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ORIGINAL PAPER

The shadow of cities: size, location and the spatial distribution of population

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Abstract
Using a large dataset on the population of Spanish municipalities between 1877 and 2001, this paper analyses how their initial size and the presence of neighbouring urban locations influence subsequent population growth and how these links have evolved over time. Our results show that initial size is negatively related to population growth, except in the 1960s and 1970s when this relationship becomes positive. Likewise, the presence of neighbouring urban locations limited local population growth in the late nineteenth century, a negative effect that persisted, but at a diminishing rate, until the second half of the twentieth century. The influence of nearby cities became increasingly positive from then onwards, and especially so during the 1970s.

JEL Classification N93 · N94 · O18 · R11 · R12

1 Introduction

Nightlight satellite imagery has evidenced the uneven spatial distribution of population and economic activity (Chen and Nordhaus 2011; Donaldson and Storeygard 2016). Within economics, understanding what drives the location of economic activity has long been debated. In short, the spatial concentration of people and firms arises from the interaction between first nature advantages and agglomeration

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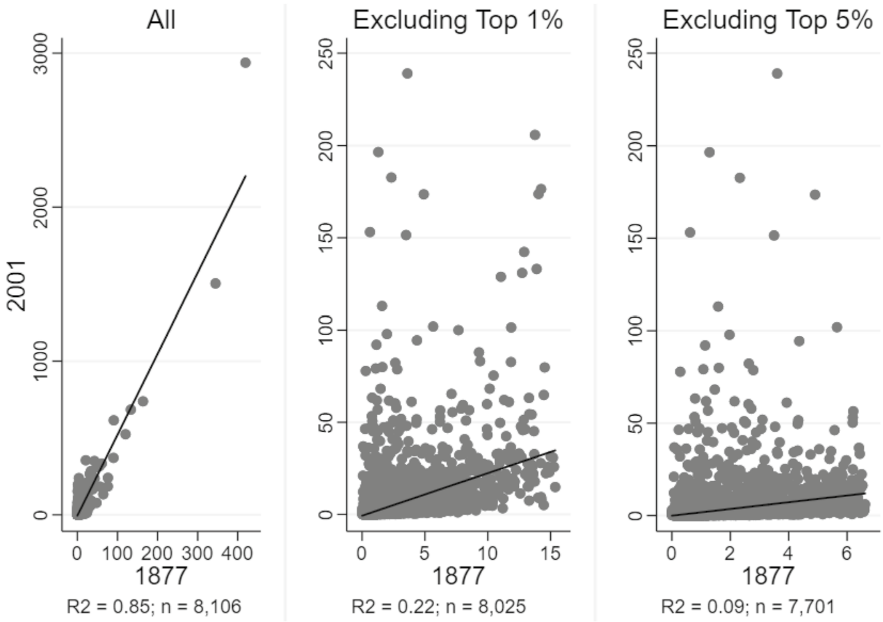

Fig. 1 Population in 1877 and 2001 (in thousands)

economies (Beeson et al. 2001; Glaeser 2010; Michaels et al. 2012; Henderson et al. 2016; Desmet and Rappaport 2017).[1] However, while location fundamentals appear to have been more relevant in pre-industrial societies, industrialisation and structural change have radically changed this. As industry, and then services, grew in importance, so did agglomeration economies which, in turn, widened existing disparities.[2] In any case, the literature has repeatedly stressed the inertia and relevance of the past in the distribution of population (Davis and Weinstein 2002, p. 1276).

Having said that, whether initial size is a good predictor of long-term population growth is basically driven by the experience of the largest cities. The Spanish experience perfectly illustrates this point (Fig. 1). Although the level of population in 1877 accurately predicts the one observed in 2001 when all municipalities are considered, the explanatory power of initial size decreases dramatically when the largest cities are excluded from the analysis. In this regard, recent research has shown that the

[1] Focusing on cities above a certain threshold, the Gibrat's law poses that initial size is unrelated to subsequent economic growth. A strand of the literature has focused on testing whether this stylised fact holds (see, for instance, Gabaix 1999; Ioannides and Overman 2004; Eeckhout 2004; Levi 2009; Rozenfeld et al. 2011; Ioannides and Skouras 2013; Desmet and Rappaport 2017).

[2] An important part of the variation in the current distribution of economic activity within countries is not explained by physical geography (Henderson et al. 2016). This study finds that the variables capturing first nature characteristics account for 57% of the within-country variation. As the authors explain, given that these physical features are often shared by neighbouring locations, part of the effect captured by these variables is actually due to agglomeration forces (Henderson et al. 2016, p. 14).

effect of initial size on subsequent growth not only greatly varies across the whole distribution, but it also evolves over time as structural change intensifies (Michaels et al. 2012; Desmet and Rapappor 2017; Beltrán Tapia et al. 2018; Cuberes et al. 2019).

If the fortune of the majority of locations is thus far from being determined by their initial size, what other forces may explain the changes in the spatial distribution of the population? Recent research has stressed the role played by the spatial interactions with other locations (Fujita et al. 1999; Dobkins and Ioannides 2001; Black and Henderson 2003; Redding and Sturm 2008; Partridge et al. 2008; Cuberes et al. 2019). In this regard, the presence of neighbouring towns and cities may not only positively affect population growth by increasing market size, but also limit it through competition. Therefore, we should aim at understanding how these counterbalancing forces evolve over time, especially associated with the reduction in transportation costs and the growing relevance of agglomeration economies (Bosker and Buringh 2017).

This study relies on a large dataset on Spanish population between 1877 and 2001 in order to assess how the effect of initial size and neighbouring locations has evolved over time, thus stressing the role of history in understanding the spatial distribution of the population. Although location fundamentals accounted for most of the spatial disparities in population in pre-industrial Spain, these differences increased from 1900 onwards once second nature factors grew in relevance (Ayuda et al. 2010; Beltrán Tapia et al. 2018). Instead of focusing on first nature characteristics, we then look at the role played by agglomeration economies and the spatial interactions between entities. By exploiting the panel structure of the data (comprising 8106 municipalities over 12 time periods), the empirical analysis effectively controls for first nature characteristics and is thus able to isolate the effect of initial size and existing neighbouring urban locations on local population growth.

Our results show that initial size is mostly negatively related to subsequent population growth, except in the 1960s and 1970s when this relationship becomes positive. Likewise, a location's growth rate crucially depends on the existence of neighbouring urban locations. Nearby cities limited local population growth in the late nineteenth century. This negative effect persisted, but at a diminishing rate, until 1950. Interestingly, the influence of neighbouring cities became increasingly positive from then onwards, especially during the 1970s. The changing role of neighbouring locations, from competing between each other up to the mid-twentieth century to begin benefiting from their mutual coexistence from then onwards, is associated with decreasing transportation and communication costs and wider structural changes in the economy. Taken together, these results suggest that, rather than within the largest cities, agglomeration economies take place within clusters of cities in response to increasing congestion costs and improved transportation and communication technologies. Our findings also closely align with recent research for US locations that finds that, while proximity to large urban centres was negatively associated with growth between 1840 and 1920, this relationship became positive from 1920 onwards (Cuberes et al. 2019).

This study presents several advantages over the previous literature. Firstly, instead of focusing on cities above a certain population threshold, it employs all Spanish municipalities. It thus avoids survival bias by not only considering those locations that have been relatively successful, but also those that did not grow enough to reach that threshold or those that declined and fell below that figure. In this regard, understanding the overall spatial distribution of the population is not possible if cities are treated as islands, especially as we move back in time when a large fraction of the population lived in rural areas (Desmet and Henderson 2015, p. 1463).[3] Secondly, considering the effect of neighbouring cities is crucial because cities have increasingly tended to cluster near other cities (Dobkins and Ioannides 2001; Partridge et al. 2008). If their presence is not considered and local population is correlated with the existence of other nearby locations, the estimated coefficient on initial size would be capturing the effect of neighbouring locations and therefore would be biased. Lastly, by adopting a long-term perspective (1877–2001), this article traces how the relationship between agglomeration economies and the spatial distribution of the population has evolved over time as transportation costs and other structural changes affected agglomeration economies and congestion costs.

The rest of the paper is structured as follows. While Sect. 2 provides the theoretical background, Sect. 3 presents the data, and Sect. 4 explains the methodology and reports the results of the empirical analysis. Section 5 discusses our findings, and Sect. 6 concludes.

2 Theoretical background

The distribution of the population and economic activity across the geography arises from the combination of first nature advantages, agglomeration economies and interactions with other locations.[4] On the one hand, the physical features of a location, such as its agricultural potential, availability of natural resources or access to transportation routes, crucially influence its growth prospects, especially in the initial stages of development (Bosker et al. 2013; Henderson et al. 2016; Bosker and Buringh 2017). On the other hand, large and more diverse local economies enjoy better market access, thus leading to cheaper and more varied inputs. The sharing of risk and indivisible infrastructures, knowledge spillovers and a more efficient matching between firms and individuals also lead to increasing returns from size (Henderson 2003; Duranton and Puga 2004; Glaeser 2010). Larger cities thus tend to exhibit faster growth rates providing that congestion costs (land prices, commuting costs, pollution, etc.) do not offset the advantages of agglomeration. The role of increasing returns has indeed grown stronger as countries industrialized (Davis and Weinstein 2002; Beltrán Tapia et al. 2018). Lastly, the literature has also stressed the role of the spatial interactions with other locations. In this regard, having access to the markets

[3] Hinterlands and small cities still accounted for up to 53 per cent of the US Population in 1990 (Partridge et al. 2008, p. 728).

[4] Diverse patterns of population growth are also related to institutional dimensions favouring certain locations (DeLong and Shleifer 1993; Acemoglu et al. 2005; Bosker et al. 2013). In this regard, economic policy can significantly shape both the location and the concentration of economic activities (Desmet and Henderson 2015, p. 1459).

that other cities provide appear to foster economic dynamism and population growth (Redding and Sturm 2008). However, the presence of neighbouring cities may not only positively affect local population growth by increasing market access, but also limiting it by acting as competitors (Fujita et al. 1999; Black and Henderson 2003; Bosker and Buringh 2017).

Although a substantial part of the literature assesses the importance of these factors on the current situation,[5] it is likely that the relative importance of these forces has changed over time in response to technological progress and structural change (Duranton 1999; Desmet and Henderson 2015). First, increases in agricultural productivity release labour to relocate in urban centres. Second, transportation costs have declined significantly, thus further facilitating the development of large cities. Economies of scale in manufacturing also favoured the concentration of labour in urban areas as industrialisation progressed. Lastly, the increasing role played by the service sector also affects the nature of city growth. In general, agglomeration economies tend to induce larger cities providing that congestion costs do not offset their advantages. It is therefore no wonder that the spatial distribution of the population, both worldwide and within countries, has become more concentrated over time.

Several studies have addressed these issues from a historical or long-term point of view. Although locational fundamentals initially established the spatial pattern of population densities in agricultural economies, increasing returns progressively helped determining the degree of spatial concentration in modern, industrial economies (Davis and Weinstein 2002; Michaels et al. 2012; Desmet and Rappaport 2017).[6] The role of path dependence is crucial because initial advantages provided a head start and then cumulated as agglomeration economies started to favour large locations in later stages of development (Bleakley and Lin 2012). Henderson et al. (2016) argue that economic activity is less spatially concentrated in today's developed countries than in developing ones because structural change and agglomeration processes in the former began when transport costs were still relatively high. The existing spatial distribution persisted and reinforced itself once agglomeration forces increased their role. In later developing countries, in contrast, structural transformation started when transport costs were already low, so urban economies of scale favoured agglomeration in relatively few, often coastal, locations.

Another strand of the literature has addressed how the spatial interactions between different locations have evolved over time. During the twentieth century, larger cities in the USA have tended to have more and larger neighbours (Dobkins and Ioannides 2001). In this regard, proximity to large urban centres has played a positive role on population growth in the American hinterlands and small cities from at least 1950 onwards, an effect that appears to be increasing over time (Partridge

[5] See, for instance, Ciccone and Hall (1996), Ellison and Glaeser (1997), Hanson (2005), Rappaport and Sachs (2003), Partridge et al. (2008), Ellison et al. (2010), and Combes et al. (2010).

[6] In this vein, relying on data on US manufacturing industries between 1880 and 1987, Kim (1999) shows that the explanatory power of natural advantages slightly declined over time, thus suggesting the growing importance of spillovers and increasing returns.

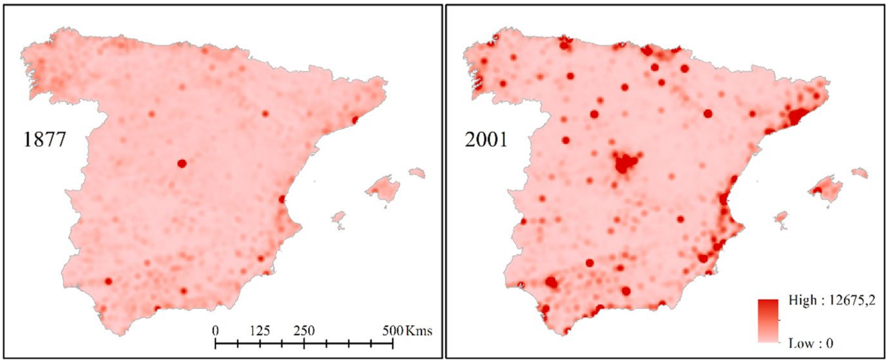

Fig. 2 Population in Spain (kernel density), 1877–2001

et al. 2008).[7] From a different perspective and focusing on a more restrictive period (1970 and 1990), Hanson (2005) shows that demand linkages between US counties are strong and growing over time but limited in geographic scope. Focusing on pre-industrial Europe, Bosker and Buringh (2017) find that nearby cities negatively affected urban growth. Despite the better understanding of the general processes at play, the timing and intensity of these changes is still an open question.

3 Data

This study relies on the Spanish population censuses between 1877 and 2001. These registers offer information at the municipality level. In brief, the dataset comprises 8,106 homogenous municipalities over 12 time periods (105,000 observations).[8] Figure 2 compares the spatial distribution of the population at the beginning and at the end of our period of study. Not only population grew from 1877 (16.5 millions) to 2001 (41.1 millions), but it also became more concentrated in urban agglomerations and more widely distributed across the territory. During these almost 125 years, the population became significantly more spatially concentrated in large cities and their surroundings.[9]

During this period, the Spanish economy undertook a profound structural transformation that turned a predominantly agricultural society into a modern economy: labour shifted away from agriculture to industry and services, and income per capita increased accordingly. This modernisation, however, was not linear, nor was the

[7] The distance to the nearest higher-tier city, however, does not always appear to be a significant determinant of city growth (Dobkins and Ioannides 2001).

[8] Given that some municipalities underwent changes in their territorial boundaries or got absorbed into other municipalities, this information has been homogenised using the municipal boundaries existing in 2001 as reference (Franch Auladell et al. 2013).

[9] The share of the population living in the five largest municipalities increased from 7.0 per cent in 1877 to 15.9 per cent in 2001. The Global Moran Index went from around 0.12 to 0.33 between these two dates (Franch Auladell et al. 2013).

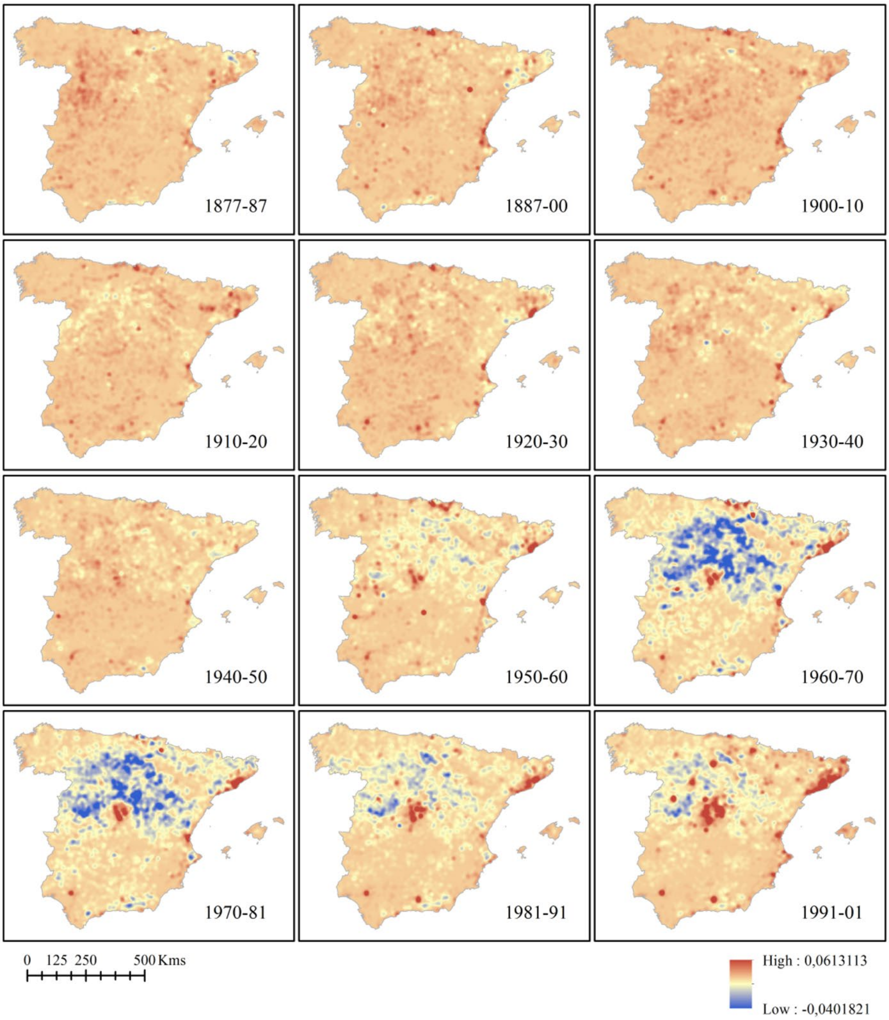

Fig. 3 Population growth in Spain (kernel densities; in logs), 1877–2001

increasing spatial concentration of the population.[10] Figure 3 illustrates the rates of population growth in each of the periods covered by the dataset. As shown there, there is not a clear trend towards a more spatial concentration of the population up to 1950. From then onwards, large cities and their surroundings greatly increased their relative importance and a large number of small locations began to lose population systematically. Rural exodus was especially intense during the 1960s and 1970s in response to rapid socio-economic change.

Apart from the influence of initial size on subsequent population growth, we are interested in how neighbouring locations may affect local growth rates. Considering

[10] See Beltrán Tapia et al. (2018) for a more detailed characterisation of the processes at play.

Table 1 Pearson's correlation between local size and neighbouring locations

	Urban population living within				
	0–25 km	25–50 km	50–100 km	100–250 km	250–500 km
	(1)	(2)	(3)	(4)	(5)
1877	0.1249	0.1655	0.1473	−0.1206	−0.1568
1887	0.1218	0.1459	0.1100	−0.1350	−0.1481
1900	0.1440	0.1683	0.1303	−0.1355	−0.1529
1910	0.1471	0.1550	0.1061	−0.1426	−0.1633
1920	0.1634	0.1765	0.1154	−0.1730	−0.1607
1930	0.1739	0.1844	0.0890	−0.1829	−0.1678
1940	0.1768	0.1662	0.0401	−0.1824	−0.1724
1950	0.2017	0.1901	0.0349	−0.1850	−0.1762
1960	0.2127	0.1891	0.0092	−0.2395	−0.1720
1970	0.2506	0.1873	−0.0300	−0.3568	−0.1699
1981	0.2967	0.2070	−0.0348	−0.3956	−0.1644
1991	0.3376	0.2215	−0.0145	−0.4109	−0.1634
2001	0.3854	0.2371	−0.0019	−0.4371	−0.1577

Computed using information for 8106 locations in each period. Urban population refers to the total population living in cities larger than 20,000 inhabitants within different distances from each location. The patterns displayed here do not change when a different threshold is employed

nearby cities in the analysis is not only interesting in itself, but it is also crucial because failing to taking them into account will bias the estimates on the relationship between initial size and growth if both variables are related.[11] In order to quantify their importance, we have computed the total urban population living at different distances from each municipality: in particular within rings of 0–25, 25–50, 50–100, 100–250 and 250–500 km. Given that the definition of what constitutes an urban location is questionable and, more importantly, it may change over time, we have considered several alternatives. We have thus computed the total urban population living within those concentric circles employing increasingly restrictive thresholds of what a city is: locations larger than 20, 50, 100, 250 and 500 thousands inhabitants, respectively. The size of a location goes indeed hand in hand with more and larger neighbouring cities throughout our sample, a relationship that becomes stronger over the period under study, and especially so within the first ring (see Table 1).

Our measure of neighbouring urban locations has several advantages over others proposed in the literature.[12] On the one hand, instead of only taking into account the importance of the closest city, we consider all cities falling within each particular ring. This is particularly important because cities sometimes tend to locate near each

[11] During the twentieth century, larger cities in the USA have had more and larger neighbours (Dobkins and Ioannides 2001).

[12] See, for instance, Dobkins and Ioannides (2001), Partridge et al. (2008) and Bosker and Buringh (2017).

other. Failing to control for this feature misses the economic importance of these clusters. Moreover, by computing the total population living in those cities, we better capture the total size of neighbouring locations. On the other hand, measures of market or urban potential, which compute a distanced weighted sum of the population of all other existing cities, are not able to adequately capture nonlinearities in the data. Our measure, on the contrary, is able to assess whether the effect of other urban location on local population growth varies across different distance ranges.

4 Empirical exercise

Our empirical strategy explores how size affects subsequent growth. For this purpose, we first estimate the following model for the whole period, 1877–2001:

$$\Delta y_{it} = \alpha + \beta \cdot y_{it} + \gamma \cdot \sum_{j=0-25}^{250-500} y_{jt} + \varepsilon_{it} \tag{1}$$

where Δy_{it} is the population growth rate of each municipality between two censuses ($\Delta y_{it} = \ln\ y_i^{t+1} - \ln\ y_i^t$). Likewise, y_{it} refers to the initial population size, whereas the second term captures the *shadow* of each municipality, measured as the total population living in neighbouring cities at different distances or radius (0–25 km, 25–50 km, 50–100 km, 100–250 km and 250–500 km). Both the dependent and the independent variables are measured in logs, so the estimated parameters can be interpreted as elasticities.[13] The model includes municipal fixed effects to control for unobserved heterogeneity arising from "first nature" advantages, as well as time fixed effects. Contrary to cross-sectional regressions that link initial size with subsequent growth, the inclusion of location fixed effects implies that the regression coefficient measures how increasing size is associated with subsequent growth.

Table 2 reports the results of estimating Eq. (1). Columns (1) to (5) present the main findings according to different ways of measuring the *shadow* of municipalities. In column (1) we consider neighbouring municipalities larger than 20,000, while in columns (2) to (5) the *shadow* is composed of urban agglomerations exceeding either 50,000, 100,000, 250,000 and 500,000 inhabitants, respectively. Overall, although initial size appears to exert a sizeable positive influence on subsequent population growth, its effect is not statistically significant. In contrast, the

[13] Population censuses directly measured population by counting every individual in each location. Household heads and local state agents filled in family cards where they reported information on the sex, age and level of instruction, among other characteristics, for each member of the household. This procedure implies that measurement error was negligible, especially in small locations, which account for most of the observations analysed here. If anything, population figures may underestimate the true population living in big cities. Measurement error, however, potentially affects both periods (t and $t+1$), so those biases tend to cancel each other out when estimating the relationship between initial size and subsequent growth. Although this issue may nonetheless affect particularly dynamic periods/cities and thus downward biasing our estimates, the large number of observations analysed here (around 100,000 data points) imply that this bias is likely to be negligible.

Table 2 Population growth between censuses, 1877–2001

	Dependent variable: population growth (ln pop. $t+1-$ln pop. t)				
	(1)	(2)	(3)	(4)	(5)
Initial population	0.020*	0.018	0.014	0.013	0.017
	(0.012)	(0.011)	(0.011)	(0.012)	(0.011)
Urb. pop. within 0–25 km	0.006***	0.009***	0.011***	0.010***	0.018***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Urb. pop. within 25–50 km	0.001	0.004***	0.003**	0.004***	0.009***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Urb. pop. within 50–100 km	−0.002	0.001	−0.001	−0.002	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Urb. pop. within 100–250 km	−0.011	0.002	0.004***	0.003***	−0.001
	(0.014)	(0.002)	(0.002)	(0.001)	(0.001)
Urb. pop. within 250–500 km	0.017	−0.011	−0.001	0.000	0.000
	(0.011)	(0.009)	(0.002)	(0.001)	(0.001)
Municipal FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Observations	97,262	97,262	97,262	97,262	97,262
Number of municipalities	8106	8106	8106	8106	8106
R-squared	0.233	0.240	0.242	0.234	0.238

Robust standard errors clustered at the provincial level in parentheses

Both the dependent and the independent variables are measured in natural logs, so the coefficients can be interpreted as elasticities. The difference between columns (1) and (5) hinges on how the population living at different distances is computed. While column (1) considers the total population living in cities larger than 20 k inhabitants, the remaining columns employ more restricting thresholds: 50 k, 100 k, 250 k and 500 k, respectively

***$p<0.01$; **$p<0.05$; *$p<0.1$

existence neighbouring urban agglomerations, the shadow of cities, have a positive and statistically significant effect within a radius of 0–25 km. In fact, the magnitude of this effect appears to be larger as the size of those neighbouring cities increases. Interestingly, large urban agglomerations, those above 500,000 inhabitants, extend their shadow much further than the rest, up to 100 km. Besides, municipalities situated within the second ring (25–50 km) also exert a positive influence, providing that those are big enough, but smaller than the first ring (approximately half the effect).

Although the above results are suggestive, it is likely that the effect of the variables under analysis has evolved over time in response to changes in transportation costs and in the underlying economic structure. Therefore, we now estimate the coefficients of interest using a fully flexible model according to the following equation:

$$\Delta y_{it} = \alpha + \sum_{k=1877}^{2001} \beta y_{it} \cdot T_t^k + \sum_{k=1877}^{2001} \sum_{j=0-25}^{250-500} \gamma \cdot y_{jt} \cdot T_t^k + \varepsilon_{it}. \tag{2}$$

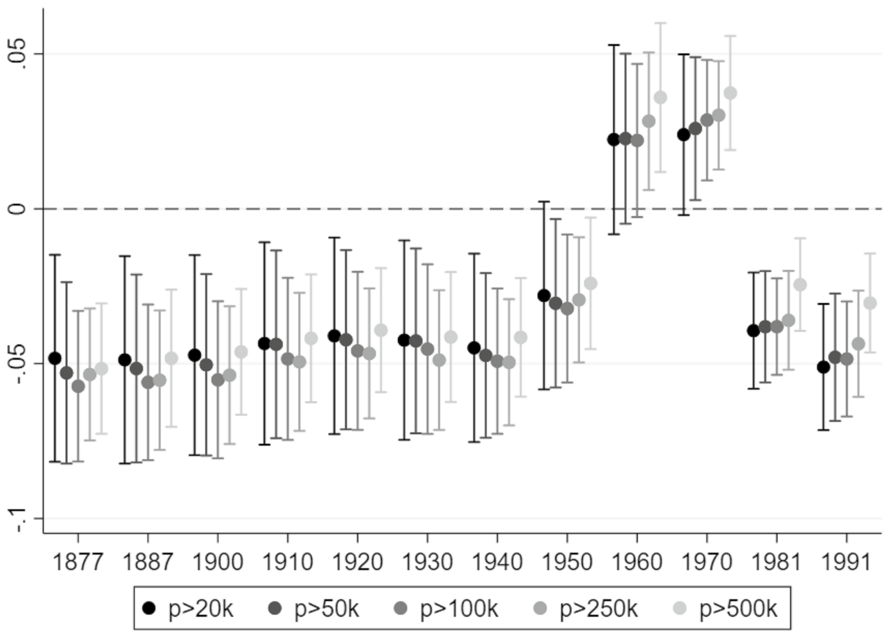

Fig. 4 Initial size and population growth. *Note* Estimated coefficient of the relationship between initial size and subsequent population growth (Eq. 2). Both the dependent and the independent variables are measured in natural logs, so the coefficients can be interpreted as elasticities. As well as including location and time fixed effects, this model controls for the total population living in neighbouring cities. The different specifications reflect the threshold used to consider those neighbouring locations as urban: cities larger than 20 k, 50 k, 100 k, 250 k or 500 k inhabitants, respectively. Full results are reported in Table 4 in "Appendix"

This model interacts the variables of interest with each of the time-period fixed effects, thus allowing to empirically assess how the effect of initial size and neighbouring urban locations change over time. As before, municipal and time fixed effects are included in the estimation.

Figures 4, 5, 6 and 7 illustrate the findings. Although each figure presents the coefficients for each variable, we should stress that all belong to the same model. Again, we have employed five different specifications depending on how the importance of neighbouring locations is computed. For illustrative purposes, we here concentrate on the specification capturing neighbouring locations within a radius of 100 km (Figs. 5, 6, 7). Full results are reported in Table 4 in "Appendix".

On the one hand, there is a negative relationship between initial population and subsequent growth during most of the period under study. Only in the 1960s and 1970s, this effect turns out to be positive. On the other hand, neighbouring urban locations had a negative effect on local population growth, that is, nearby municipalities acted as competitors and attracted population. This negative influence decreased over time and actually became increasingly positive from the 1950s

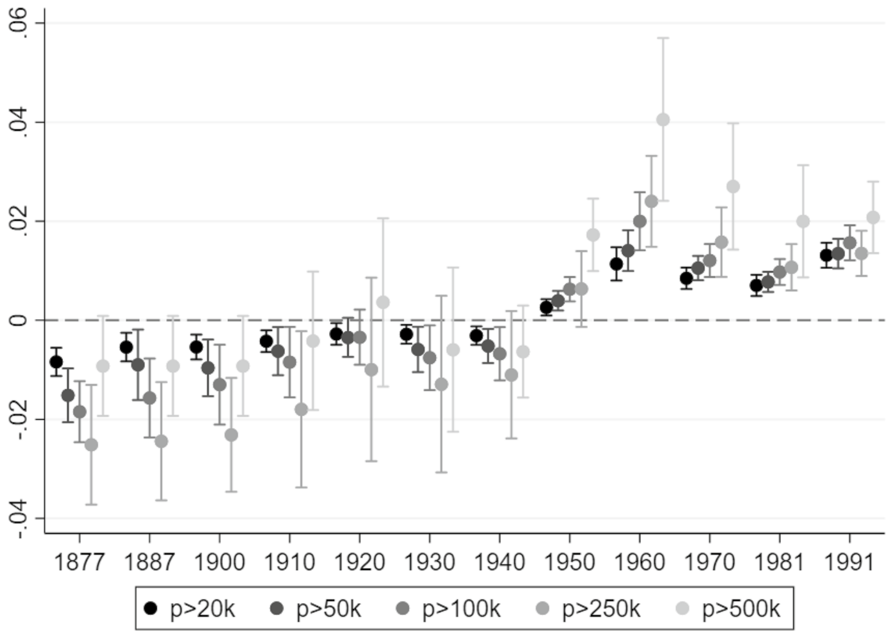

Fig. 5 Neighbouring cities (within 25 km) and population growth. *Note* Estimated coefficient of the relationship between the total population living in neighbouring cities (within a 25 km radius) and subsequent local population growth (see Eq. 2). Both the dependent and the independent variables are measured in natural logs, so the coefficients can be interpreted as elasticities. As well as including location and time fixed effects, this model controls for the size of the local population and the population living in cities located further away. The different specifications reflect the threshold used to consider those neighbouring locations as urban: cities larger than 20 k, 50 k, 100 k, 250 k or 500 k inhabitants, respectively. Full results are reported in Table 4 in "Appendix"

onwards.[14] Instead of limiting local population growth, neighbouring cities have thus promoted it in recent decades. Although this pattern is strongest for those urban locations situated within the first ring (0–25 km), it is also visible for those in the second ring (25–50 km). Cities farther away do not have a clear-cut effect on local population growth. These findings are even stronger as we limit our definition of what constitutes a city and focus on larger neighbouring locations. In other words, larger neighbouring cities impose a larger shadow effect, either positive or negative depending on the period analysed.

[14] As an example of the magnitudes involved and according to column (4) in Table 4 in "Appendix", a city as Madrid, which in 1877 had 419,243 inhabitants, reduced population growth in nearby cities (within 0–25 kms.) by 32.4 percentile points between 1877 and 1887. By 1991, Madrid had reached 3,010,492 inhabitants and it now promoted population growth in neighbouring cities by 20.9 percentile points in the next decade.

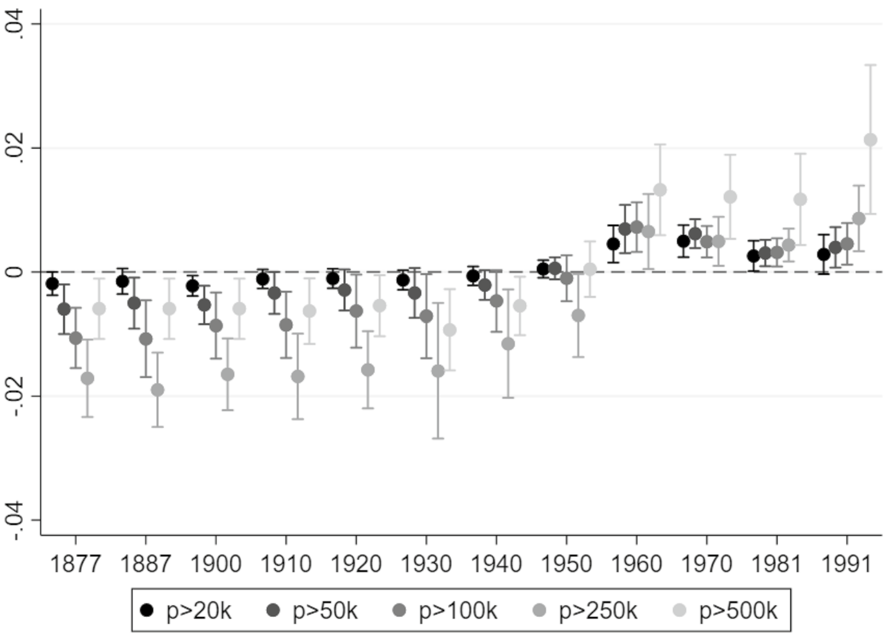

Fig. 6 Neighbouring cities (within 25–50 km) and population growth. *Note* Estimated coefficient of the relationship between the total population living in cities located within a ring of 25–50 km and subsequent local population growth (see Eq. 2). Both the dependent and the independent variables are measured in natural logs, so the coefficients can be interpreted as elasticities. As well as including location and time fixed effects, this model controls for the size of the local population and the population living at other distances. The different specifications reflect the threshold used to consider those neighbouring locations as urban: cities larger than 20 k, 50 k, 100 k, 250 k or 500 k inhabitants, respectively. Full results are reported in Table 4 in "Appendix"

5 Discussion

Contrary to other studies that find a positive association between initial size and subsequent population growth, especially among intermediate and large locations (Michaels et al. 2012; Desmet and Rappaport 2017),[15] our research shows that this relationship is mostly negative except in the 1960s and 1970s. The positive link between initial size and subsequent population growth found in those decades rests on the strong rural exodus towards big cities, especially Madrid and Barcelona, that took place during that period in response to rapid socio-economic changes (Bover

[15] Although the empirical literature on cities, which crucially does not usually consider rural areas, tends to find that there is no correlation between initial size and population growth (Gabaix 1999; Eeckhout 2004; Rossi-Hansberg and Wright 2007), there are some exceptions (Black and Henderson 2003; González-Val et al. 2013). The experience of the USA is however a special case due to its expanding frontier and the continual entry of new locations into the system.

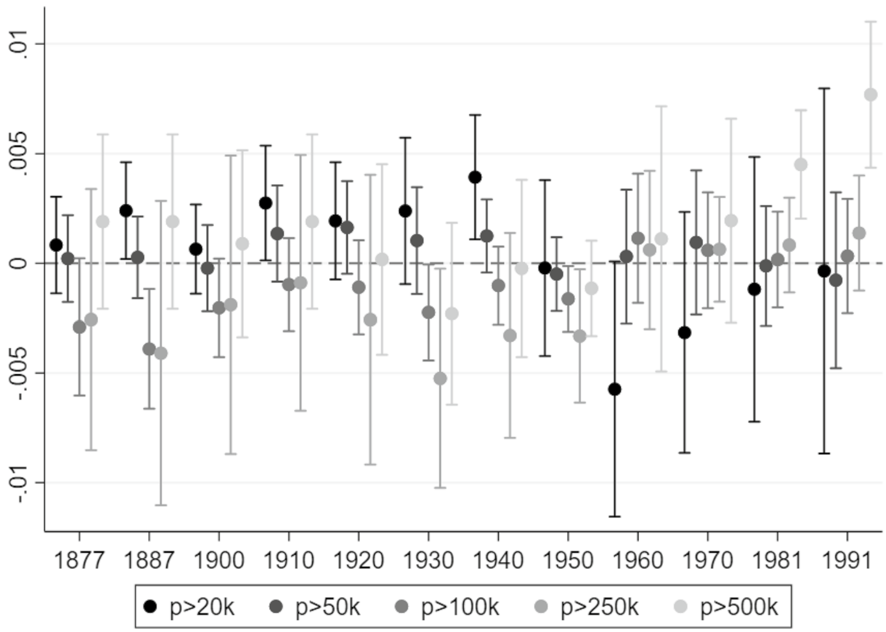

Fig. 7 Neighbouring cities (within 50–100 km.) and population growth. *Note* Estimated coefficient of the relationship between the total population living in cities located within a ring of 50–100 km and subsequent local population growth (see Eq. 2). Both the dependent and the independent variables are measured in natural logs, so the coefficients can be interpreted as elasticities. As well as including location and time fixed effects, this model controls for the size of the local population and the population living at other distances. The different specifications reflect the threshold used to consider those neighbouring locations as urban: cities larger than 20 k, 50 k, 100 k, 250 k or 500 k inhabitants, respectively. Full results are reported in Table 4 in "Appendix"

and Velilla 1999; Bentolilla 2001). These results contrast to the lack of association found in Table 2 and therefore stress the importance of particular historical processes occurring in certain periods and the need to adopt flexible specifications that allow the coefficient of interest to change over time.

The fact that our results show that initial size tends to be negatively related to subsequent growth is largely explained because large cities usually tend to have more, and larger, neighbouring locations. In this regard, US data show that, while city growth responds positively to the presence of neighbouring cities, it is negatively related to its own size (Dobkins and Ioannides 2001, p. 724; Partridge et al. 2008, p. 740).[16] Accounting for spatial interactions by using a market potential indicator based on the sum of the population living in other location weighted by

[16] Using nonparametric kernel estimation techniques, Ioannides and Overman (2004) do not find such clear patterns.

distance, Black and Henderson (2003, p. 361) also find a significant negative effect of initial size on urban population growth. It appears thus that failing to control for the effect of the existence of nearby population centres biases the estimates of initial size. Agglomeration therefore does not mostly take place within cities but within clusters of cities. The results here also contrast to those found in Beltrán Tapia et al. (2018). This is explained by the different unit of analysis: relying on district-level information, the latter is not able to distinguish the spatial interactions taking place between different locations within districts. The point estimates then conflate the effect of both initial size and neighbouring locations.

The role of neighbouring cities has often been conceptualised in terms of market potential and agglomeration economies (Fujita et al. 1999). Large locations nearby promote growth by providing markets and facilitating information spillovers. Redding and Sturm (2008) find that, following the division of Germany after the Second World War, cities in West Germany close to the East–West German border grew less than other German cities due to the disproportionate loss of market access. Using data on US counties between 1970 and 1990, Hanson (2005) shows that demand linkages between regions are strong and growing over time but limited in geographic scope. However, neighbouring cities also compete in those markets and in terms of attracting population, so their effect on local population growth is not necessarily positive (Black and Henderson 2003).

Focusing on the Spanish case, this paper shows that agglomeration economies fostering the mutual growth of nearby locations only began to play a role from the 1950s onwards. Before that date, neighbouring cities actually acted as competitors and limited local population growth, a negative effect that is stronger as we move back in time. Our results are in line with what has been found elsewhere. Since 1950, small US cities have been growing at a lower rate the farther away from large locations, a cost of distance that seems to be increasing over time (Partridge et al. 2008). Moreover, nearby cities negatively affected urban growth in Europe before 1800 (Bosker and Buringh 2017, p. 150). In the Spanish case, this negative shadow effect declines steadily from the late nineteenth century to the mid-twentieth century and then becomes increasingly positive.

The changing role of neighbouring cities on local population growth is related to both the increasing importance of agglomeration economies and the decrease in transport and communication costs that facilitates living increasingly farther away from the workplace. The fact that the effect is lower in the 1980–1990s than in the 1960–1970s is likely to be associated with increasing congestion costs (land prices, commuting costs, pollution, etc.). In this regard and taking into account that the influence of initial population appears to be mostly negative, this result suggests that it was the improvements in transportation and communication technologies that made benefiting from agglomeration economies possible. By extending the individuals' sphere of action, falling transport and communication costs have allowed distributing congestion costs among an increasingly larger area. A similar process is visible in the USA where the rural population tends "to be redistributing itself to be *nearer* to, if not exactly *in*, large urban centers" (Partridge et al. 2008, p. 729). In this regard, Cuberes et al. (2019) shows that, while proximity to large urban centres was negatively associated with growth until the early twentieth century in the USA, this relationship became positive from 1920 onwards in response to the evolution of commuting costs.

In line with Partridge et al. (2008, p. 753), these results also stress that, despite advances on transportation and communication technologies, the costs of remoteness have increased significantly, especially during the 1960s and 1970s. Although increasing congestion costs and the decreasing importance of manufacturing triggered by the industrial reconversion beginning in the 1980s have slightly reduced the scope for agglomeration economies (Beltrán Tapia et al. 2018), more isolated locations have continued to grow at a significantly slower rate during the 1980s and 1990s.

6 Conclusion

Spatial interactions are crucial in explaining population growth and thus the distribution of the population across space. This paper shows how the impact of neighbouring urban locations on local population growth has changed over time as transportation costs declined and structural transformation proceeded. While nearby cities limited local population growth in the late nineteenth century, this negative effect gradually declined during the first half of the twentieth century. This shadow effect then became increasingly positive, especially during the 1970s. The location's own size, however, is negatively related to subsequent growth, except in the 1960s and 1970s when a significant fraction of the rural population migrated to urban areas. Taken together, these results suggest that, rather than within the largest cities, agglomeration economies take place within clusters of cities. In this regard, improved transportation and communication technologies have allowed distributing congestions costs among an increasingly larger area, thus facilitating that population growth in neighbouring locations reinforces each other. Despite these technological advances, the tyranny of distance has increased during the last decades and has therefore greatly reduced the economic prospects of a large number of villages and small towns that are located relatively isolated from large urban centres.

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Statistical appendix

See Tables 3 and 4.

Table 3 Summary statistics (by year) *Source* Franch Auladell et al. (2013) based on the corresponding population censuses

	Obs. (1)	Mean (2)	SD (3)	Min (4)	Max (5)
1877					
Population	8106	2065	7551	0	419,243
Pop. growth (ln pop. $t+1-$ln pop. t)	8106	0.040	0.146	−1.607	7.519
Urb. pop. within 0–25 km	8106	12,308	46,527	0	419,243
Urb. pop. within 25–50 km	8106	28,519	74,930	0	439,574
Urb. pop. within 50–100 km	8106	97,265	125,796	0	494,666
Urb. pop. within 100–250 km	8106	487,841	258,710	0	1,328,266
Urb. pop. within 250–500 km	8106	1,216,938	449,441	0	2,309,406
1887					
Population	8106	2177	8547	0	495,063
Pop. growth (ln pop. $t+1-$ln pop. t)	8106	0.029	0.135	−2.404	2.389
Urb. pop. within 0–25 km	8106	14,156	52,847	0	495,063
Urb. pop. within 25–50 km	8106	32,900	86,144	0	495,063
Urb. pop. within 50–100 km	8106	112,390	144,914	0	583,718
Urb. pop. within 100–250 km	8106	546,096	295,070	0	1,495,698
Urb. pop. within 250–500 km	8106	1,357,142	484,411	0	2,520,145
1900					
Population	8106	2320	10,316	0	575,675
Pop. growth (ln pop. $t+1-$ln pop. t)	8106	0.061	0.112	−0.879	1.432
Urb. pop. within 0–25 km	8106	17,624	69,088	0	606,089
Urb. pop. within 25–50 km	8106	39,982	108,456	0	660,382
Urb. pop. within 50–100 km	8106	135,997	180,456	0	681,734
Urb. pop. within 100–250 km	8106	650,742	353,306	0	1,738,098
Urb. pop. within 250–500 km	8106	1,637,859	588,845	0	3,069,194
1910					
Population	8106	2504	11,139	0	614,322
Pop. growth (ln pop. $t+1-$ln pop. t)	8106	0.026	0.123	−0.893	1.822
Urb. pop. within 0–25 km	8106	20,189	76,290	0	661,095
Urb. pop. within 25–50 km	8106	45,695	118,125	0	711,389
Urb. pop. within 50–100 km	8106	154,183	196,096	0	763,607
Urb. pop. within 100–250 km	8106	739,421	393,711	0	1,918,655
Urb. pop. within 250–500 km	8106	1,869,662	669,046	0	3,436,976
1920					
Population	8106	2705	13,863	0	823,711
Pop. growth (ln pop. $t+1-$ln pop. t)	8106	0.031	0.132	−0.894	1.661
Urb. pop. within 0–25 km	8106	25,133	96,029	0	835,315
Urb. pop. within 25–50 km	8106	57,421	150,262	0	900,164
Urb. pop. within 50–100 km	8106	195,032	252,204	0	972,734
Urb. pop. within 100–250 km	8106	943,293	498,431	0	2,287,776
Urb. pop. within 250–500 km	8106	2,320,371	796,365	0	4,149,869

Table 3 (continued)

	Obs. (1)	Mean (2)	SD (3)	Min (4)	Max (5)
1930					
Population	8106	2949	17,505	0	1,041,767
Pop. growth (ln pop. $t+1$ – ln pop. t)	8106	0.016	0.129	– 1.520	2.395
Urb. pop. within 0–25 km	8106	31,834	126,094	0	1,144,521
Urb. pop. within 25–50 km	8106	73,323	195,696	0	1,210,041
Urb. pop. within 50–100 km	8106	248,669	328,053	0	1,312,403
Urb. pop. within 100–250 km	8106	1,179,748	633,668	0	2,826,386
Urb. pop. within 250–500 km	8106	2,877,731	1,000,365	0	5,015,332
1940					
Population	8106	3238	21,360	0	1,322,835
Pop. growth (ln pop. $t+1$ – ln pop. t)	8106	0.001	0.119	– 1.272	2.143
Urb. pop. within 0–25 km	8106	40,357	150,807	0	1,344,371
Urb. pop. within 25–50 km	8106	93,858	238,539	0	1,375,838
Urb. pop. within 50–100 km	8106	317,193	402,749	0	1,523,431
Urb. pop. within 100–250 km	8106	1,523,639	825,207	0	3,870,026
Urb. pop. within 250–500 km	8106	3,719,534	1,231,980	0	6,307,940
1950					
Population	8106	3459	25,037	0	1,553,338
Pop. growth (ln pop. $t+1$ – ln pop. t)	8106	0.043	0.199	– 2.803	6.965
Urb. pop. within 0–25 km	8106	48,104	178,320	0	1,575,248
Urb. pop. within 25–50 km	8106	111,617	280,561	0	1,613,384
Urb. pop. within 50–100 km	8106	379,334	473,796	0	1,803,715
Urb. pop. within 100–250 km	8106	1,829,394	969,399	0	4,433,726
Urb. pop. within 250–500 km	8106	4,453,208	1,468,301	0	7,548,725
1960					
Population	8106	3780	32,260	23	2,177,123
Pop. growth (ln pop. $t+1$ – ln pop. t)	8106	0.217	0.318	–2.104	4.036
Urb. pop. within 0–25 km	8106	62,526	236,348	0	2,202,964
Urb. pop. within 25–50 km	8106	144,914	377,440	0	2,257,669
Urb. pop. within 50–100 km	8106	491,438	640,126	0	2,487,646
Urb. pop. within 100–250 km	8106	2,347,203	1,310,603	0	5,302,245
Urb. pop. within 250–500 km	8106	5,525,936	1,759,171	0	9,164,195
1970					
Population	8106	4184	43,164	10	3,120,941
Pop. growth (ln pop. $t+1$ – ln pop. t)	8106	0.201	0.291	– 2.484	2.361
Urb. pop. within 0–25 km	8106	90,491	344,137	0	3,396,148
Urb. pop. within 25–50 km	8106	209,166	554,454	0	3,456,973
Urb. pop. within 50–100 km	8106	706,216	954,747	0	3,741,421
Urb. pop. within 100–250 km	8106	3,320,169	1,980,195	0	7,272,549
Urb. pop. within 250–500 km	8106	7,567,839	2,305,425	0	12,563,286

Table 3 (continued)

	Obs. (1)	Mean (2)	SD (3)	Min (4)	Max (5)
1981					
Population	8106	4634	45,316	7	3,158,818
Pop. growth (ln pop. $t+1-$ ln pop. t)	8106	0.085	0.223	−3.045	5.693
Urb. pop. within 0–25 km	8106	114,298	406,349	0	4,055,179
Urb. pop. within 25–50 km	8106	262,706	651,785	0	4,362,783
Urb. pop. within 50–100 km	8106	887,415	1,155,625	0	4,760,363
Urb. pop. within 100–250 km	8106	4,176,504	2,479,818	20,624	9,221,403
Urb. pop. within 250–500 km	8106	9,546,191	2,832,887	0	15,461,227
1991					
Population	8106	4780	43,985	0	3,010,492
Pop. growth (ln pop. $t+1-$ ln pop. t)	8106	0.036	0.247	−1.985	3.257
Urb. pop. within 0–25 km	8106	118,932	404,092	0	4,214,294
Urb. pop. within 25–50 km	8106	274,436	654,059	0	4,507,677
Urb. pop. within 50–100 km	8106	929,478	1,175,987	0	5,023,289
Urb. pop. within 100–250 km	8106	4,402,906	2,567,562	21,807	9,958,560
Urb. pop. within 250–500 km	8106	10,090,113	2,973,860	0	16,315,620
2001					
Population	8106	5022	42,993	7	2,938,723
Pop. growth (ln pop. $t+1-$ ln pop. t)					
Urb. pop. within 0–25 km	8106	124,088	408,646	0	4,436,512
Urb. pop. within 25–50 km	8106	288,347	671,646	0	4,730,199
Urb. pop. within 50–100 km	8106	977,128	1,230,312	0	5,380,377
Urb. pop. within 100–250 km	8106	4,666,501	2,719,929	65,859	10,706,678
Urb. pop. within 250–500 km	8106	10,671,026	3,108,660	0	17,211,206

Table 4 Population growth between censuses, 1877–2001

	Dependent variable: population growth (ln pop. $t+1-$ ln pop. t)				
	(1)	(2)	(3)	(4)	(5)
Initial population	−0.048***	−0.053***	−0.057***	−0.054***	−0.052***
	(0.017)	(0.015)	(0.012)	(0.011)	(0.011)
*d_1887	−0.000	0.001	0.001	−0.002	0.003
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
*d_1900	0.001	0.003	0.002	−0.000	0.005
	(0.003)	(0.004)	(0.004)	(0.003)	(0.004)
*d_1910	0.005	0.009**	0.009**	0.004	0.010**
	(0.004)	(0.004)	(0.004)	(0.003)	(0.004)
*d_1920	0.007*	0.011**	0.011**	0.007*	0.012**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)
*d_1930	0.006	0.010***	0.012***	0.005	0.010**
	(0.004)	(0.004)	(0.004)	(0.003)	(0.004)
*d_1940	0.003	0.006	0.008*	0.004	0.010**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)
*d_1950	0.020***	0.023***	0.025***	0.024***	0.028***
	(0.005)	(0.005)	(0.005)	(0.006)	(0.005)
*d_1960	0.071***	0.076***	0.079***	0.082***	0.088***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
*d_1970	0.072***	0.079***	0.086***	0.084***	0.089***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.009)
*d_1981	0.009	0.015	0.019*	0.017**	0.027***
	(0.011)	(0.011)	(0.010)	(0.009)	(0.010)
*d_1991	−0.003	0.005	0.009	0.010	0.021**
	(0.011)	(0.011)	(0.010)	(0.009)	(0.010)
Urb. pop. within 0–25 km	−0.008***	−0.015***	−0.018***	−0.025***	−0.004
	(0.001)	(0.003)	(0.003)	(0.006)	(0.007)
*d_1887	0.003***	0.006**	0.003*	0.001	–
	(0.001)	(0.002)	(0.001)	(0.001)	
*d_1900	0.003***	0.006***	0.005**	0.002**	−0.005*
	(0.001)	(0.002)	(0.002)	(0.001)	(0.003)
*d_1910	0.004***	0.009***	0.010***	0.007***	–
	(0.001)	(0.002)	(0.003)	(0.003)	
*d_1920	0.006***	0.012***	0.015***	0.015***	0.008***
	(0.001)	(0.002)	(0.003)	(0.004)	(0.002)
*d_1930	0.006***	0.009***	0.011***	0.012**	−0.002
	(0.001)	(0.002)	(0.002)	(0.005)	(0.002)
*d_1940	0.005***	0.010***	0.012***	0.014**	−0.002
	(0.001)	(0.002)	(0.002)	(0.005)	(0.003)
*d_1950	0.011***	0.019***	0.025***	0.031***	0.021***
	(0.002)	(0.003)	(0.003)	(0.003)	(0.005)
*d_1960	0.020***	0.029***	0.038***	0.049***	0.045***

Table 4 (continued)

	Dependent variable: population growth (ln pop. $t+1-$ ln pop. t)				
	(1)	(2)	(3)	(4)	(5)
	(0.002)	(0.004)	(0.005)	(0.005)	(0.007)
*d_1970	0.017***	0.026***	0.030***	0.041***	0.031***
	(0.002)	(0.003)	(0.004)	(0.006)	(0.009)
*d_1981	0.015***	0.023***	0.028***	0.036***	0.024***
	(0.002)	(0.003)	(0.004)	(0.006)	(0.008)
*d_1991	0.021***	0.029***	0.034***	0.039***	0.025***
	(0.002)	(0.003)	(0.004)	(0.006)	(0.006)
Urb. pop. within 25–50 km	−0.002*	−0.006***	−0.011***	−0.017***	−0.006**
	(0.001)	(0.002)	(0.002)	(0.003)	(0.002)
*d_1887	0.000	0.001	−0.000	−0.002	–
	(0.001)	(0.001)	(0.002)	(0.002)	
*d_1900	−0.000	0.001	0.002	0.001	–
	(0.001)	(0.001)	(0.001)	(0.001)	
*d_1910	0.001	0.003*	0.002	0.000	−0.000
	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)
*d_1920	0.001	0.003**	0.004**	0.001	0.000
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
*d_1930	0.001	0.003**	0.004*	0.001	−0.003
	(0.001)	(0.001)	(0.002)	(0.003)	(0.002)
*d_1940	0.001	0.004**	0.006***	0.006**	0.000
	(0.001)	(0.001)	(0.002)	(0.003)	(0.001)
*d_1950	0.002**	0.007***	0.010***	0.010***	0.006***
	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)
*d_1960	0.006***	0.013***	0.018***	0.024***	0.019***
	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)
*d_1970	0.007***	0.012***	0.016***	0.022***	0.018***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
*d_1981	0.004***	0.009***	0.014***	0.021***	0.018***
	(0.001)	(0.002)	(0.003)	(0.003)	(0.002)
*d_1991	0.005**	0.010***	0.015***	0.026***	0.027***
	(0.002)	(0.003)	(0.003)	(0.004)	(0.004)
Urb. pop. within 50–100 km	0.001	0.000	−0.003*	−0.003	0.002
	(0.001)	(0.001)	(0.002)	(0.003)	(0.002)
*d_1887	0.002*	0.000	−0.001	−0.002	–
	(0.001)	(0.001)	(0.001)	(0.001)	
*d_1900	−0.000	−0.000	0.001	0.001	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
*d_1910	0.002	0.001	0.002	0.002	–
	(0.001)	(0.001)	(0.002)	(0.002)	
*d_1920	0.001	0.001	0.002	−0.000	−0.002*
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)

Table 4 (continued)

	Dependent variable: population growth (ln pop. $t+1-$ ln pop. t)				
	(1)	(2)	(3)	(4)	(5)
*d_1930	−0.002	0.001	0.001	−0.003*	−0.004**
	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)
*d_1940	0.003**	0.001	0.002	−0.001	−0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
*d_1950	−0.001	−0.001	0.001	−0.001	−0.003*
	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
*d_1960	−0.007*	0.000	0.004***	0.003	−0.001
	(0.003)	(0.002)	(0.001)	(0.003)	(0.004)
*d_1970	−0.004	0.001	0.003**	0.003	0.000
	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)
*d_1981	−0.002	−0.000	0.003*	0.003	0.003
	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)
*d_1991	−0.001	−0.001	0.003	0.004	0.006**
	(0.004)	(0.002)	(0.002)	(0.003)	(0.002)
Urb. pop. within 100–250 km	0.007	0.001	0.002*	0.006***	−0.000
	(0.010)	(0.002)	(0.001)	(0.002)	(0.001)
*d_1887	−0.002	−0.002	−0.002***	−0.002***	–
	(0.004)	(0.001)	(0.001)	(0.001)	
*d_1900	−0.007	−0.003**	−0.002	−0.002*	0.002
	(0.006)	(0.001)	(0.001)	(0.001)	(0.002)
*d_1910	−0.011	−0.004*	−0.002	−0.003**	0.001
	(0.009)	(0.002)	(0.001)	(0.001)	(0.002)
*d_1920	−0.009	−0.002	−0.001	−0.004***	−0.000
	(0.009)	(0.002)	(0.001)	(0.001)	(0.002)
*d_1930	−0.006	−0.001	−0.001	−0.004***	0.000
	(0.006)	(0.002)	(0.002)	(0.001)	(0.002)
*d_1940	−0.005	−0.002	−0.001	−0.003***	0.001
	(0.004)	(0.002)	(0.002)	(0.001)	(0.002)
*d_1950	−0.030**	−0.019**	−0.004***	−0.005***	−0.002
	(0.012)	(0.009)	(0.001)	(0.002)	(0.001)
*d_1960	−0.071**	−0.041*	−0.008	−0.008***	−0.004*
	(0.027)	(0.021)	(0.005)	(0.002)	(0.002)
*d_1970	−0.062***	−0.035**	−0.013***	−0.007***	−0.003
	(0.016)	(0.017)	(0.003)	(0.002)	(0.002)
*d_1981	−0.055***	−0.035**	−0.018***	−0.006**	–
	(0.015)	(0.017)	(0.006)	(0.002)	
*d_1991	−0.071***	−0.044**	−0.028**	−0.007**	0.000
	(0.018)	(0.022)	(0.011)	(0.003)	(0.001)
Urb. pop. within 250–500 km	0.011	0.002	0.000	0.000	0.001
	(0.009)	(0.009)	(0.003)	(0.001)	(0.002)
*d_1887	−0.005	−0.002	−0.001	0.000	–

Table 4 (continued)

	Dependent variable: population growth (ln pop. $t+1-$ ln pop. t)				
	(1)	(2)	(3)	(4)	(5)
	(0.004)	(0.004)	(0.002)	(0.001)	
*d_1900	−0.004	−0.001	−0.001	0.001	–
	(0.003)	(0.004)	(0.002)	(0.001)	
*d_1910	−0.003	−0.004	0.001	0.002	0.001*
	(0.004)	(0.003)	(0.002)	(0.001)	(0.001)
*d_1920	−0.005	−0.008***	−0.004**	−0.000	−0.001
	(0.004)	(0.003)	(0.002)	(0.001)	(0.001)
*d_1930	−0.009***	−0.011**	−0.004	−0.002	−0.001
	(0.003)	(0.004)	(0.003)	(0.002)	(0.001)
*d_1940	−0.006*	−0.007**	−0.005**	−0.001	−0.002***
	(0.003)	(0.003)	(0.002)	(0.001)	(0.001)
*d_1950	−0.004	−0.005	−0.007***	−0.002	−0.004***
	(0.005)	(0.004)	(0.002)	(0.002)	(0.001)
*d_1960	0.007	0.003	−0.003	−0.002	−0.003
	(0.010)	(0.008)	(0.005)	(0.003)	(0.002)
*d_1970	0.006	0.002	−0.001	−0.001	−0.003
	(0.010)	(0.006)	(0.003)	(0.003)	(0.002)
*d_1981	−0.001	−0.003	−0.006**	−0.008***	−0.007**
	(0.009)	(0.006)	(0.003)	(0.002)	(0.003)
*d_1991	0.004	−0.001	−0.004	−0.010***	−0.008*
	(0.012)	(0.008)	(0.004)	(0.004)	(0.004)
Observations	97,262	97,262	97,262	97,262	97,262
Number of municipalities	0.332	0.331	0.329	0.329	0.324
R-squared	8106	8106	8106	8106	8106

Robust standard errors in parentheses

Both the dependent and the independent variables are measured in natural logs, so the coefficients can be interpreted as elasticities. The difference between columns (1) and (5) hinges on how the population living at different distances is computed. While column (1) considers the total population living in cities larger than 20 k inhabitants, the remaining columns employ more restricting thresholds: 50 k, 100 k, 250 k and 500 k, respectively. All specifications include municipal and time fixed effects

***$p<0.01$; **$p<0.05$; *$p<0.1$

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