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ORIGINAL ARTICLE

How do cities absorb a large immigration shock? the role of housing

Nicolás González-Pampillón[1,2] · **Jordi Jofre-Monseny**[3]

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Abstract
While the literature has extensively studied the impact of immigration shocks on cities, we know surprisingly little about how cities absorb large immigration waves. This paper helps fill that gap by analyzing the neighborhood-level population dynamics among Spanish-born residents, non-EU15 immigrants, and EU15 immigrants in Spanish cities during the major immigration wave of 2001–2009. Drawing on the monocentric city model, and within a context of path-dependent urban development with outward city growth, we explore how different population groups sort spatially within cities. Higher-income Spanish-born residents tend to settle in more distant suburbs to access larger housing. In contrast, younger and highly educated EU15 immigrants concentrate in central neighborhoods to benefit from urban amenities. Initially, lower-income non-EU15 immigrants settled in central areas with deteriorated housing stock, but over time they increasingly moved to mid-distance neighborhoods with small dwellings built between 1950 and 1970.

Keywords Immigration · Housing characteristics · Neighborhoods · Cities internal structure

JEL Classification R23 · R30 · R58

✉ Jordi Jofre-Monseny
jordi.jofre@ub.edu

Nicolás González-Pampillón
ngpampillon@gmail.com

1 LSE/CEP, London, UK

2 Institut d'Economia de Barcelona (IEB), Barcelona, Spain

3 Universitat de Barcelona & Institut d'Economia de Barcelona (IEB), Barcelona, Spain

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1 Introduction

The flow of international migrants has increased significantly in the last decades. Between 1990 and 2019, the global foreign-born population increased from 153 to 272 million, and the percentage of foreign-born in high-income countries increased from 7.5 to 14% (United Nations 2019a). Moreover, substantial migration flows to wealthier nations are projected to persist in the coming decades (United Nations 2019b). Within receiving countries, immigrants are not evenly distributed geographically; rather, they tend to be heavily concentrated in large cities (IOM 2015; Albert and Monras 2022).

While the economic effects of immigration shocks on cities have been widely studied, surprisingly little is known about how cities absorb large immigration waves.[1] This paper aims to fill this gap by studying two related questions. First, what are the location patterns of immigrants and natives during a large immigration wave? Second, how do neighborhoods' housing characteristics explain their differing location patterns of immigrants and natives?

To answer these questions, we focus on the six largest urban areas in Spain during 2001–2009 and examine neighborhood-level population changes among Spanish-born, EU15 and non-EU15 immigrants.[2] Over this period, the percentage of foreign-born population in these cities rose from 6 to 18%, representing a substantial and sudden shift in both population size and composition. Thus, Spanish cities provide an ideal setting to study how cities absorb a large immigration shock –primarily of low-skilled workers– that materializes in a remarkably short period.

We first analyze population changes of Spanish-born, EU15 and non-EU15 immigrant groups as a function of distance to the Central Business District (CBD) to study their location patterns during a large immigration episode. We focus on the distance to the CBD as it is central to the monocentric city model –the core model in urban economics for analyzing the internal spatial structure of cities (Alonso 1964; Mills 1967; Muth 1969; Duranton and Puga 2015). To examine how these patterns evolve over time, we divide the 2001–2009 period into two sub-periods: 2001–2004 and 2004–2009.

Our main findings are as follows. Between 2001 and 2009, the Spanish-born population growth is negative at short and intermediate distances from the CBD, becoming positive only in neighborhoods farther from the center. This reflects a decentralization of the Spanish-born population during the immigration wave. In contrast, the EU15 population exhibited a markedly different spatial pattern, with growth sharply declining as distance from the CBD increased. Their concentration in central neighborhoods—where the Spanish-born population declined—suggests that EU15 immigrants played a key role in the urban revival of city centers. The spatial pattern of non-EU15 population growth varied significantly between the two sub-periods. From 2001 to 2004, the largest non-EU15 inflows occurred in the most central neighborhoods. This

[1] See Lewis and Peri (2015) for a review of studies on the impact of immigration on labor market outcomes. Gonzalez and Ortega (2011) analyze the labor market effects of the Spanish immigration wave studied here.

[2] We study the urban areas of Madrid, Barcelona, Sevilla, Valencia, Málaga and Zaragoza as defined in Sect. 3.

pattern reversed between 2004 and 2009, when growth in central areas slowed and the highest increases occurred in neighborhoods at intermediate distances from the CBD.

We then resort to the monocentric city model to understand why different population groups locate at different distances from the CBD. This model explains how location choices, housing prices, housing consumption, and income are jointly determined in spatial equilibrium. In line with its predictions, we first show that rents decline with distance from the CBD as lower housing costs compensate for higher commuting costs. The tendency of Spanish-born residents –who have relatively high incomes– to disproportionally locate in more distant suburbs can be explained by their higher demand for housing. Specifically, the model predicts that higher-income groups will choose suburban locations if the income elasticity of housing demand exceeds that of commuting costs. Consistent with this intuition, we show that larger dwellings are indeed concentrated in the more distant suburbs.

High housing prices in central neighborhoods suggest that these areas are highly desirable, offering superior job accessibility and amenities such as historical architecture (Koster et al. 2016) and vibrant commercial life, including bars and restaurants (Couture and Handbury 2020). The tendency of EU15 immigrants—who are generally young, highly educated, and live in smaller households—to settle in these areas is consistent with them outbidding other groups for central housing.

Interestingly, the relationship between housing consumption and distance to the CBD follows a U-shape, a pattern also observed in average neighborhood income. This is not predicted by the standard monocentric city model, which implicitly assumes that cities are rebuilt from scratch each period. In practice, urban development is path-dependent and cities tend to expand outward (Hohenberg and Lees 1995; Harari 2020). As a result, population growth is largely accommodated through new housing construction at the urban fringe –a trend reflected in both dwelling growth between 2001 and 2011 and the distribution of building ages by distance to the CBD. The more central a neighborhood, the older its housing stock tends to be.

The period in which a neighborhood develops partly determines its housing characteristics. While central areas are the most expensive, they also have a higher prevalence of buildings in poor condition, due to their age. This helps explain why non-EU15 immigrants initially concentrated in these central neighborhoods. In contrast, in the late years of the immigration wave, non-EU15 immigrants increasingly settled in areas at intermediate distances from the CBD. These neighborhoods were mostly developed between 1950 and 1970, coinciding with a period of massive rural-to-urban migration. The prevalence of small housing units built during that period suggests that, at the time, commuting costs were more income-elastic than the demand for housing. Thus, in the late years of the immigration wave, international migrants disproportionately located in neighborhoods characterized by small housing units developed between 1950 and 1970.

We then empirically assess several hypotheses that may explain the change in the location patterns of non-EU15 residents between the early and late years of the immigration boom – namely, overcrowding of city centers, transitions to homeownership, and the gentrification of central neighborhoods. We find some empirical support for all three non-competing theories.

Finally, having shown that housing stock characteristics exert a large influence on the residential choices of the different population groups, we conduct a regression analysis to assess the extent to which neighborhood housing features in 2001 explain these patterns. Specifically, we examine the role of the distribution of buildings by construction period (pre-1900, 1900–1950, and 1950–1970), average dwelling size, the share of buildings in poor condition, and the average number of floors. Our results indicate that these pre-existing housing characteristics significantly account for the distinct spatial distributions of Spanish-born, EU15, and non-EU15 residents.

Our paper is related to several strands of the literature. First, since by examining how an immigration shock affects the internal geography of cities, we relate closely to Boustan (2010), who shows that non-Southern U.S. cities that experienced greater Black in-migration between 1940 and 1970 also saw more pronounced white suburbanization. Her findings suggest substantial responses to demographic shifts, indicating that white flight was a key driver of post-war suburbanization.[3]

Second, our paper relates to the literature on housing market filtering – e.g., Brueckner and Rosenthal (2009) and Rosenthal (2014). These studies emphasize that the durability of housing generates neighborhood housing cycles: as the housing stock ages and deteriorates, it "filters down" to lower-income households.

Third, our paper is also connected to studies estimating the effect of immigrant inflows at the neighborhood level.[4] Card et al. (2008) show that in US cities, once a neighborhood surpasses a "tipping point" in terms of its minority share, it begins to experience substantial white population losses. Similarly, Saiz and Wachter (2011) find that immigrant inflows in US neighborhoods typically reduce housing values and trigger white outflows. In the UK, Sá (2015) also finds that immigration reduces housing prices which is interpreted as evidence of native preferences to avoid immigrant-dense neighborhoods. For Spain, Fernández-Huertas Moraga et al. (2019) analyze how immigrant inflows affect native population dynamics. Using an instrumental variables approach that combines a shift-share design with spatial diffusion of immigrants, they find that in densely built-up areas, immigration leads to mild native displacement at the neighborhood level. By contrast, in areas with greater development capacity, natives and immigrants tend to co-locate.

The paper makes three main contributions. First, it documents the location patterns of natives and immigrants during a massive immigration boom and interprets them through the lens of the monocentric city model, applied in a context of path-dependent urban development. Our findings show that the spatial distribution of housing characteristics—shaped in part by the historical outward growth of cities—is key to understanding how urban areas absorb large immigration episodes. Second, we show that EU15 immigrants played a central role in the urban revival of city centers,

[3] Our paper is also related to Boeri et al. (2015) and Harmon (2018), two studies that have used local housing characteristics as instruments for immigrant density at the neighborhood level. Specifically, Boeri et al. (2015) use the structure of buildings, particularly the average flat size, as an instrument for immigrant density to study the effect of this density on the labor market performance of immigrants in Italy. Harmon (2018) examines the impact of immigrant density on voting outcomes in Denmark. Immigrant density is instrumented with a lagged measure of high-rises, which is shown to attract immigrants.

[4] Studies analyzing the effect of immigration in the housing markets of cities and regions include the study of Saiz (2007) for the US and Gonzalez and Ortega (2013) and Sanchis-Guarner (2023) for Spain. In turn, Bosch et al (2010) provide evidence that immigrants are discriminated in Spanish rental markets.

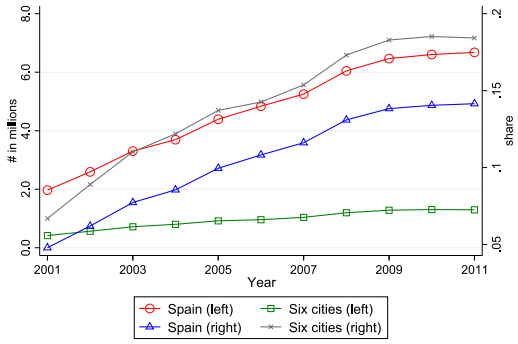

Fig. 1 Foreign-born population in Spain and its six largest cities Source: *Padrón Municipal de Habitantes.* Cities correspond to AUDES urban areas as defined in Sect. 3

offsetting the decline in native populations in these areas.[5] Third, we contribute to the literature on housing market filtering, which emphasizes the role of building age in shaping neighborhood population dynamics. Specifically, we find that non-EU15 immigrants were initially attracted to deteriorated, older buildings in central neighborhoods, but in the later years of the immigration wave, they increasingly concentrated in areas with small dwellings constructed between 1950 and 1970.

The remainder of the paper is organized as follows. Section 2 provides background on the immigration wave that Spain experienced between 2001 and 2009. Section 3 describes the data, sample, and key variables. In Sect. 4, we examine the population dynamics of Spanish-born, EU15, and non-EU15 groups as a function of distance to the CBD. Section 5 draws on insights from the monocentric city model—applied in a context of path-dependent urban development—to explain the spatial sorting of population groups. In Sect. 6, we present regression analyses to formally assess the extent to which pre-existing housing characteristics in 2001 account for the observed location patterns. Section 7 concludes.

2 Immigration in Spain, 2001–2009

Between the late nineties and 2009, Spain experienced a massive immigration wave (Gonzalez and Ortega 2011; Jofre-Monseny et al. 2016). According to the OECD International Migration Database, during this period Spain was the second-largest recipient of immigrants in absolute terms —after the US– and the highest relative to its population size. As shown in Fig. 1, the foreign-born population increased by approximately 4.5 million between 2001 and 2009, raising its share of the total population by about 9 percentage points.

In the six major urban areas that are the focus of this study—Barcelona, Madrid, Málaga, Sevilla, Valencia, and Zaragoza—the relative inflow was even more pronounced. By 2009, the foreign-born population reached 18% in these cities. This

[5] González-Pampillón et al. (2020) show that urban renewal policies implemented in the city center of Barcelona in those years accelerated gentrification processes, defined as increases in the proportion of neighbors with tertiary education. The results show that EU15 immigrants are largely responsible for the estimated effect.

immigration boom coincided with a period of sustained economic growth and a booming construction sector (González and Ortega, 2013). The inflow slowed sharply with the onset of the Great Recession in late 2008, which marked a turning point in Spain's economic conditions. From 2009 to 2011, the foreign-born population remained roughly stable.

Table 1 presents the change in the foreign-born population between 2001 and 2011 (in thousands). The data show that immigration flows during this period came from a wide range of countries and regions, including Latin America and the Caribbean, Eastern Europe, and Africa. At the national level, the largest source countries were Ecuador, Morocco, and Romania. However, the composition of immigrant populations in the six largest urban areas—Barcelona, Madrid, Málaga, Sevilla, Valencia, and Zaragoza—differs notably from national trends. In these cities, Romania tops the list, while Moroccans are significantly underrepresented. Notably, in large cities, the

Table 1 Change in foreign-born population (in thousands) for main sending countries

	Spain		Six largest cities	
	Change 2001–2011	% of overall change	Change 2001–2011	% of overall change
Romania	777.3	16.5	162.5	18.4
Morocco	469.3	10.0	35.7	4.0
Ecuador	340	7.2	100.7	11.4
Colombia	274.1	5.8	57.8	6.6
UK	272.9	5.8	6.2	0.7
Argentina	201.5	4.3	28.9	3.3
Bolivia	194.3	4.1	54	6.1
Bulgaria	153.3	3.3	22.5	2.6
Peru	150.8	3.2	59.1	6.7
China	133.2	2.8	38.7	4.4
Brazil	106.7	2.3	21	2.4
Dominican Republic	100.1	2.1	35.5	4.0
Venezuela	97	2.1	22.3	2.5
Germany	93.1	2.0	4.4	0.5
Paraguay	87.4	1.9	29.6	3.4
Portugal	83.7	1.8	8	0.9
Ukraine	73.7	1.6	16.8	1.9
Italy	69.6	1.5	11.3	1.3
Poland	67.1	1.4	14	1.6
France	65.6	1.4	10.1	1.2
Foreign-born population	4,709		882	

Note: Source is *Padrón Municipal de Habitantes*. The second and fourth columns indicate the contribution of each country of origin to the total change

Moroccan population is outnumbered by communities from Colombia, Bolivia, Peru, and China.

3 Data, sample and variables

Our primary data source is the Spanish Municipality Registry (*Padrón Municipal de Habitantes*), which contains population counts by country of birth at the census tract level –our main geographical unit of analysis. These population counts refer to January 1 of each year and are used for official population statistics. Importantly, no proof of legal status is required for registration, so both regular and irregular immigrants are included in the *Padrón*.

Registration grants residents access to public services such as primary health care and education. It also serves as proof of residence for purposes such as nationality or residence permit applications.[6] Given that many immigrants acquire Spanish nationality after a few years of residence, we classify individuals by country of birth rather than by nationality to more accurately capture the immigrant population.

We supplement this data with information from the 2001 and 2011 population censuses, which provide additional details on the socio-economic and housing characteristics of census tracts, as well as data on dwelling growth—allowing us to identify neighborhoods with more intense development. We also incorporate data on rents (2011) and income (2015) at the census tract level.[7]

We focus on the six largest cities in Spain by population: Barcelona, Madrid, Málaga, Sevilla, Valencia and Zaragoza.[8] We use a metropolitan area definition based on the contiguity of development provided by the AUDES definition of urban nuclei.[9] Appendix A presents maps showing the municipalities included in each of the six metropolitan areas. We construct a balanced panel of census tracts —our unit of analysis for neighborhood– for the period 2001–2009. Appendix B details how we address changes in census tract definitions over time and how we arrive at our final sample of 6,158 tracts. On average, each tract covers 45 hectares and includes 1,412 residents.[10] In our final sample, 2430 of them correspond to Madrid, 1931 to Barcelona, 605 to Valencia, 493 to Sevilla, 350 to Zaragoza and 349 to Málaga.

We consider three population groups. Besides the Spanish-born, we distinguish between EU15 and non-EU15 immigrants to reflect the different socioeconomic backgrounds of these two groups. Table C1 in Appendix C presents average socioeconomic

[6] See Foremny et al. (2017) for further details on the workings of the *Padrón*.

[7] Rents data come from *Sistema Estatal de Referencia del Precio del Alquiler de Vivienda* while the income data comes from *Atlas de la distribución de la renta de los hogares*.

[8] Specifically, we take the 6 largest municipalities in 2001.

[9] The AUDES definitions for *Núcleo Urbano* and *Área Urbana* are built by the Grupo Alarcos, Universidad de Castilla-La Mancha, https://alarcos.esi.uclm.es/per/fruiz/audes/. These urban areas are based on the contiguity of development. While they are smaller than the urban areas defined by the Housing Ministry and used by De la Roca and Puga (2017) among others, they are large enough to contain (suburban) census tracts that are more than 30 km away from the CBD (see Figures D1-D2 in Appendix D).

[10] For the municipality of Barcelona, the second-largest city in Spain, many tract boundaries were redrawn in 2010. Thus, our preferred period of analysis is 2001–2009, although we examine the 2001–2011 period when the analysis involves 2011 census data.

characteristics from the 2004 Living Conditions Survey, focusing only on individuals residing in highly urbanized areas within the six Spanish regions included in the analysis.

Compared to the other groups, non-EU15 immigrants have lower income, higher unemployment rates, and are more likely to experience severe material deprivation and risk of poverty or social exclusion. Individuals in this group tend to live in households with more members but live in smaller dwellings and are much more likely to be renters, with a homeownership rate of only 28%. Unlike in many other European countries, the stock of social housing is meager and, thus, renters pay market rents.[11] In contrast, the EU15 group more closely resembles the Spanish-born population in terms of income, unemployment, and the risk of severe material deprivation or poverty or social exclusion. However, EU15 individuals are more likely to have attained higher education (45% vs 29% among the Spanish-born) and live in households with fewer members. As for housing, EU15 individuals are more likely to be renters. Their homeownership rate is 62%, notably lower than the 85% observed among the Spanish-born. These differences in education and homeownership can be partly attributed to age, as EU15 individuals are, on average, younger (45.7 vs 50.2 years).

One limitation of our data is that, at the census tract level, country of origin is only reported for the main sending countries. For the remaining foreign-born individuals, only the broader region of origin is available. As a result, we are unable to assign all immigrants to either the EU15 or non-EU15 group. However, this limitation is not particularly restrictive in our sample, as we are able to classify 87% of the foreign-born population accordingly.[12]

In order to study neighborhood population dynamics, we use the population growth decomposition proposed by Card et al. (2008), namely:

$$\frac{\text{Pop}_{i,c,t_1} - \text{Pop}_{i,t_0}}{\text{Pop}_{i,c,t_0}} = \frac{\text{Spain}_{i,c,t_1} - \text{Spain}_{i,c,t_0}}{\text{Pop}_{i,c,t_0}} + \frac{\text{EU15}_{i,c,t_1} - \text{EU15}_{i,c,t_0}}{\text{Pop}_{i,c,t_0}} + \frac{\text{Non - EU15}_{i,c,t_1} - \text{non - EU15}_{i,c,t_0}}{\text{Pop}_{i,c,t_0}} \quad (1)$$

where i stands for census tract, c for city and t for time. Equation 1 recognizes that the population growth rate of a neighborhood between two points in time can be decomposed into the growth contribution of different subgroups of the population.[13] In our analysis, we focus on the period between 2001 and 2009 (or 2011) and on the three groups described above (Spanish-born, EU15 immigrants excluding Spain, and non-EU15 immigrants).

[11] This contrasts with other European countries. Verdugo (2016) shows that in France public housing acts as an immigration magnet.

[12] In practice, our non-EU15 classification includes individuals born in Romania, Bulgaria, Poland, Russia, Ukraine, Asia and Africa. It also includes individuals born in Argentina, Bolivia, Brazil, Chile, Colombia, Cuba, Paraguay, Peru, Dominican Republic, Uruguay and Venezuela. Note that we do not include all immigrants born in America in order to exclude those born in the US or Canada. Our EU15 definition includes those born in France, Germany, Italy, Portugal and UK.

[13] In our setting, the decomposition does not hold exactly because, as explained above, some immigrants are not included in any of the two categories.

Table 2 Descriptive statistics for neighborhood variables

Variable	Mean	Std. Dev	Min	Max
Neighborhood population changes 2009–2001				
Population growth rate (2009—2001)	0.09	0.27	- 0.39	5.31
ΔSpanish born (2009—2001, relative to pop. in 2001)	- 0.04	0.25	- 0.46	4.50
ΔEU15 (2009—2001, relative to pop. in 2001)	0.01	0.01	- 0.14	0.17
Δnon-EU15 (2009—2001, relative to pop. in 2001)	0.11	0.09	- 0.04	0.95
Δshare non-EU15 (2009—2001)	0.10	0.07	- 0.05	0.52
% of non-EU15 immigrants, 2001	0.04	0.04	0.00	0.33
Neighborhood characteristics, 2001 census				
Distance to the CBD (km)	6.69	5.80	0	35.5
Share of dwellings built before 1900	0.04	0.11	0.00	1.00
Share of dwellings built between 1900 and 1950	0.16	0.20	0.00	1.00
Share of dwellings built between 1950 and 1970	0.37	0.30	0.00	1.00
Av. dwelling size (squared meters)	81.75	18.17	39.38	174.88
% of building in poor condition	3.86	7.32	0.00	100.00
Av. number of floors	4.67	2.32	1.01	12.00
Other outcomes				
Rents per squared meter, 2011	8.47	2.47	2.17	16.80
Average net per capita income, 2015	12,738	4,696	3,281	28,350
Dwelling growth rate, 2001–2011	17.82	26.06	- 10.00	198.30

Note: See main text for data sources. For the main analysis, the number of observations is 6.158. This number is reduced to 5,041 for rents per squared meters and 5,507 for net income per capita

The top panel of Table 2 presents summary statistics for the main outcomes of interest. Between 2001 and 2009, the average population growth rate is 9%, indicating that most tracts gained population over this period. This growth was largely driven by the immigration boom. In contrast, the contribution of the native (Spanish-born) population to overall growth was, on average, slightly negative, though there is substantial variation across neighborhoods. As expected, the population of non-EU15 immigrants increased dramatically between 2001 and 2009. On average, the number of non-EU15 immigrants rose by 11% relative to the 2001 population level, and the share of non-EU15 immigrants in the average neighborhood increased by 10 percentage points. Although smaller in magnitude, EU15 immigration is non-negligible. The average increase in the number of EU15 immigrants between 2001 and 2009 was around 1% relative to the 2001 population.

The middle panel of Table 2 presents relevant census tract characteristics drawn from the 2001 census. First, we include the distance (in kilometers) from the centroid of each tract to the city's Central Business District (CBD), defined as the center of the

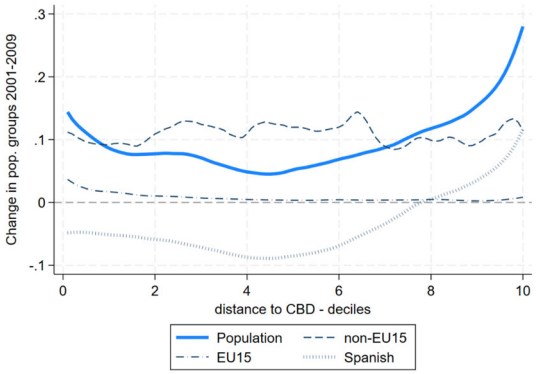

Fig. 2 Spanish-born, EU15 and non-EU15 population growth vs. distance to CBD: 2001–2009 Notes: Non-parametric local-linear regression fits. Distance to CBD normalized within each city

core municipality in each city.[14] Given the varying sizes of the urban areas in our study, we normalize the distance to the CBD within each city and consider the percentile each track occupies within its city.[15] To characterize the pre-existing local housing stock in 2001, we consider the share of dwellings built before 1900, between 1900 and 1950 and between 1950 and 1970), being the share of dwellings built between 1970 and 2000 the omitted category. We also consider average dwelling size (in squared meters), the percentage of buildings in poor condition, and the average number of floors per building, which serves as a proxy for building height. The average dwelling is 82 square meters and less than 4% of dwellings are in poor condition. On average, dwellings measure 82 square meters, less than 4% of buildings are classified as being in poor condition, and buildings typically have nearly five floors, reflecting the prominence of tall buildings as a feature of southern European cities (Fielding 1989).

To better understand who locates where, we also examine outcomes that urban economics theories suggest are jointly determined with residential location choices. Specifically, we analyze census tract–level rents in 2011, average net per capita income in 2015, and the growth rate in the number of dwellings between 2001 and 2011.[16]

4 Neighborhood population dynamics

Figure 2 presents non-parametric kernel fits of population growth and its components, as specified in Eq. 1, plotted against distance to the city's CBD.[17] The solid line, representing total population growth, remains positive throughout the city, reflecting

[14] The center of the core municipality is defined by INE (*centro del municipio*) based on historical/administrative criteria and is not necessarily the point with the highest employment density as in the monocentric city model.

[15] In Figure D1-D2 in the Appendix D we reproduce the main analysis with the non-normalized distance to the CBD in km.

[16] This is the first year that data on rents at the Census tract level from *Sistema Estatal de Referencia del Precio del Alquiler de Vivienda* are available. As for income, the first available data from *Atlas de la distribución de la renta de los hogares* is for 2015. Dwelling growth rate measures the relative change in the number of dwellings between the 2001 and 2011 Censuses.

[17] We use the npregress Stata command that performs non-parametric local-linear regressions.

Spain's substantial population increase between 2001 and 2009 due to the immigration boom. Interestingly, this growth is not uniform throughout the city but follows a U-shaped pattern, with lower population growth observed at intermediate distances from the CBD.

Interestingly, different population groups exhibit distinct location patterns. The growth of the Spanish-born population (dashed-line) is consistently negative at short and intermediate distances from the CBD but becomes positive in neighborhoods located farther from the center. This pattern indicates a clear decentralization of the Spanish-born population between 2001 and 2009.

The EU15 population (dash-and-dot line) shows positive growth rates throughout the city, consistent with the overall increase in their aggregate numbers in Spain, as shown in Table 1. However, the spatial distribution of this growth is notably uneven, with a sharp decline in growth rates as distance from the CBD increases. The strong presence of EU15 immigrants in the most central neighborhoods contrasts with the negative growth of the Spanish-born population in those same areas. This pattern suggests that EU15 immigrants have played a pivotal role in the urban revival processes occurring in the city centers of Spanish metropolitan areas. Finally, as can be expected from inspecting Table 1, the growth contributions of non-EU15 (dashed line) are consistently positive and large –centered around 10%– reflecting the large inflow of this population group into Spanish cities during this period. In contrast to the other population groups, the contribution of the non-EU15 to population growth is similar across different distances to the CBD.

In Fig. 3, we split the immigration episode into two sub-periods: 2001–2004 and 2004–2009. The population dynamics in the Spanish-born and EU15 groups are relatively similar in both periods. In contrast, the location patterns of the non-EU15 group differ significantly between the early and late years of the immigration wave. Between 2001 and 2004, the growth of non-EU15 immigrants is a decreasing function of the distance to the CBD, with the highest inflows concentrated in the most central neighborhoods. However, this pattern reverses in the latter period, 2004–2009, when growth among non-EU15 immigrants slows in central areas and becomes more pronounced in neighborhoods located at intermediate distances from the CBD.

In Appendix D we report the results of two different robustness checks for Figs. 2 and 3. Figures D1 and D2 replicate the analysis using raw (non-normalized) distances to the CBD, measured in kilometers, instead of normalized distances. The results remain consistent, indicating that our findings are robust to the distance specification. In Figures D3 and D4 we change the estimation method by employing binscatter regressions, which are well-suited for capturing non-linear relationships between variables (Cattaneo et al. 2025). The resulting patterns closely mirror those obtained with kernel fits. A key advantage of the binscatter approach is that it generates analytical confidence intervals, allowing for a more precise assessment of differences in location patterns across population groups and time periods.

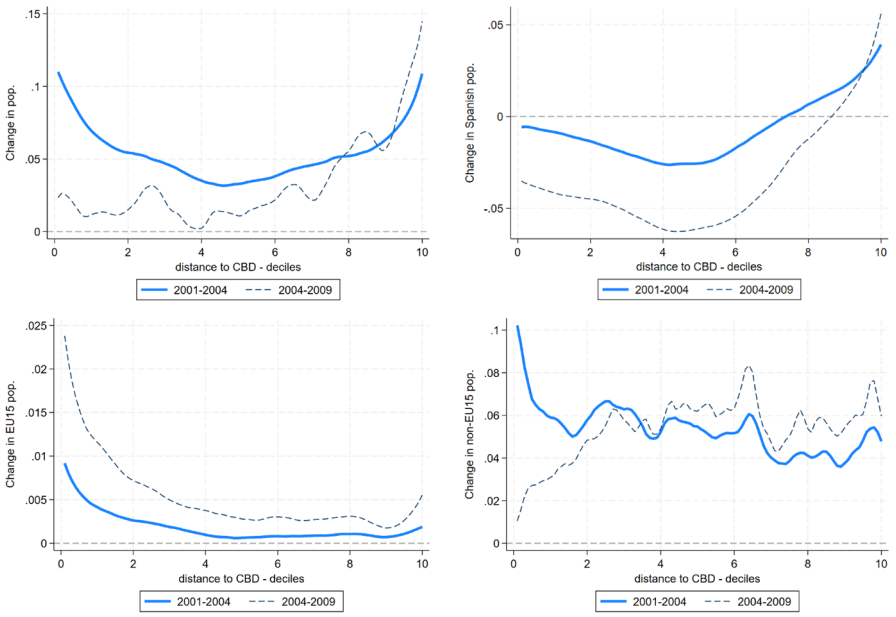

Fig. 3 Spanish-born, EU15 and non-EU15 population growth vs. distance to CBD by sub-periods.Notes: Non-parametric local-linear regression fits. Distance to CBD normalized within each city

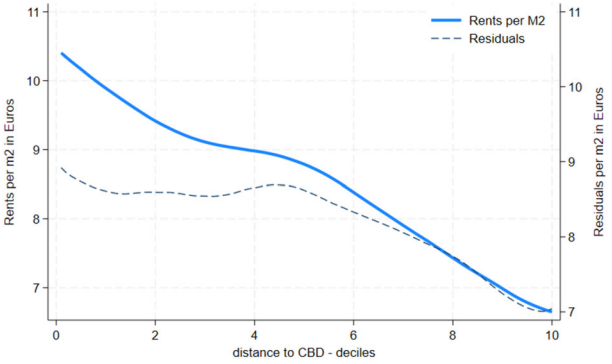

Fig. 4 Rents vs. distance to CBD in 2011. Notes: Non-parametric local-linear regression fits. Rescaled residuals from a linear regression of average log rents against census tract housing characteristics' variables and province fixed effects

5 Understanding who locates where

Having described the spatial distribution of the different population groups during the immigration wave, this section seeks to explore the underlying factors driving their differential residential patterns across the city. The canonical framework in urban economics for analyzing such location decisions is the monocentric city model (Alonso

1964; Mills 1967; Muth 1969), which characterizes the joint determination of residential location, housing prices, housing consumption and income in spatial equilibrium. Duranton and Puga (2015) provide an in-depth presentation of this foundational model, including several key extensions, while also highlighting its primary limitations.

A central insight of the monocentric model is that proximity to the central business district (CBD) is desirable due to better access to employment opportunities, as it minimizes commuting costs. In equilibrium, utility must be equalized across locations within the city. As a result, areas located farther from the CBD must offer lower housing costs to compensate for the higher commuting burden. This trade-off leads to a spatial gradient in housing prices. The solid line in Fig. 4 illustrates this relationship by plotting rents per square meter in 2011 against distance from the CBD. The figure reveals a clear decline in rents as one moves away from the CBD, consistent with the core predictions of the monocentric city model.

Differences in housing prices can partly reflect differences in housing stock characteristics. To better isolate the location-specific component of housing costs, we compute residualized rents—i.e., rents purged of the influence of observable housing attributes. Specifically, we regress the logarithm of average rents per square meter on a set of census tract-level housing characteristics, along with city-specific fixed effects. The resulting measure, depicted as the dashed line in Fig. 4, captures the component of rents attributable to location-specific factors, net of housing characteristics. As such, residualized rents can be interpreted as a proxy for the relative level of local amenities or desirability across different areas within a city.

Following the logic of the monocentric city model, such amenities are expected to reflect proximity to the CBD or job accessibility more broadly. However, in practice, a wide range of neighborhood-level factors beyond simple distance to the CBD can influence location desirability. Compared to raw rents, the relationship between residualized rents and distance to the CBD exhibits greater non-linearity. The negative relationship is initially steep perhaps reflecting the value of downtown amenities such as historical buildings (Koster et al 2016) and bars and restaurants (Couture and Handbury 2020). Between deciles 2 and 5, residualized rents remain relatively flat, suggesting a plateau in amenity value at intermediate distances. Beyond this range, rents decline more sharply in the outer suburbs, potentially reflecting lower accessibility and fewer desirable amenities in those peripheral areas.

At first glance, the relatively low rents per square meter in the more distant suburbs may appear to contradict the observation that these areas are disproportionately attracting native residents, who tend to have comparatively high levels of income as shown in Table C1. However, this pattern is consistent with the predictions of the monocentric city model, which highlights two opposing forces shaping residential location decisions based on income. On one hand, higher-income households face a greater opportunity cost of time and thus place a higher value on proximity to the central business district (CBD). On the other hand, they also exhibit a stronger preference for larger housing, making them more responsive to the lower housing prices typically found in suburban areas. From a theoretical perspective, wealthier households will choose suburban locations if the income elasticity of the demand for housing exceeds the income elasticity of commuting costs (Duranton and Puga 2015). Consequently,

the observed suburbanization of native households during the study period can be interpreted as a reflection of their relatively stronger demand for housing.

The top-left panel in Fig. 5 illustrates the relationship between housing consumption—measured as the neighborhood-level average dwelling size in 2001—and distance to the CBD.[18] As expected, larger dwellings are predominantly located in the more distant suburbs, which helps explain why native residents disproportionately located in these areas between 2001 and 2009, consistent with the predictions of the monocentric city model. Interestingly, the relationship between dwelling size and distance to the CBD is non-linear, displaying a U-shaped pattern with the smallest dwellings found at intermediate distances from the CBD. We will return to this empirical regularity in the discussion that follows.

Turning to neighbourhood income, Fig. 6 illustrates the relationship between average per capita net income in 2015 and distance to the CBD.[19] The relationship is distinctly non-monotonic and closely resembles the U-shaped pattern observed in housing consumption (top-left panel of Fig. 5). Income levels are relatively low at intermediate distances from the CBD —roughly between deciles 4 and 6—and increase as one moves toward the outer suburbs, albeit with a localized dip around the 9th decile. Income also rises when approaching the inner-city areas, reaching particularly high levels between deciles 1 and 2. However, there is a notable decline in income in the most central neighbourhoods, suggesting a concentration of lower-income households in the most central locations.

The standard monocentric city model does not predict a non-monotonic relationship between housing consumption (or income) and distance to the CBD. A key limitation of the model in fully capturing the internal structure of cities is its implicit assumption that urban areas are rebuilt from scratch in each period, thereby neglecting the durability of housing as a long-lived asset. In reality, urban development is path-dependent: cities tend to expand outward rather than redevelop existing areas (Hohenberg and Lees 1995; Harari 2020). As a result, population growth tends to be accommodated through new housing construction at the urban fringe. This outward growth pattern is clearly reflected in the solid line of Fig. 7, which shows that the majority of dwelling construction between 2001 and 2011 occurred in the more distant suburbs.

Further evidence of the path-dependent nature of urban development is provided by the age distribution of buildings reported in the 2001 census, as shown in Fig. 6. Buildings constructed before 1900 (top-center panel) are heavily concentrated in the urban core, reflecting the historical origins of these cities. Buildings built between 1900 and 1950 (top-right panel) are also predominantly located in central neighborhoods, with their density peaking around the first decile of distance from the CBD. In contrast, buildings constructed between 1950 and 1970 (bottom-left panel) are most common at intermediate distances, corresponding to a period of rapid urban expansion driven by intense rural-to-urban migration (Fielding 1989; Bover and Arellano 2002; Bover and Velilla 2005). Finally, beyond the 7th decile, the housing stock consists primarily of

[18] For the sake of comparability with rents in Fig. 4, it would be preferable to look at housing consumption in 2011. However, neighborhood housing characteristics are missing for the majority the Census tracts in the 2011 Census.

[19] As discussed in Sect. 3, income data at the neighborhood level is only available since 2015.

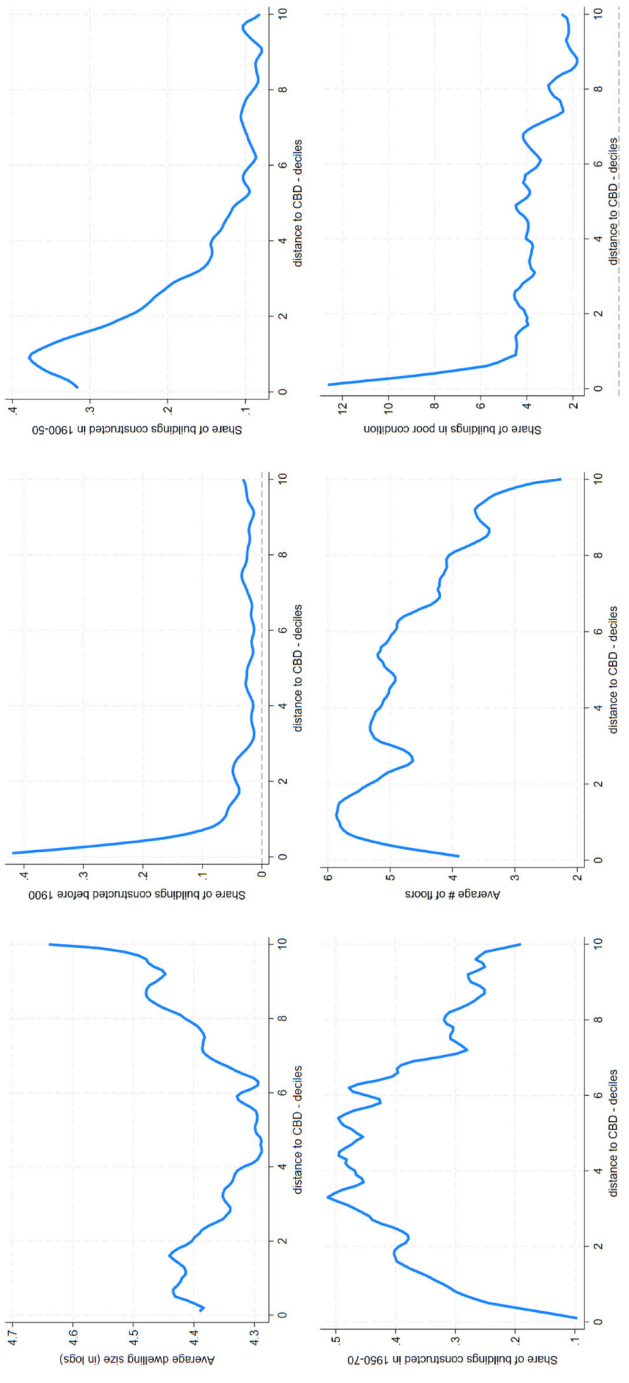

Fig. 5 Housing characteristics in 2001 vs distance to CBD Notes: Housing characteristics in 2001. Non-parametric local-linear regression fits. Distance to CBD normalized within each city

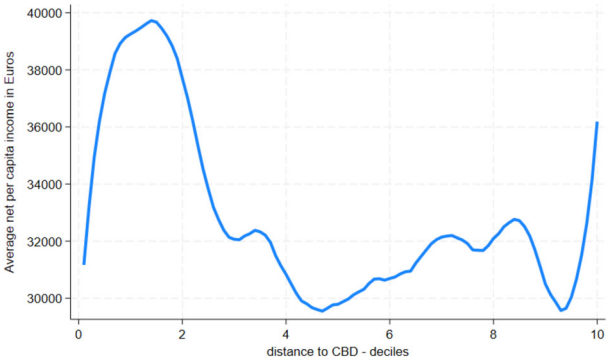

Fig. 6 Net income per capita in 2015. Notes: Non-parametric local-linear regression fits. Distance to CBD normalized within each city

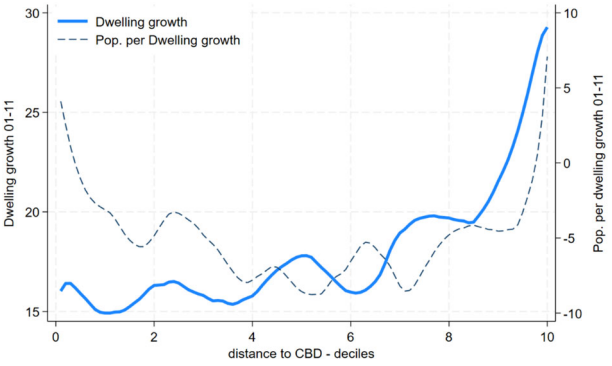

Fig. 7 Dwelling growth/population per dwelling growth and distance to CBD. Notes: Non-parametric local-linear regression fits. Distance to CBD normalized within each city

dwellings built after 1970, indicating more recent suburban development at the urban fringe.

Although the monocentric city model has limitations, it remains useful for understanding residential sorting dynamics during successive phases of outward urban expansion. During the period of intense rural-to-urban internal migration between 1950 and 1970, new housing constructed at the urban fringe typically consisted of smaller units, suggesting that these newly developed peripheral areas were primarily inhabited by lower-income households. In contrast, as discussed above, during the 2001–2009 period, higher-income households increasingly relocated to the more distant suburbs, attracted by the opportunity to consume larger housing units. This shift helps explain the U-shaped relationship between income (and housing consumption) and distance to the CBD: affluent households are concentrated both in the central neighborhoods and in the outer suburbs, while lower-income groups are disproportionately located at intermediate distances. This pattern reflects a leapfrogging process, whereby wealthier households bypassed the poorer residents in earlier-developed suburbs from the

1950–1970 expansion phase, relocating instead to newer and more spacious suburban developments.

The period during which a neighborhood develops plays a crucial role in shaping its housing characteristics. As noted earlier, average dwelling size follows a U-shaped pattern with respect to distance from the central business district (CBD). Additional insights are provided by the middle and left panels in the bottom row of Fig. 6, which plot average building height and the share of buildings in poor condition, respectively. Building height is relatively low in the innermost city center but increases sharply just beyond the core, reaching its peak between the first and second deciles of distance from the CBD. Beyond this point, building height declines monotonically, with the lowest structures found in the most distant suburbs. A similar spatial pattern is observed in building condition: the share of buildings in poor condition is highly concentrated in the urban core and drops steeply up to the first distance decile. Beyond this point, the decline becomes much more gradual, and the relationship between building condition and distance remains relatively flat between the first and ninth deciles.

Examining housing prices, income and the characteristics of the housing stock through the lens of the monocentric city models helps us to understand why different groups locate in different parts of the city in the period 2001–2009. The Spanish-born population, who tend to be relatively high income, disproportionately move to the more distant suburbs and consume more housing. This area also saw the most intense new construction during the immigration wave. In contrast, EU-15 residents are highly concentrated in the most central city locations. These are the most expensive city areas which is consistent with their preference for shorter commutes and access to downtown amenities. Since EU-15 immigrants and Spanish-born individuals have similar income levels (see Table C1), one may hypothesize that differences in preferences likely explain why EU-15 residents cluster downtown. This is supported by the fact that EU-15 individuals tend to be younger, more likely to have tertiary education, and live in smaller households, as shown in Table C1.

It is noteworthy that the innermost city center exhibits both the highest rents and the highest concentration of buildings in poor condition. This combination may help explain why, during the early years of the immigration wave, these central areas attracted both high-income individuals (primarily from EU-15 countries) and low-income groups (notably from non-EU15 countries).[20] In the later phase of the immigration wave (2004–2009), non-EU15 immigrants increasingly settled in neighborhoods at intermediate distances from the CBD, where rents were more affordable and dwellings tended to be the smallest in the city.[21]

[20] Besides those considered by the standard monocentric city model described above, the literature has identified other factors that could attract immigrants such as public transportation (Glaeser et al 2008) or the presence of earlier migrants. In their study that assesses if immigrants displace natives in Spanish neighborhoods, Fernández-Huertas Moraga et al (2019) instrument the inflow of immigrants with a shift-share approach. Their first stage results suggest that network effects have been at play in this period, suggesting that the location of migrants in 2001–2009 might be affected by the early distribution of migrants in 2001. This could partly explain why in the early years of the immigration wave non-EU15 immigrants locate in very central areas.

[21] The location patterns of non-EU15 immigrants are consistent with theories that stress the importance of filtering in housing markets, see e.g. Brueckner and Rosenthal (2009) and Rosenthal (2014).

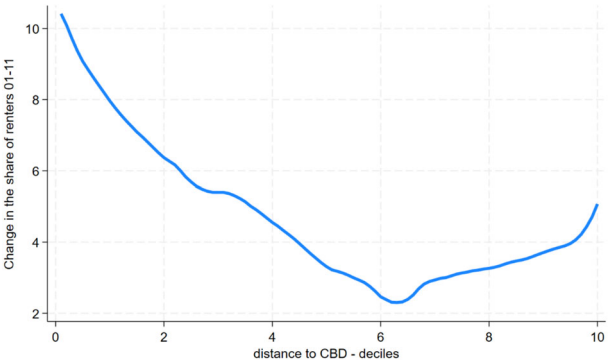

Fig. 8 Change in the share of renters, 2001–2011 and distance to CBD Notes: Difference in non-parametric local-linear regression fits for the share of renters between 2011 and 2001. Distance to CBD normalized within each city

There are, at least, three non-competing hypothesis that may explain why the residential location patterns of non-EU15 immigrants changed between the early and late years of the immigration wave.[22] First, a plausible hypothesis is that city centers became increasingly crowded and there was a shortage of suitable dwellings to home the new immigrant arrivals. Second, and relatedly, immigrants may initially enter the housing market as renters but transition to homeownership after a few years. If the determinants of where to rent and where to buy differ, this could account for the observed shift in settlement patterns. Finally, a third hypothesis is that the ongoing gentrification of city centers during this period (see, e.g., González-Pampillón et al., 2020) may have displaced low-skilled non-EU15 immigrants from central neighborhoods to more affordable areas at intermediate distances from the CBD.

Figures 7, 8 and 9 provide empirical support for the three hypotheses discussed above. The dashed line in Fig. 7 shows the growth rate of the ratio between population and the number of dwellings in each neighborhood between 2001 and 2011. This graph supports the hypothesis that the most central areas became increasingly crowded, reducing the availability of suitable dwellings for new immigrant arrivals. Additionally, the figure shows that the population-per-dwelling ratio also increased in the more distant suburbs. This pattern is consistent with the arrival of larger households in these suburban areas.

To assess whether the change in the location of non-EU15 immigrants is related to transitions into homeownership, Fig. 8 plots the change in the share of renters between 2001 and 2008.[23] The largest increases in rental rates are observed in downtown areas, while the smallest increases occur in neighborhoods at intermediate distances from the

[22] Besides the three theories that we test, there are at least two other plausible hypotheses that could explain the change in the location patterns of non-EU15 migrants. First, it could be a story of assimilation. Immigrants initially locate in enclaves in central areas and later on they move to other parts of the city. Second, it could be a composition story, namely, that the socioeconomic characteristics of immigrants changed between the early and late years of the immigration boom.

[23] To compute the change in the share of renters, we estimate the 2001 and 2011 level kernels separately and then compute the difference. This approach is used due to the small number of observations in 2011.

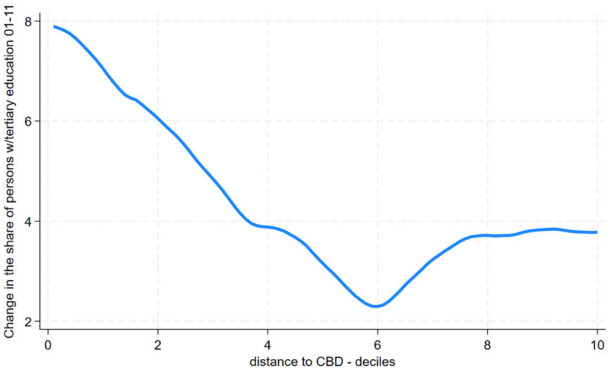

Fig. 9 Change in the share of persons with tertiary education, 2001–2011 and distance to CBD Notes: Non-parametric local-linear regression fits. Distance to CBD normalized within each city

CBD—precisely where non-EU15 immigrants concentrated during the later years of the immigration wave. Therefore, Fig. 8 supports the hypothesis that transitions from renting to homeownership may explain the shift in the residential location patterns of the non-EU15 group.

Finally, Fig. 9 presents the relationship between changes in the share of individuals with tertiary education and distance to the CBD. The graph clearly indicates that city centers experienced gentrification between 2001 and 2009. This urban revival may have contributed to the displacement of non-EU15 immigrants from central neighborhoods to areas located at intermediate distances from the CBD. Overall, the evidence provides empirical support for all three hypotheses discussed above.

6 The role of housing characteristics to explain neighborhood population dynamics

The evidence presented above suggests that pre-determined housing characteristics as of 2001 may have played an important role in shaping the residential location patterns observed during the 2001–2009 period. To assess this relationship more formally we resort to regression analysis. More specifically, we run regressions of the following type:

$$\frac{y_{ic,t_1} - y_{ic,t_0}}{Pop_{ic,t_0}} = X_{ic}\prime\rho + \delta_c + \varepsilon_{ic} \tag{2}$$

where y can denote total, Spanish born, EU15 or non-EU15 populations, X_{ic} is a set of characteristics of the stock of housing in 2001 shown in Fig. 5, δ_c is a city-specific fixed effect and ε_{ic} is the error term.[24] Standard errors are clustered at the district level to account for spatial autocorrelation.[25] The estimates are reported in Table 3. To make

[24] The set of city fixed-effects accounts for differences in aggregate immigration inflows across cities and including them amounts to compare data variation across neighborhoods within the same city.

[25] Districts (*distritos censales*) are aggregations of census tracts (*secciones censales*), our definition of neighborhood, and are smaller than municipalities.

Table 3 Housing characteristics and population growth by groups

Variable	**2001–04**	**2004–09**	**2001–09**
Panel A: Spanish born			
Share of buildings constructed before 1900	− 0.024**[− 0.02]**	− 0.033**[− 0.03]**	− 0.081***[0.03]**
	(0.020)	(0.014)	(0.027)
Share of buildings constructed in 1900–50	− 0.050***[− 0.07]**	− 0.025***[− 0.04]**	− 0.096***[− 0.08]**
	(0.011)	(0.009)	(0.018)
Share of buildings constructed in 1950–70	− 0.073*** **[− 0.16]**	− 0.044*** **[− 0.11]**	− 0.133***[− 0.15]**
	(0.008)	(0.007)	(0.016)
Average dwelling size (in logs)	0.093*** **[0.14]**	0.136***[0.24]**	0.243***[0.21]**
	(0.009)	(0.012)	(0.018)
Share of buildings in poor condition	0.000**[0.01]**	0.000**[0.03]**	0.001*[0.02]**
	(0.000)	(0.000)	(0.000)
Average # of floors	− 0.008***[− 0.14]**	− 0.012***[− 0.24]**	− 0.022***[− 0.21]**
	(0.001)	(0.001)	(0.002)
Adjusted R-squared	0.074	0.144	0.124
Panel B: EU15 pop			
Share of buildings constructed before 1900	0.013***[0.27]**	0.033***[0.40]**	0.051***[0.40]**
	(0.003)	(0.006)	(0.010)
Share of buildings constructed in 1900–50	0.003***[0.14]**	0.011***[0.25]**	0.015***[0.22]**
	(0.001)	(0.002)	(0.003)
Share of buildings constructed in 1950–70	− 0.000**[− 0.01]**	0.001**[0.02]**	0.000**[0.00]**
	(0.000)	(0.000)	(0.001)
Average dwelling size (in logs)	0.003***[0.12]**	0.006***[0.14]**	0.009***[0.14]**
	(0.001)	(0.001)	(0.002)
Share of buildings in poor condition	− 0.000**[− 0.02]**	− 0.000*[− 0.03]**	− 0.000**[− 0.03]**
	(0.000)	(0.000)	(0.000)
Average # of floors	− 0.000**[− 0.00]**	0.000**[0.02]**	− 0.000**[− 0.00]**
	(0.000)	(0.000)	(0.000)
Adjusted R-squared	0.157	0.314	0.305
Panel C: non-EU15 pop			
Share of buildings constructed before 1900	0.062***[0.14]**	− 0.061***[− 0.12]**	− 0.004**[− 0.00]**
	(0.010)	(0.020)	(0.022)
Share of buildings constructed in 1900–50	0.029***[0.12]**	− 0.027***[− 0.10]**	− 0.00**[− 0.00]**
	(0.006)	(0.007)	(0.012)
Share of buildings constructed in 1950–70	0.017***[0.10]**	0.024***[0.14]**	0.040***[0.13]**
	(0.004)	(0.004)	(0.008)

Table 3 (continued)

Variable	**2001–04**	**2004–09**	**2001–09**
Average dwelling size (in logs)	− 0.083***[**− 0.36**]	− 0.093***[**− 0.37**]	− 0.179***[**− 0.42**]
	(0.007)	(0.006)	(0.011)
Share of buildings in poor condition	0.000**[**0.05**]	0.000[**0.03**]	0.001**[**0.05**]
	(0.000)	(0.000)	(0.000)
Average # of floors	− 0.002***[**− 0.11**]	− 0.004***[**− 0.19**]	− 0.007***[**− 0.19**]
	(0.000)	(0.000)	(0.001)
Adjusted R-squared	0.318	0.307	0.365
Observations	6,158	6,158	6,158
Nbr. Clusters	306	306	306

Note: Regressions include city fixed effects. Standard errors in parenthesis are clustered at the district level.*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

the coefficient estimates more comparable across population groups and periods, we provide within brackets the effect of one standard deviation in the regressor in terms of standard deviations of the outcome variable.

Starting with the Spanish-born population (panel A), the results indicate that housing characteristics exert similar effects across periods. Population growth among the Spanish-born is negatively associated with neighborhoods that have a high share of buildings constructed before 1900, between 1900 and 1950, and especially during the 1950–1970 period. Given that the omitted reference category consists of buildings constructed after 1970, these findings imply that the Spanish-born population is more likely to settle in areas with a newer housing stock. Additionally, neighborhoods with larger average dwelling sizes and lower average building heights (i.e., fewer floors) are also associated with greater Spanish-born population growth.

The determinants of location choices for the EU15 population differ markedly from those observed for the Spanish-born, particularly in relation to the age of the housing stock. Population growth among the EU15 group is positively and significantly associated with neighborhoods containing a high share of very old buildings—specifically, those constructed before 1900—and, to a lesser extent, those built between 1900 and 1950. Controlling for the age composition of the housing stock, the presence of larger dwellings is also positively associated with EU15 population growth, which is consistent with their relatively high income levels. In contrast, average building height does not appear to play a significant role in shaping their residential location decisions.

In contrast to the other two groups, the non-EU15 population shows very distinct location patterns between the 2001–2004 and 2004–2009 periods. During the initial years of the immigration boom, the non-EU15 population growth was higher in neighborhoods characterized by older buildings, particularly those built before 1900. However, in the 2004–2009 period, this group preferred neighborhoods with buildings

constructed between 1950 and 1970, and was negatively associated with areas dominated by older housing stock. Across the entire period, non-EU15 immigrants tended to locate in areas with smaller dwellings (as indicated by a negative effect of average dwelling size) and a higher share of buildings in poor condition.

To assess the extent to which housing characteristics explain the differing residential locations relative to the CBD, Fig. 10 plots actual (solid lines) and predicted (dashed lines) contributions to population growth based on the coefficient estimates from Table 3. As shown, predicted and actual growth patterns closely align across all population groups and periods, indicating that housing characteristics effectively account for the distinct location patterns of the Spanish-born, EU-15, and non-EU15 populations.

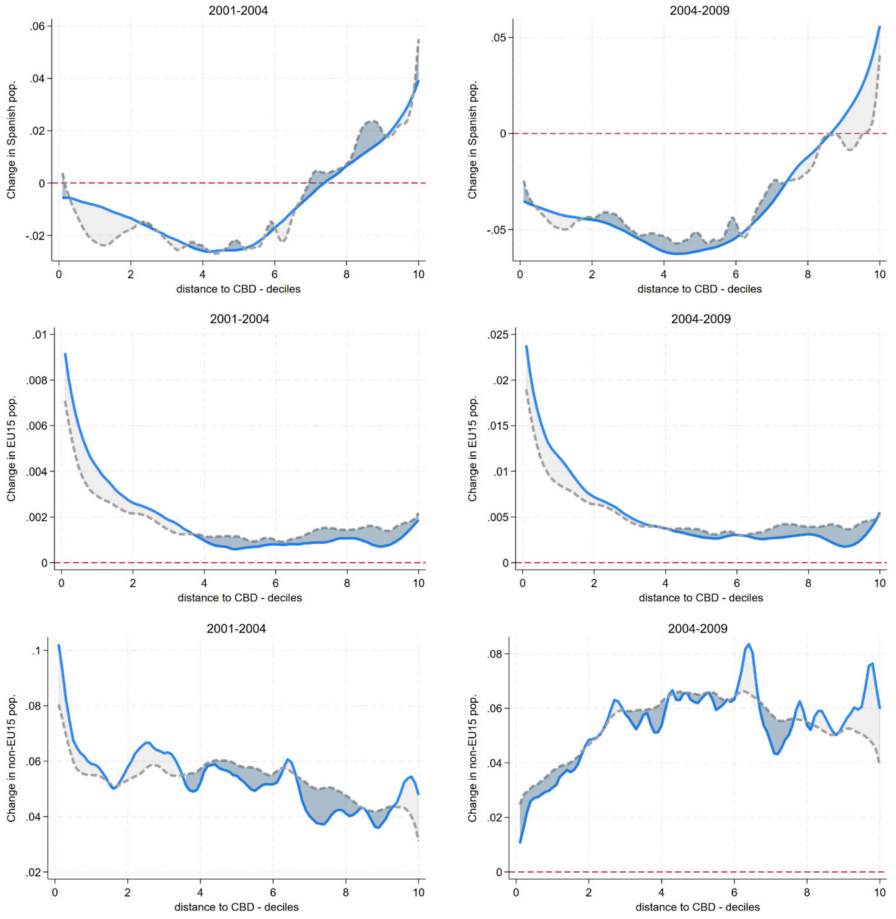

Fig. 10 Actual versus predicted growth by sub-periods Notes: Non-parametric local-linear regression fits of population growth against distance to CBD which is normalized within each city. Solid lines for raw data while dashed lines are predicted values from Eq. 2

The difference between actual and predicted values represents the residuals shown in Fig. 10. Residuals are positive (shaded in grey) when predicted growth underestimates actual growth, and negative (shaded in blue) when predicted growth exceeds actual growth. For the EU15 group, residuals are systematically negative near the CBD and positive farther away. This indicates that the model underestimates EU15 population growth in central locations while overestimating it in the suburbs, consistent with the attraction of downtown amenities for this highly educated and younger population.

7 Concluding remarks

At the beginning of the twenty-first century, immigration from low- and middle-income countries to major cities in high-income nations became a defining and sustained phenomenon. While the literature has thoroughly examined the impact of immigration on labor and housing markets, much less is known about how immigration reshapes the internal geography of cities. To address this gap, we study how Spanish cities absorbed the large inflows of immigrants between 2001 and 2009. Specifically, we analyze neighborhood-level changes in the residential patterns of three population groups—Spanish-born, EU15, and non-EU15—across the six largest cities: Madrid, Barcelona, Sevilla, Valencia, Málaga, and Zaragoza.

During the whole immigration wave, the Spanish-born population disproportionally moved to more distant suburbs. The EU15 immigrant group presents a very distinct location pattern, being highly concentrated in inner-city centers. Since EU15 immigrants tend to have high levels of education, this group has contributed to the urban revival of Spanish downtowns. As for the non-EU15 immigrants, they initially located in very central city locations while, towards the end of the period, their growth was the highest in neighborhoods at intermediate distances to the CBD.

Our study underscores the value of the monocentric city model—particularly when adapted to account for path-dependent urban development and outward city growth—in understanding how cities absorb large immigration waves. Spanish-born individuals, typically higher-income, increasingly settled in distant suburban areas to access larger housing. In contrast, EU15 immigrants, who tend to be younger and highly educated, concentrated in central neighborhoods to benefit from urban amenities. Non-EU15 immigrants, generally lower-income, initially located in central areas with older, often poorer-quality housing. However, in the later years of the immigration wave, they increasingly moved to neighborhoods at intermediate distances from the CBD, characterized by small dwellings built during the 1950–1970 expansion period.

Appendix

Appendix A: AUDES nucleous definitions of cities.

See (Fig. 11).

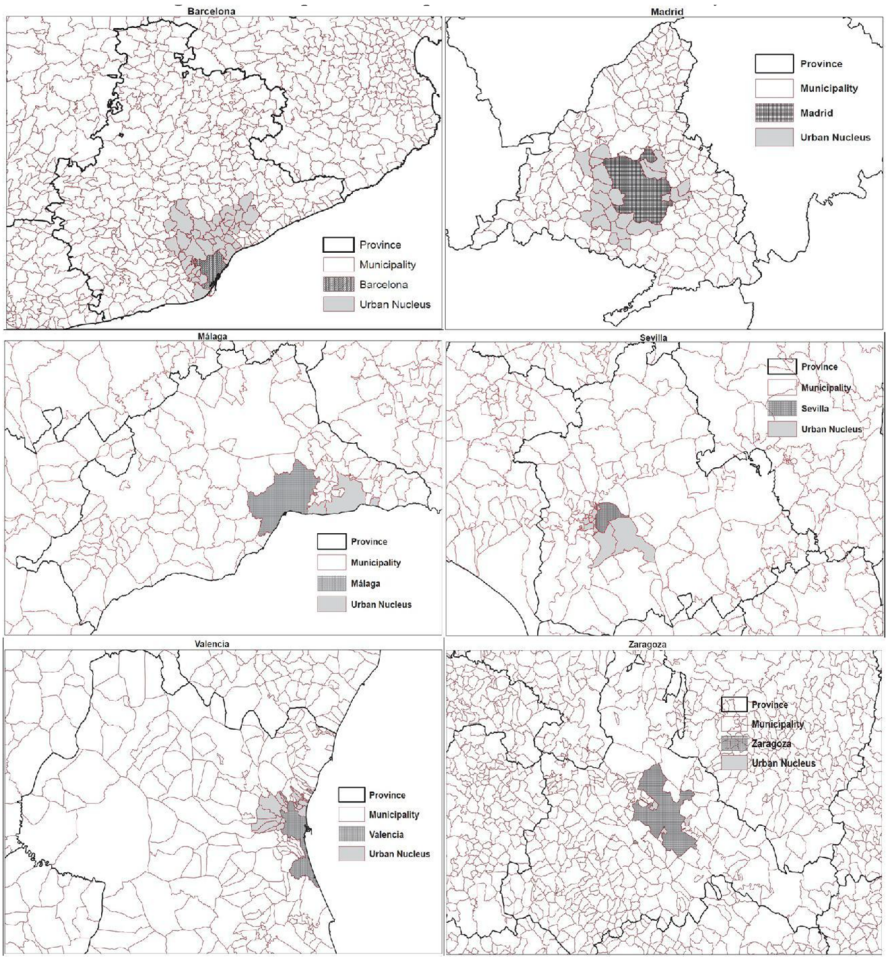

Fig. 11 Maps of municipalities considered in each city Note: In 2001, according to *Padrón municipal de habitantes*, Barcelona had 3,349,810 inhabitants and 46 municipalities, Madrid 4,520,290 inhabitants and 21 municipalities, Málaga 558,431 inhabitants and 2 municipalities, Sevilla 1,010,419 inhabitants and 12 municipalities, Valencia 1,069,767 inhabitants and 18 municipalities and Zaragoza 626,392 inhabitants and 4 municipalities

Appendix B: Construction of a balanced panel of tracts.

To build a consolidated panel of tracts, we proceed with the following steps. First, we intersect each census tract layer from 2002 to 2015 with the 2001 layer, which is used as the base layer. Second, whenever a tract changed with respect to the base, we build weights as the portion of the tract surface that belongs to the reference layer divided by the tract's area. Then, the number of inhabitants in tracts that changed are reconstructed as weighted averages. This approach implicitly assumes population to

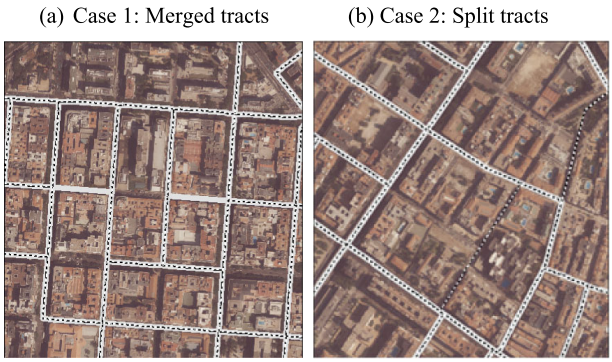

Fig. 12 Example of census tracts redefinitions

be uniformly distributed across space. This assumption is not unrealistic in densely populated areas as it is the case in the city definition that we use.

The following figure shows an example of census tract redefinitions. In the first case, two 2001 census tracts (solid line) were merged into a single tract in the 2015 layer (dashed line). To assign weights to these tracts, we divide the overlapped portion of the 2015 layer with 2001 by the 2015 census tract area. The resulting weights are multiplied by the 2015 populations and then, summed up to get the 2015 population keeping the 2001 tract definition. The second case shows the opposite example. We observe a 2001 tract which is split into two tracts according to the 2015 layer. Weights equal one for those tracts. That is, we basically sum the 2015 population of both tracts to keep the 2001 census tract definition.

Overall, there are a total of 8,463 census tracts. Since tract redefinitions might lead abnormal population growth, we drop i) tracts with a yearly growth rate above 50%, below -50%, or with a yearly population growth rate above 20% with the previous or following year experiencing a growth rate below -10%, ii) tracts with a growth rate in the number of dwellings above 200% between 2001 and 2011 censuses, and iii) tracts with no dwellings in either 2001 or 2011. The final sample contains 6,158 tracts (Fig. 12).

Appendix C: Characterizing Population Groups Using the 2004 Living Conditions Survey (ECV).

See (Table 4).

Table 4 Socioeconomic characteristics by population group

	Spain	EU15	non-EU15
Male	0.473 (0.499)	0.583 (0.493)	0.455 (0.498)
Age	50.200 (16.695)	45.750 (16.943)	38.036 (10.981)
Higher education	0.287 (0.453)	0.470 (0.499)	0.339 (0.474)
Share of unemployed	0.068 (0.252)	0.077 (0.267)	0.169 (0.375)
Share of people at risk of poverty /social exclusion	0.175 (0.380)	0.167 (0.373)	0.351 (0.477)
Share of property owners	0.850 (0.357)	0.616 (0.486)	0.277 (0.447)
Number of rooms	4.161 (0.883)	3.618 (1.236)	3.623 (0.916)
Number of household members	2.994 (1.350)	2.439 (1.282)	3.244 (1.459)
Disposable household income pc	9,410.058 (6,017.427)	10,932.126 (5,542.826)	6,989.312 (4,775.946)
Share households in severe material deprivation	0.035 (0.184)	0.041 (0.198)	0.179 (0.383)
Obs. (weighted)	10,630,771 (90.6%)	190,805 (1.6%)	906,124 (7.7%)

Note: Mean (standard deviation) weighted by the survey expansion factor

Appendix D: Neighborhood population dynamics using distance to CBD in km and using bisncatter regressions.

See (Figs. 13, 14, 15 and 16).

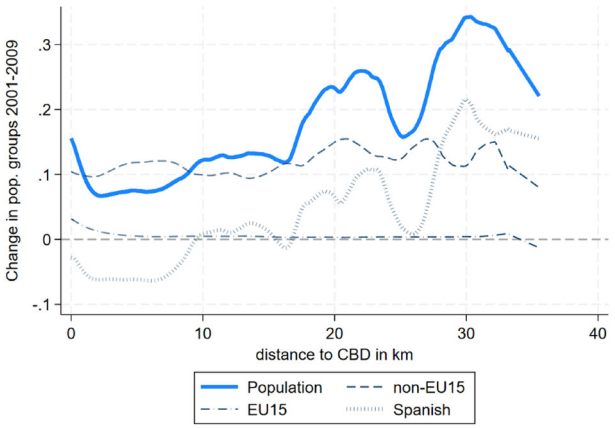

Fig. 13 Spanish-born, EU15 and non-EU15 population growth vs. distance to CBD: 2001–2009 Notes: Non-parametric local-linear regression fits. Distance to CBD measured in km

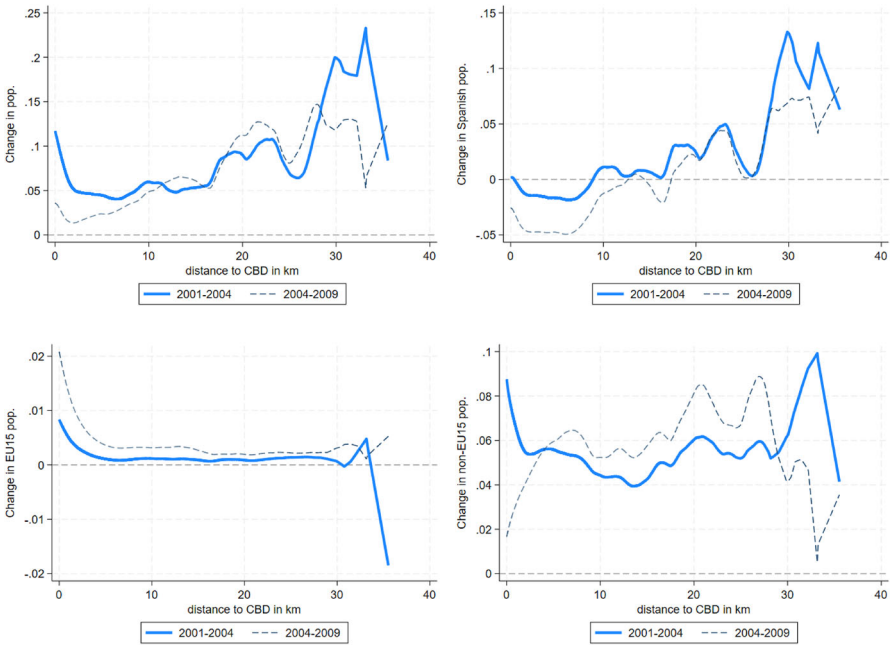

Fig. 14 Spanish-born, EU15 and non-EU15 population growth vs. distance to CBD by sub-periods. Notes: Non-parametric local-linear regression fits. Distance to CBD measured in km

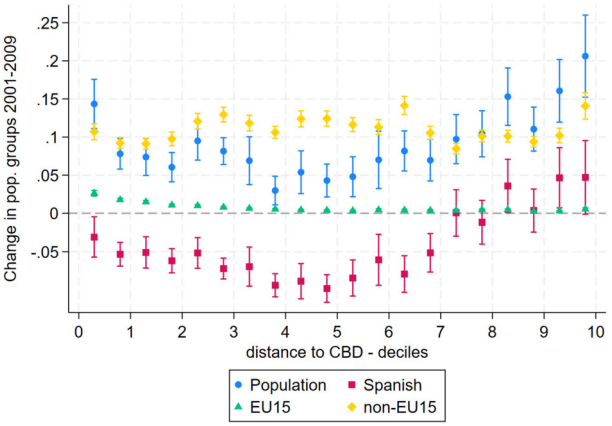

Fig. 15 Spanish-born, EU15 and non-EU15 population growth vs. distance to CBD 2001–2009. Robustness check with binscatter regressions. Notes: Binscatter regressions (Cattaneo et al 2025). Distance to CBD normalized within each city

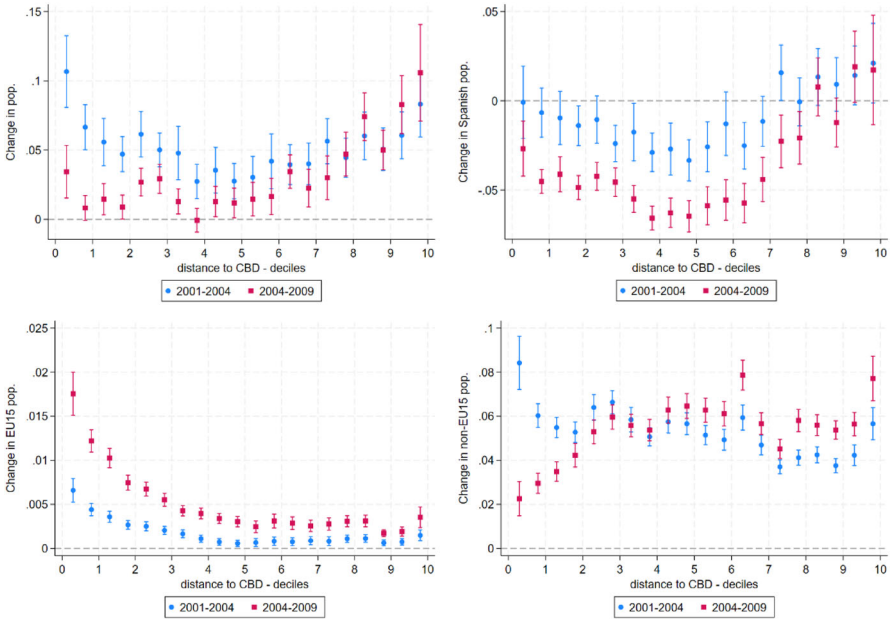

Fig. 16 Spanish-born, EU15 and non-EU15 population growth vs. distance to CBD by subperiods. Robustness check with binscatter regressions Notes: Binscatter regressions (Cattaneo et al 2025). Distance to CBD normalized within

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Data availability All the data used in the article is publicly available data that can be shared upon request.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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