing challenges. In this context, immigration emerges as a potentially significant factor in demographic rebalancing. The analyses conducted enabled a more detailed interpretation of the results by explicitly accounting for spatial heterogeneity. They emphasise the importance of adopting methodological tools capable of capturing the territorial variability of demographic phenomena. Consequently, this study can support the development of targeted, differentiated policy interventions at the local level that recognise and address the varying ageing dynamics present across Italian municipalities.

Acknowledgements

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