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Articles

Growth in small cities: The case of Aragon (Spain)

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Abstract:

In this paper, we analyse the effects of productive specialisation and diversity on population growth at the local level in Aragon, a NUTS 2 region in Spain. This region is characterised by a highly uneven population distribution, with numerous small cities, and a large proportion of small businesses. We estimate panel data models considering data from 2000 to 2015 at the local level, encompassing 577 municipalities. Our results show that both localisation and urbanisation have a statistically significant positive effect on growth in Aragonese municipalities but only in cities with a population threshold of 3,000 or more inhabitants.

Keywords: Population; agglomeration economies; small and medium-sized enterprises; small cities; Aragon.

JEL Classification: C23; R12; R23.

El crecimiento de las ciudades pequeñas: El caso de Aragón (España)

Resumen:

En este trabajo analizamos los efectos de la especialización y diversidad productiva en el crecimiento de la población a nivel local en Aragón, una región NUTS 2 de España. Esta región se caracteriza por una distribución de la población altamente desigual, con numerosas ciudades pequeñas, y una elevada proporción de empresas pequeñas. Estimamos modelos de datos panel considerando datos desde el año 2000 al 2015 a nivel local que abarcan 577 municipios. Nuestros resultados muestran que tanto la especialización como la diversidad tienen un efecto positivo estadísticamente significativo en el crecimiento de los municipios aragoneses, pero solo en aquellas ciudades con una población superior a los 3.000 habitantes.

Palabras Clave: Población; economías de aglomeración; pequeñas y medianas empresas; ciudades pequeñas; Aragón.

Clasificación JEL: C23; R12; R23.

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1. Introduction

Since 1975, the population of Spain has increased by approximately 37%, from 34.2 million people to approximately 47 million. However, this population increase has not been evenly distributed spatially. Although the population of Spain has grown by 15.4% since 2000, more than 60% of municipalities and 13 provinces (NUTS 3 regions) have experienced population declines (Fundación BBVA, 2019)[1]. Most significantly, these population losses demonstrate a clear spatial and continuous pattern over time. Since the last population census in 2011, the number of municipalities with 1,000 inhabitants or fewer has risen, reaching 4,997 in 2021; this represents 61.4% of all Spanish municipalities, the highest value since 2000. These small municipalities also exhibit a specific spatial distribution and are typically located in inland and rural Spain.

This paper focuses on the case of Aragon, one of the NUTS 2 regions of Spain (known as Autonomous Communities) that has been greatly affected by depopulation. In Aragon, the territorial imbalance is a significant characteristic that is even more pronounced than in Spain as a whole, with the population and productive activities concentrated in the metropolitan area of Zaragoza, the regional capital. This study conducts an empirical analysis of the impact of industrial concentration on population growth in municipalities across Aragon. In other words, can a particular productive structure, whether specialised or diversified, help attract new inhabitants? We question whether the theoretical benefits of firm concentration contributed in some way to population changes in Aragonese municipalities during the Great Recession and the periods immediately before and after.

Aragon accounts for 9.4% of the total territory of the country but only 2.1% of the population. Regarding population density, there are 28 inhabitants per km^2, one of the lowest rates in the entire country and the European Union. Therefore, most cities (also referred to as municipalities) are small. Approximately 95.2% of the region is classified as rural, and much of it is characterised by population loss, depopulation, and low population densities. According to the Spanish Ministry of Agriculture, Aragon has the emptiest and most depopulated rural areas in Spain, with population densities in many areas of less than five inhabitants per km^2 (Lardiés Bosque et al., 2020).

Figure 1 displays the geographical location of the region within Spain. As mentioned earlier, Aragon possesses two distinctive characteristics that justify the significance of this case study. First, despite the region's vast territory, the economic activity and population are highly concentrated. The region comprises three provinces: Huesca in the north, Zaragoza in the centre, and Teruel in the south. The three provincial capitals, particularly Zaragoza, account for over half of the entire region's population (57.7% in 2021). This large disparity results in most cities having small populations.

Similarly, the distribution of economic activity in Aragon is highly unequal. The province of Zaragoza has an average added value of 85% and 80% of the employees in the region, while Huesca has an added value of 10% and a slightly higher proportion of employment (13.5%), and Teruel represents 5% of the added value and 6.5% of the workers. The spatial distribution of firms is also highly concentrated, with a significant proportion of firms located in the city of Zaragoza. We present some evidence on the spatial distribution of firms in Section 2.

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[1] The acronym NUTS derives from the French term *Nomenclature des unités territoriales statistiques*. NUTS regions are the European Union's standard classification of European regions at different geographical levels of aggregation (1, 2, and 3).

FIGURE 1.
The geographical location of Aragon within Spain (provincial boundaries, NUTS 3 regions)

Table 1 illustrates the size distribution of municipalities in the region (Panel B) compared to the size distribution for the entire country (Panel A). Out of 731 municipalities, only a small proportion have an urban character. The vast majority (86%) had fewer than 1,000 people in 2021, reflecting the rural character of most of the region's territory. For cities of the same size, the percentage for Spain is significantly lower (with 61% of municipalities having less than 1,000 inhabitants), indicating an overrepresentation of small municipalities in Aragon. If we focus on large city sizes, although the percentage of people living in large cities in Aragon is comparable to that for the entire country (around 50% of the total population in 2021), the difference is that in Aragon, there is only one large city, Zaragoza, acting as the primary demographic and economic focal point, with a population of 675,301 inhabitants. Nevertheless, the main difference between both city size distributions lies in the number of middle-sized cities (municipalities with populations between 20,000 and 60,000) in Aragon, which is much lower than that for Spain. In summary, compared to the entire country, Aragon has only one large city, a few middle-sized municipalities, and many small settlements.

When examining the period from 2000 to 2015, we can distinguish two subperiods with very different population trends (Palacios et al., 2017). Between 2000 and 2008, the population of Aragon increased by 137,009 inhabitants, representing an 11.51% increase in relative terms in comparison to the initial population. However, this growth was not uniform across the municipalities. Those with fewer than 500 inhabitants (approximately 74% of the total number of municipalities) experienced a population decline between 2000 and 2008, while the rest gained inhabitants. The substantial demographic growth during these years was due to the migration flow received, which was largely composed of individuals from abroad. The positive migration balance was the sole cause of the demographic increase. The positive migration rate outweighed the negative natural growth, which was only positive in the capital area of Zaragoza. However, between 2008 and 2015, Aragon lost almost 20,000 inhabitants. Only municipalities with more than 20,000 inhabitants (the three provincial capitals) and those in the metropolitan area of Zaragoza increased their population. The rest of the municipalities experienced a population decline. The migration rate suffered a reversal compared to the preceding period, shifting from a period of high immigrant influx to one predominantly of emigration. During these years, the decrease in population in most municipalities can be explained by both the negative migration rate and the negative natural growth.

TABLE 1.
Distribution of municipalities by size in 2021

Panel A: Spain			
Population	**Cities (municipalities)**	**% of total cities**	**% of total population**
> 60,000	124	1.5%	50%
40,000–60,000	52	0.7%	5.4%
20,000–40,000	238	2.9%	14%
10,000–20,000	346	4.3%	10.4%
1,000–10,000	2,377	29.2%	17.2%
500–1,000	1,003	12.3%	1.5%
< 500	3,991	49.1%	1.5%
Total	8,131	100%	100%
Panel B: Aragon			
Population	**Cities (municipalities)**	**% of total cities**	**% of total population**
> 60,000	1	0.1%	51%
40,000–60,000	1	0.1%	4%
20,000–40,000	1	0.1%	2.7%
10,000–20,000	11	1.5%	12.8%
1,000–10,000	88	12.1%	18.3%
500–1,000	86	11.8%	4.5%
< 500	543	74.3%	6.7%
Total	731	100%	100%

Note: Population data come from *Instituto Nacional de Estadística* (INE).

Second, one of the peculiarities of the Aragonese case is the significance of small and medium-sized enterprises (SMEs). Roughly 95% of the Aragonese business sector comprises micro-enterprises with no salaried employees or fewer than 10 employees. The weight of small and medium-sized firms stands at 4% and 0.6%, respectively. As such, large firms (those with more than 250 workers) are limited to barely 0.1%.

Given this geographical-economic composition of small cities and firms, we investigate the empirical impact of firm concentration (i.e., agglomeration economies) on population growth in these small areas. Urban growth in small cities is frequently overlooked in the empirical literature, which has mostly concentrated on the dynamics of large cities, whereas some studies have discovered that small cities behave differently (Reed, 2001, 2002; Partridge et al., 2008; Devadoss and Luckstead, 2015).

The notion of agglomeration economies is critical in urban economics, as the very existence of cities is based on the presence of externalities that encourage the agglomeration of firms and people. This concept dates back to Marshall (1890). Duranton and Puga (2004) updated Marshall's original concept of agglomeration economies by proposing three mechanisms based on micro-foundations to clarify the positive impact of the density of firms and populations through geographical proximity: sharing, matching, and learning. The sharing mechanism relates to the benefits that arise from the wide range of productive factors available as well as industrial specialisation. Matching refers to the best fit between employees, employers, buyers, suppliers, or business pairs. Learning corresponds to creating, disseminating, and accumulating applied knowledge for productive purposes.

Combes (2000) and Desmet and Fafchamps (2005) distinguished between localisation and urbanisation economies. Localisation economies are benefits derived from being located close to other firms in the same industry, while urbanisation economies are associated with proximity to overall economic activity. Localisation economies include factors that externally affect firms and originate from the economic sector where the activity is performed. These include the decrease in transportation costs, the appearance of economies of scale, the decrease in transaction costs, the formation of a specialised labour market, or the creation of an industrial environment capable of generating innovation in these fields and its rapid spread. On the other hand, urbanisation economies include all external effects that do not originate from within the firm or the specific sector to which the firm belongs, but instead stem from the advantages of the place itself, which are internal to the region or city. These include economies of diversity, the qualities of cities or regions such as infrastructure, or access to an efficient and skilled labour market.

Based on the distinction between localisation and urbanisation economies, recent empirical papers have estimated the impact of external economics on local productivity results, wages, employment, and the location decisions of firms. Numerous works have sought to quantify these effects in various countries and geographical scales. Torres Gutiérrez et al. (2019) provided a detailed summary of the primary findings from empirical studies. Overall, the results confirm the positive effects of diversity and competition on urban growth, while the outcomes derived from productive specialisation are more ambiguous (Beaudry and Schiffauraurova, 2009; Melo et al., 2009; De Vor and De Groot, 2010; Combes and Gobillon, 2015; Groot et al., 2015).

Industrial concentration can arise spontaneously or be sponsored or encouraged by public authorities. In the former case, several small or medium-sized firms typically locate themselves near a highly successful firm in their sector to provide a series of specific productive factors or services. In the latter case, public authorities pursue the concentration of firms in a cluster through various incentive mechanisms (Martin et al., 2011). In Aragon, a Business Cooperation Plan has been in place since 2016 to support regional clusters. Encouraging and promoting business cooperation, especially in firm clusters, is one of the main objectives of this plan, which is considered a driver for business development. In addition to improving the competitiveness and productivity of the firms involved, promoting these clusters can also have other social objectives. As such, it is understood that these business clusters generate employment growth and may secure the population or attract new individuals, thereby contributing to the fight against depopulation.

The empirical literature has established that spatial concentration of industrial activity improves economic growth, productivity, and innovation through various approaches, most of which analyse the localisation-urbanisation dichotomy. In this study, we examine the role of industrial concentration in the population growth of municipalities in Aragon. Given the serious depopulation problem in Aragon, the conclusions of this work could have significant implications for economic policy, such as promoting business clusters or supporting industries to reverse negative demographic trends. Moreover, these findings could be useful for other regions in Spain and the rest of Europe that face similar negative population dynamics.

This paper is organised as follows. Section 2 presents the data used in this study. Section 3 describes the empirical methodology and presents the main results, and Section 4 concludes this work.

2. Data

Like González-Val and Marcén (2019), we use geographical data for all firms in Aragon based on their main activities as per the National Classification of Economic Activities CNAE-2009 (the Spanish version of the EU Statistical Classification of Economic Activities, NACE Rev. 2). The sample of firms is drawn from the Iberian Balance Sheet Analysis System (*Sistema de Análisis de Balances Ibéricos*, SABI) database, which contains comprehensive general information and annual accounts for companies (i.e., corporations) in Spain and Portugal. On average, we have information for approximately 25,000 active firms based in Aragon, although that number varies from one year to the next[2]. This database provides detailed geographic information, including not only the province and municipality where the company's headquarters are located (per the Mercantile Registry's records), but also the geographic coordinates (latitude and longitude).

As previously mentioned, the distribution of population and economic activity in Aragon is largely unequal. Consequently, the spatial distribution of firms is also highly concentrated, with many situated in the city of Zaragoza. To illustrate this concentration, Figures 2 and 3 show the 2017 spatial distribution of firms in two sectors: manufacturing and real estate services, a branch of activity in the service sector[3]. The spatial density of firms is calculated utilising the methodology of Duranton and Overman (2005, 2008), which is a widely used empirical procedure in the literature.

This approach involves analysing the distribution of bilateral distances between all pairs of firms in each economic activity. We consider only the range of distances between 0 and 63 kilometres, which is the median distance between all firms in the sample. We then test whether the observed distribution of bilateral distances for each activity category significantly differs from a randomly drawn set of bilateral distances. We build global confidence intervals around the expected distribution based on simulated random draws to test this hypothesis. Firms in a particular industry will be significantly localised or dispersed if their bilateral distance distribution falls outside the global confidence interval.

The interpretation is straightforward: when the estimated K-densities are located within the global confidence bands for any distance, the spatial location of cities is not significantly different from randomness. Deviations from randomness involve a localisation pattern if, graphically, the estimated K-densities lie above the upper global confidence band for at least one distance. Similarly, a dispersion pattern can be observed when the estimated K-densities graphically fall below the lower global confidence band for any distance. Figure 3 shows a significant localisation pattern for short distances in the service sector, which, by nature, requires less physical space and tends to be located in populated areas near demand. Conversely, the manufacturing industry (Figure 2) displays a spatial dispersion pattern for distances less than 8 kilometres, while for distances between 8 and 10 kilometres, the density estimate is situated within the global confidence bands indicating a random distribution of firms. Finally, for distances from 10 to 45 kilometres, a localisation pattern emerges for manufacturing firms, potentially due to the specific features of Aragon's vast territory, where industrial firms are typically located far apart in big cities. Additionally, several density peaks are observed at various distances (15, 25, 45, or 60 kilometres), which could indicate different clusters of industrial firms.

Based on micro-geographic data from SABI, we obtained municipal and regional employment data, along with the number and sector distribution of firms. Our spatial unit of analysis is the municipality (local administrative units 2/NUTS 5 regions), although we used aggregated data at the regional level (NUTS 2 regions) to calculate some ratios. We aggregated employment data for Aragonese firms according to their municipal location. To obtain municipal and regional population data from 2000 to 2015, we relied on the yearly municipal register (*Padrón continuo*) published by the Spanish Statistical Office (INE). The municipal register includes individuals who regularly reside in each municipality and is updated with information on births, deaths, and migration flows. Registration is compulsory.

The empirical analysis covers the period from 2000 to 2015, encompassing the severe economic crisis that began in 2008 and the periods of growth and recovery immediately preceding and following it. Regarding population dynamics, Figure 4 displays the temporal evolution of the size distribution of the municipalities, measured by relative population (i.e., the municipality's population as a proportion of the entire regional population, in logarithmic scale). The distributions are estimated using adaptive kernels. Over the 15 years, the empirical distribution shifted leftward, indicating a population decline in most municipalities. Not only are most of these municipalities small, but they also exhibit negative temporal evolution, losing population over time.

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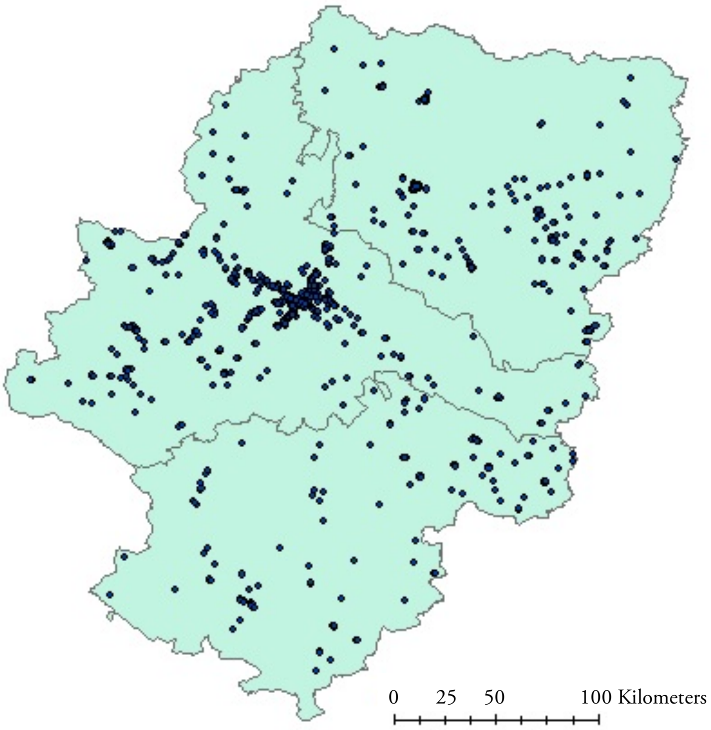
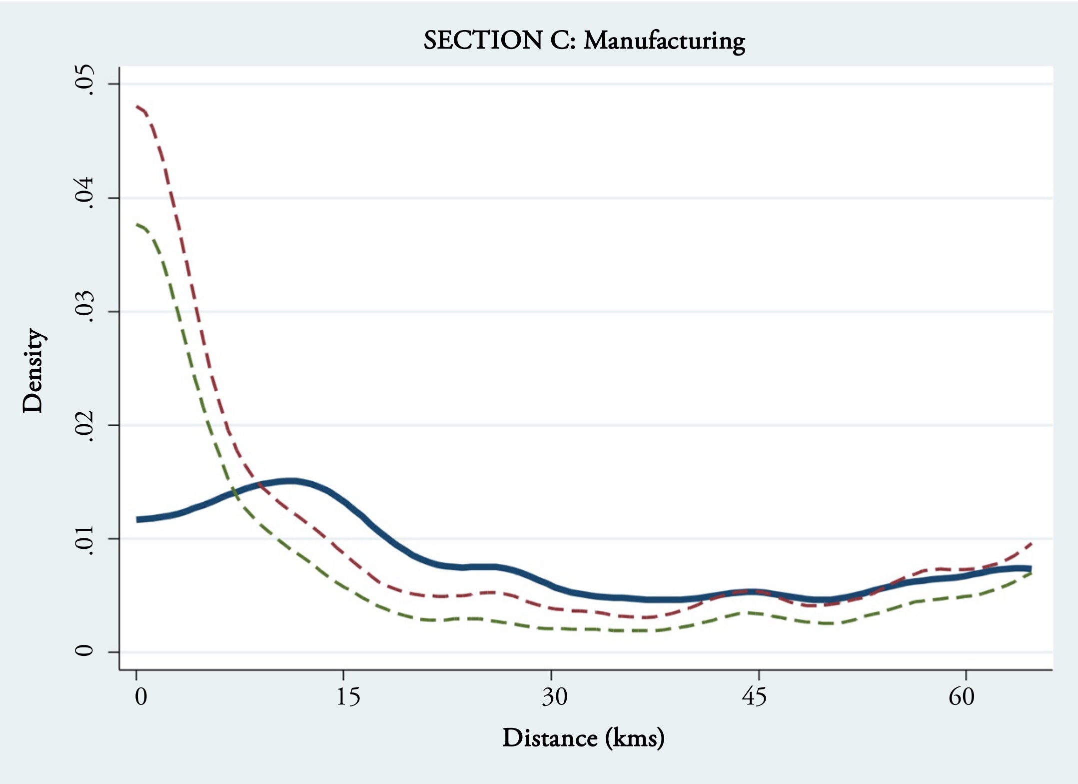
[2] Software version 72.00.

[3] Results for other years are similar and are available from the authors upon request.

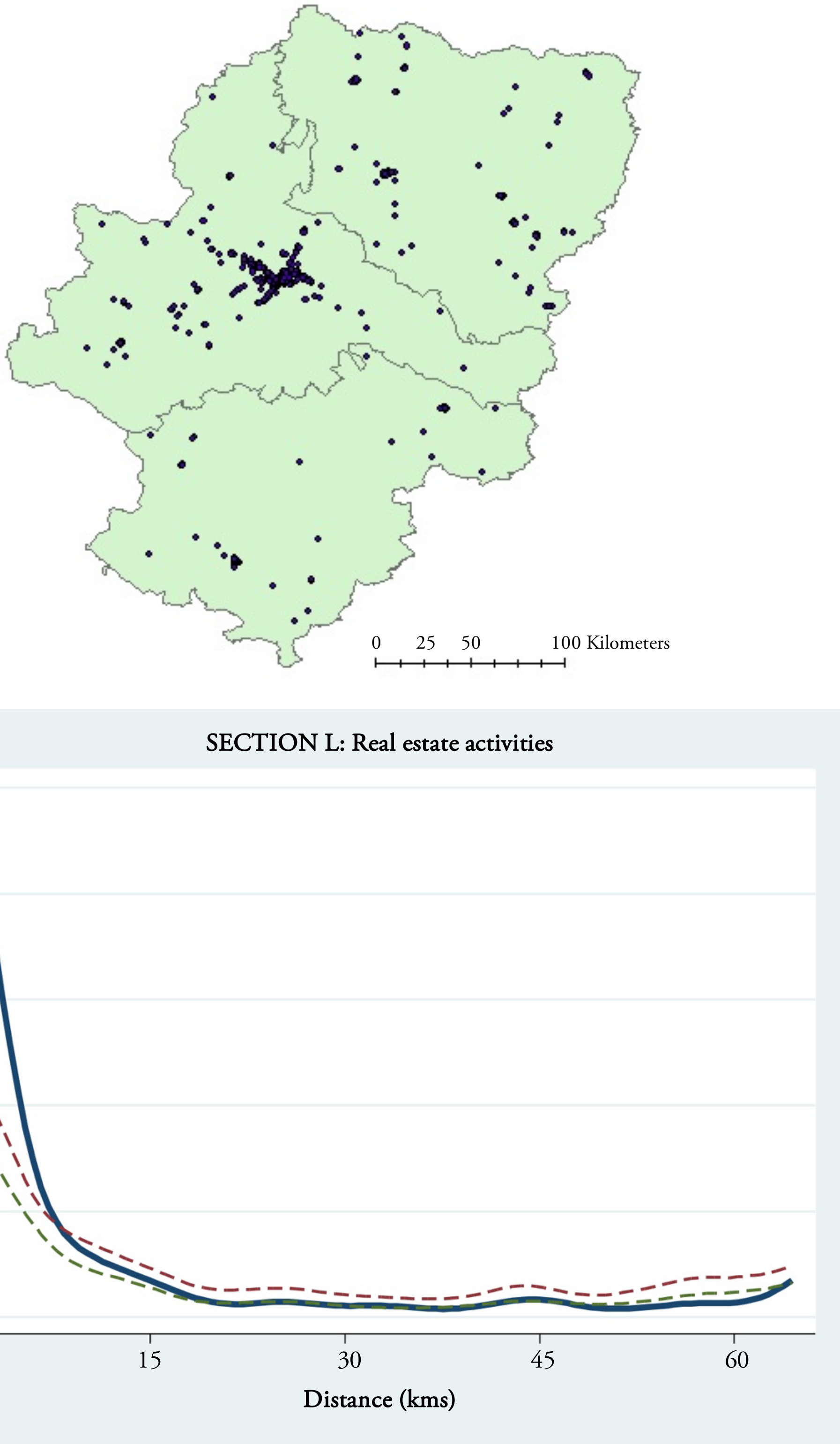
FIGURE 2.
Spatial distribution of industrial firms





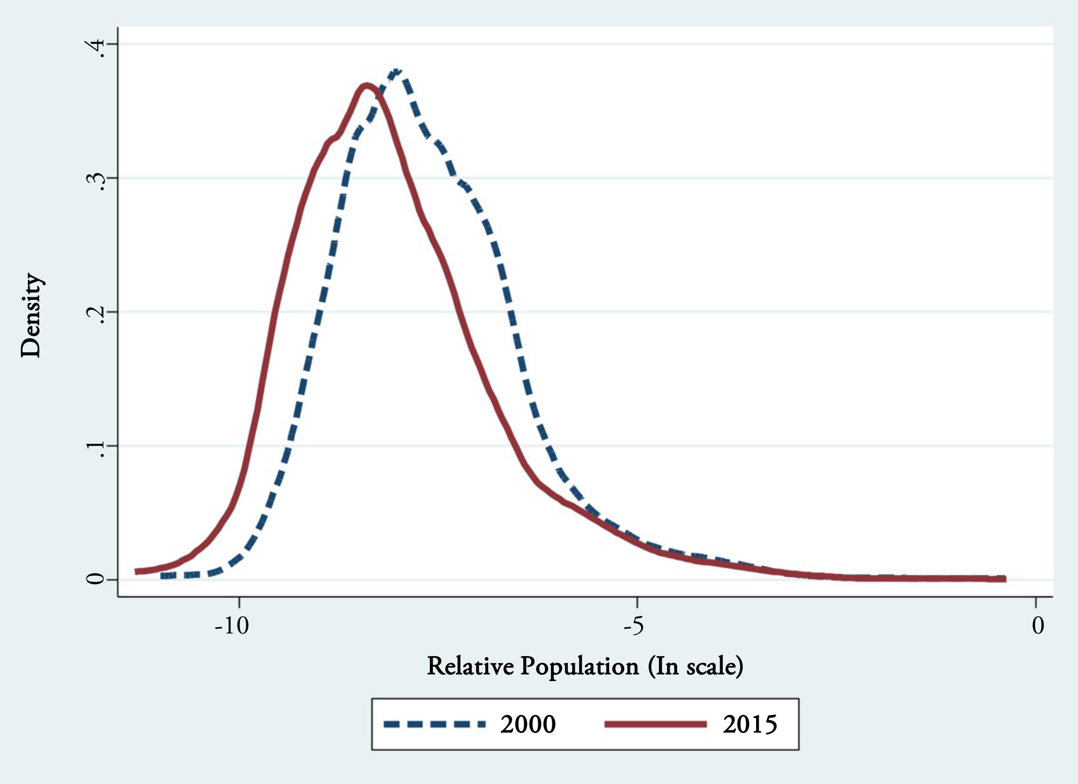
Notes: K-densities are estimated using the method of Duranton and Overman (2005). Dashed lines represent the 95% global confidence bands, based on 2,000 simulations.

FIGURE 3.
Spatial distribution of real estate firms



Notes: K-densities are estimated using the method of Duranton and Overman (2005). Dashed lines represent the 95% global confidence bands, based on 2,000 simulations.

FIGURE 4.
Empirical distribution of relative population, 2000 and 2015



Note: Population data come from INE.

3. Methodology and results

To explain the population growth of Aragonese municipalities, we utilise an unbalanced panel data model in which the main explanatory variables are related to agglomeration economies (localisation or urbanisation economies). Initially, we define the variable to be explained as relative population growth:

$$g_{ct} = ln(Relative\ size_{ct}) - ln(Relative\ size_{ct-1}) =$$
$$= ln\left(\frac{Pop_{ct}}{Pop_t}\right) - ln\left(\frac{Pop_{ct-1}}{Pop_{t-1}}\right) = ln\left(\frac{Pop_{ct}}{Pop_{ct-1}}\right) - ln\left(\frac{Pop_t}{Pop_{t-1}}\right), \quad (1)$$

where Pop_{ct} is the population of municipality c at time t and Pop_t is the total population of Aragon; t spans 15 years, from 2000 to 2015. Using relative population growth (i.e., the population of each municipality as a proportion of the total population in Aragon) means that we are not attempting to explain why the population growth of a given municipality is x% (absolute growth) but why it is y% higher or lower than the population growth of the entire region.

Next, we define the indices for measuring localisation economies (productive specialisation) and urbanisation economies (productive diversity) at the municipal level. It is worth noting that, as mentioned earlier, localisation economies are associated with a business concentration within a particular sector, whereas urbanisation economies operate through the overall concentration of economic activity. Furthermore, the spatial unit of analysis is the municipality; as such, all explanatory variables have been constructed at this level.

The degree of specialisation (spe_{ct}) related to localisation economies at a municipal level is given by the Krugman Specialisation Index, which is defined as:

$$spe_{ct} = \sum_{i=1}^{I} \left| \frac{emp_{ict}}{emp_{it}} - \frac{emp_{ct}}{emp_t} \right|, \tag{2}$$

where emp_{ict} is the employment in sector i in municipality *c*, emp_{ct} is the total municipal employment, emp_{it} is the total employment of the sector in Aragon, and emp_t is total employment in Aragon; all of these are measured in year *t*, and *I* is the total number of sectors in the municipality (at the two-digit classification). The index is bounded by zero (indicating that the economic structure of the municipality resembles the economic structure of Aragon) and $\frac{2(I-1)}{I}$. We include all productive sectors available in the database, not only industrial activities. The index is the absolute value obtained by adding the deviations in the productive structure of the municipality, which are measured through the employment proportion of each sector relative to the total employment of the municipality, related to the sectoral employment structure of Aragon. The interpretation is straightforward: the higher the index, the more the economic structure of the municipality deviates from that of Aragon (i.e., it is more specialised).

Urbanisation economies (div_{ct}) are measured using the normalised inverse Herfindahl index:

$$div_{ct} = \frac{1/\sum_{i=1}^{I}(emp_{ict}/(emp_{ct}-emp_{ict}))^2}{1/\sum_{i=1}^{I}(emp_{it}/(emp_t-emp_{it}))^2} \tag{3}$$

The index ranges from zero to one. The numerator reaches its maximum value when all municipality sectors are the same size. This index reflects the sectoral diversity of municipality *c*, considering all productive sectors present in the municipality.

In addition to the two indices measuring productive diversity and specialisation at a municipal level, representing localisation and urbanisation economies, the literature suggests the introduction of additional variables. Glaeser et al. (1992) suggested adding the average size of firms within the local industry as an additional control because large companies tend to be more capable of internalising some of the local benefits, while small firms experience greater difficulty doing so. By normalising the average size of the firms in each sector of each municipality by the average size of the firms in the same sector throughout Aragon, the following quotient is obtained:

$$size_{ct} = \frac{1}{I}\sum_{i=1}^{I}\left(\frac{emp_{ict}/n_{ict}}{emp_{it}/n_{it}}\right), \tag{4}$$

where n_{ict} is the number of firms in industry i in municipality *c* at time *t*, and n_{it} is the total number of firms in the sector in Aragon in the same year.

Finally, Combes (2000) suggested that, to simultaneously control the differences between cities, it is relevant to consider the density of total employment in these cities using the following indicator:

$$den_{ct} = \frac{emp_{ct}}{area_c}, \tag{5}$$

where $area_c$ is the geographical area of the municipality, measured in km^2.

Table 2 presents the mean values per year for each defined variable. The distinct behaviour of the two indices that measure the two types of agglomeration economies is noteworthy. While specialisation continuously decreased throughout the entire analysed period, industrial diversity declined over the first few years but rose again after the 2008 economic crisis as part of the recovery that occurred during the final years of the sample. These averages have been calculated for an unbalanced panel of 577 municipalities. Our sample size is smaller than the total number of municipalities (731, as shown in Table 1) because there are some municipalities (154) for which we lack employment information from any firm in any year, making it impossible to calculate variables (2) to (5). These municipalities are excluded from the sample. Furthermore, the panel is unbalanced because employment data are unavailable for some municipalities in some years, precluding computation of the indices. The average number of observations per year is 481.

TABLE 2.
Average values by year

Year	Relative pop. growth	Population	Relative population	Population density	Specialisation	Diversity	Size	Density
2000	-0.006	3,003.658	0.003	33.154	0.778	0.230	0.646	9.384
2001	-0.010	2,688.135	0.002	30.640	0.764	0.169	0.602	8.597
2002	-0.012	2,598.394	0.002	29.601	0.788	0.142	0.616	8.368
2003	-0.013	2,552.599	0.002	29.291	0.812	0.152	0.599	8.450
2004	-0.010	2,491.953	0.002	28.427	0.783	0.136	0.624	8.382
2005	-0.003	2,479.976	0.002	21.232	0.801	0.123	0.617	7.573
2006	-0.005	2,488.097	0.002	21.714	0.766	0.177	0.648	7.801
2007	-0.015	2,594.928	0.002	22.912	0.709	0.151	0.641	8.397
2008	-0.015	2,616.445	0.002	23.506	0.696	0.127	0.643	8.209
2009	-0.008	2,623.795	0.002	23.931	0.695	0.152	0.639	7.277
2010	-0.003	2,658.561	0.002	24.565	0.685	0.180	0.648	7.628
2011	-0.016	2,641.704	0.002	24.717	0.619	0.135	0.690	7.311
2012	-0.020	2,711.900	0.002	25.293	0.454	0.308	0.704	7.651
2013	0.000	2,635.068	0.002	24.762	0.484	0.241	0.686	7.197
2014	-0.009	2,621.849	0.002	25.040	0.478	0.277	0.694	7.295
2015		2,578.257	0.002	24.711	0.464	0.217	0.681	7.405

Notes: Average values by year for an unbalanced panel of 577 cities.

Having defined these variables and indicators of diversity and productive concentration at the local level, we proceed to estimate a model in which the dependent variable is the relative population growth in municipality c in year t (equation (1)), and the explanatory variables are defined in equations (2) to (5). The panel data model is as follows:

$$g_{ct} = \beta_0 + \beta_1 ln(spe_{ct}) + \beta_2 ln(div_{ct}) + \beta_3 ln(size_{ct}) + \beta_4 ln(den_{ct}) + \varphi_c + \eta_t + v_{ct}, \quad (6)$$

where φ_c indicates the municipal fixed effects, η_t represents the annual fixed effects and v_{ct} is the error term. Similar growth equations can be found in Glaeser et al. (1995) and Glaeser and Shapiro (2003). This linear equation (6) finds theoretical support in the urban growth model by Glaeser et al. (1995), which was later developed by Glaeser (2000) and Glaeser and Shapiro (2003). This model is a theoretical extension of the classic spatial equilibrium model by Roback (1982) and constitutes a framework that includes supply and demand factors that may influence the growth of the local population.

While it is true that many local characteristics could influence population growth (such as climate, available transportation networks, and housing prices), the selected explanatory variables only include factors related to agglomeration economies. Other local characteristics that may affect local population growth are understood to be included in the municipal fixed effects. Moreover, information about certain geographical characteristics (e.g., climate variables or house prices) is unavailable for all municipalities.

Additionally, time fixed effects help control changes in the temporal evolution of the population. During the study period (2000–2015), González Pampillón (2018) identified two distinct phases in the development of the immigrant population in Spain: the immigrant boom period (2001–2009) and the subsequent period of freezing of the immigrant population (2010–2015). These phases had different effects on the population dynamics of major cities in Spain and on the distribution of the immigrant population among the various neighbourhoods in these cities. As explained by González Pampillón (2018), Spain experienced a massive influx of immigrants between the late 1990s and 2009, driven by sustained growth. Over this period, Spain was the second-largest recipient of immigrants in absolute terms (behind the United States) and the largest in relation to its population. However, the recession that ended in Spain in 2013 halted this influx of immigrants. In fact, immigrant participation slightly decreased between 2010 and 2015. Palacios et al. (2017) corroborated that the evolution of migratory flows in Aragon was similar, as mentioned earlier. Although these time dynamics may have some implications for the population of Aragonese municipalities, we have attempted to isolate these effects by including annual fixed effects in our analysis.

We estimate the panel data model (6) with robust standard errors clustered by city. To address any concerns about possible multicollinearity, we calculate the variance inflation factor, which yields values within limits suggested by the literature, indicating no multicollinearity issues. However, although we include fixed effects and time fixed effects to control for possible unobserved characteristics at the city level and year-specific shocks, some potential issues remain. These include possible persistence in the trend of the dependent variable (population growth) related to dynamic issues of the variable, as well as endogeneity concerns and reverse causality. To address these issues, some of the models we estimate also include the initial value of the relative population of the municipality (which transforms model (6) into a dynamic panel data model) as an explanatory variable.

Furthermore, we utilise the difference generalised method-of-moments (GMM) estimator by Arellano and Bond (1991). Through a first-differencing transformation, individual specific unobserved effects are eliminated, and the effect of possible time trends in our main variables of interest is controlled. After first-differencing the model (6), the equation is estimated via GMM. The independent variable is instrumented with lagged values of the dependent and independent variables. In our case, we use lag 3 of all the explanatory variables as instruments.

Model (6) is estimated for a panel data set from 2000 to 2015, covering the 577 Aragonese municipalities for which we have data on all variables, including time and municipal fixed effects. The number of temporal observations is 14, given that a year is lost after calculating the growth rate. Table 3 shows the estimation results for the effect of agglomeration economies on relative population growth (the dependent variable in equation (1)). Table 3 has seven columns representing seven different specifications of the model (6). The model is estimated, including all controls but using different samples of municipalities in columns (1), (3), and (5). In the models in columns (2), (4), (6), and (7), the initial population of the municipality is also included to control for persistence in population growth, making these models dynamic panel data models. Within the dynamic models, the estimation in column (7) is performed with the difference GMM estimator by Arellano and Bond (1991) to address potential issues of endogeneity and reverse causality.

We consider three samples of municipalities for the estimation: columns (1) and (2) report the results using an unbalanced panel with all available observations each year, while columns (3) and (4) utilise a balanced panel of 322 municipalities with complete information for all the variables in all years. Finally, the models in columns (5), (6), and (7) employ a subsample of 46 cities with over 3,000 people (also a balanced panel). This subsample focuses on the largest cities, excluding less populated areas, which are typically rural, where agglomeration economies may not be strong enough to generate significant effects[4].

Considering all the municipalities (columns (1) and (2)), none of the variables introduced (equations (2) to (5)) are significant. This suggests that if all Aragonese municipalities are included, no evidence of significant effects from localisation (specialisation) or urbanisation (diversity) economies on population growth can be observed. Neither coefficients are significant, and the estimated values are very close to zero in both cases. Similar results are found when we limit the sample to a balanced panel in columns (3) and (4). Once again, we cannot identify a significant effect on population growth from either localisation or urbanisation economies.

The explanation for the lack of the statistical significance of agglomeration economies in columns (1) to (4) is the overrepresentation of small municipalities in the sample: 92% of the municipalities in the unbalanced sample including all cities have less than 3,000 inhabitants (columns (1) and (2)), and the equivalent figure for the balanced sample (columns (3) and (4)) is 86%. These low-populated places have a specific productive structure. For the municipalities with less than 3,000 inhabitants, the average values of the specialisation and diversity indices for the whole period considered are 0.697 and 0.156, respectively, while the equivalent average values for the large municipalities with more than 3,000 people are 0.545 for specialisation and 0.443 for diversity. That is, specialisation is higher in the small municipalities than in the large ones, while large municipalities have a more diversified productive structure than the small ones. This makes sense because a low population implies a small number of working positions in a few activities. However, these activities are, in many cases, subject to decreasing returns to scale (e.g., agriculture, hotels, and restaurants).

Furthermore, even if they are highly specialised and most employees work in the same productive activity, the total number of workers is not high enough to generate agglomeration economies, that is, the average size of firms is quite limited in small municipalities. Consequently, the only difference in results between the unbalanced and balanced panels is a positive and significant effect of the average size of firms in the case of the balanced panel (columns (3) and (4)), which means that municipalities with large firms (that tend to locate in populous places) grow more than small municipalities with small-size firms.

When we focus on the results obtained from the sample with the most populous municipalities (columns (5), (6), and (7)), we see a change in results, with a positive effect from both the specialisation and diversity indices. In most estimations, there are no significant coefficients for other variables (average firm size and employment density), except for the employment density coefficient in the model estimated in column (4) and the average firm size coefficient in columns (3) and (4).

In cases where the initial population of the municipality is included as an additional explanatory variable (columns (2), (4), (6), and (7)), the coefficient of this variable is significant in all cases. This provides evidence of the dynamic behaviour of our dependent variable, supporting the use of the dynamic panel data model. The coefficient is negative, which could indicate that over the analysed period (2000–2015), population growth in municipalities would have been convergent. This means that once the municipal fixed effects control the individual growth trend of each city, the general pattern extracted is that municipalities with larger initial populations grew less than less populated ones.

[4] The use of alternative thresholds (e.g. 2,000 or 4,000 inhabitants) yields similar results.

TABLE 3.
Population growth, 2000–2015

	FE Panel	FE Panel	FE Panel	FE Panel	FE Panel	FE Panel	Difference GMM
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Cities:	All (unbalanced)	All (unbalanced)	All (balanced)	All (balanced)	Population ≥ 3,000	Population ≥ 3,000	Population ≥ 3,000
Relative Pop_{t-1}		-0.132***		-0.111***		-0.142***	-0.098*
		(0.014)		(0.014)		(0.010)	(0.050)
Specialisation	-0.001	-0.001	0.000	-0.004	0.046**	0.021*	0.151**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.017)	(0.011)	(0.063)
Diversity	-0.000	-0.001	0.001	-0.001	0.018***	0.006*	0.059**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.006)	(0.004)	(0.028)
Size	0.003	-0.000	0.006***	0.004**	0.005	0.003	-0.029
	(0.002)	(0.002)	(0.002)	(0.002)	(0.008)	(0.005)	(0.040)
Density	-0.002	0.001	-0.004	-0.002	0.014	0.016***	0.005
	(0.002)	(0.003)	(0.003)	(0.003)	(0.009)	(0.004)	(0.032)
City fixed effects	Y	Y	Y	Y	Y	Y	N
Year fixed effects	Y	Y	Y	Y	Y	Y	Y
Observations	7,196	7,196	4,830	4,830	593	593	561
Cities	577	577	322	322	46	46	46
R^2	0.016	0.109	0.017	0.111	0.187	0.447	
AR(2), p-value							0.482
Sargan test, p-value							0.488
Hansen test, p-value							0.967

Notes: Dependent variable: Relative population growth. The logarithm is taken for all variables. FE Panel models include a constant. Robust standard errors in all cases, clustered by city in the FE Panel estimations. The difference GMM method is utilised to remove the cross-section fixed effect and control for possible trends in the data. As instruments we use lag 3 of all the explanatory variables. *, **, and *** denote significant at the 10%, 5%, and 1% level, respectively.

Lastly, the comparison between the estimates shown in columns (6) and (7) reveals that the results do not change substantively when the difference GMM estimator is applied (column (7)). The coefficients of the two variables related to agglomeration economies (specialisation and diversity) remain positive and significant, although their magnitude increases when using the GMM estimator. Therefore, the results are robust, even when utilising the GMM estimator to control for possible endogeneity and reverse causality issues. Arellano and Bond (1991) emphasise the importance of passing certain tests to confirm the use of the GMM method. Specifically, the second-order lag test (AR (2)) allows for testing serial correlation in the residuals, while the Sargan-Hansen tests enable us to check the validity of the instruments employed. The last entries in column (7) report the p-values for these three tests, indicating that the instruments are valid, and no evidence of serial correlation has been found.

4. Conclusions

Depopulation has been a persistent trend in many areas of Aragon over the last few decades, mainly affecting smaller population centres (Bielza de Ory, 1977; Escolano and De la Riva, 2003; Palacios et al., 2017; Lardiés Bosque et al., 2020). The nature of this problem has become more complicated, as various investigations have shown (Escolano Utrilla, 1999; Lardiés Bosque et al., 2020). Scholars argue that while emigration was once the main cause of demographic decline, negative natural growth resulting from an ageing population and difficulty in replacing inhabitants, mainly due to a lack of women, is now the primary issue (Frutos Mejías et al., 2009). Ageing has serious consequences for the survival and future of many municipalities, not only for maintaining current population levels but also for growth (Palacios et al., 2017; Lardiés Bosque et al., 2020). Many small population centres will likely disappear in a short time if they cannot attract new inhabitants.

Despite depopulation becoming a significant challenge for the region, regional policies against depopulation have been meticulously planned but have scarcely been implemented (Sáez Pérez et al., 2016). However, other policy and economic interventions may have significant demographic effects. For instance, the regional plan promoting regional clusters could increase the local population through agglomeration economies.

This paper estimates the impact of agglomeration economies on population growth at the local level, using panel data models that include the initial population as well as the city and year fixed effects to capture the persistence (positive or negative) in population growth and idiosyncratic components across municipalities. Agglomeration economies are measured with different indices. We find evidence of a significant positive effect from both localisation and urbanisation economies on growth in Aragonese municipalities, but only in large cities. If we consider all municipalities, no significant effect is identified. This suggests that agglomeration economies require a minimum population scale, which, in this case, is quantified to be 3,000 people (46 out of the 731 municipalities in Aragon).

The urban growth model developed by Glaeser et al. (1995) helps us to understand the supply or demand factors that might be responsible for the positive effects of agglomeration economies in large cities. According to this theoretical model, a local feature (in this case, the productive diversity or specialisation represented) can influence local growth in three ways. First, this local characteristic might become more important in the production process. However, González-Val and Marcén (2019) analysed the sectoral growth of employment at the local level during the same period in Aragon and found that specialisation harmed employment growth, while diversity had no significant effect, except for service activities in large municipalities. Given these results, this pathway can be ruled out in the case of Aragonese municipalities.

Second, from a demand point of view, specialisation and diversity could have become more important to consumers by decreasing the cost of living or increasing the number of available local amenities. Greater specialisation at the municipal level implies more firms in the same sector producing similar goods. From a demand point of view, this can increase the value for individuals, given their preference structure and the love-of-variety effect – consumers prefer to consume different varieties of the same differentiated goods. Regarding productive diversity, a high presence of firms from different sectors offering a variety of goods and services could attract both consumers and other firms that prefer to have a wide range available in one place.

Third, specialisation or productive diversity could have contributed to the increase in the technological growth rate. The concentration of businesses, regardless of whether they belong to the same sector or not, facilitates the exchange of knowledge about products, processes, and innovations (knowledge spillovers). This means that specialisation could influence supply through technological changes and, thus, affect population growth. This knowledge transmission is usually easier through specialisation (as it is easier to share production processes or workers' knowledge within the same sector).

In conclusion, both localisation (specialisation) and urbanisation (diversity) economies can influence supply and demand and, through these, local population growth. Based on our results, the effects of these two external effects on population growth would be positive. This outcome supports public policies aimed at attracting firms to achieve growth in the local population and reverse negative dynamics, either through incentives to create industrial clusters of the same sector or by attracting firms from different ones.

Therefore, we have identified a demographic effect of these economic policies. However, we must be aware that from a regional perspective, this effect on the population is limited for two reasons. First, it can only be found in large cities, so small declining municipalities will not benefit from industrial concentration in terms of population. Second, as the effect on the population is only significant for large cities, it can lead to an increasingly unbalanced distribution of economic activity and population, which is a relevant issue for Aragon as this region already has a high concentration of economic activity and population in the capital, Zaragoza.

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