Urban spatial structure in Barcelona (1902-2011): Immigration, segregation and new centrality governance.

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Abstract

This study tracks changes in the urban spatial structure of Barcelona in the presence of constant increasing immigration inflows across various decades. Using an urban theory perspective, we assess whether the city experienced a rise and consolidation of segregation patterns among communities. To this end, we construct an original database covering Barcelona from 1902 to 2011. The results indicate the existence of segregation that harmed the spatial urban structure of the city up until the 1960s. However, a political initiative delegating part of the administrative action to local committees then reinforced the attractiveness of the central business district (CBD), resulting in the *de-facto* avoidance of the creation of urban ghettos.

Key-words: Population, migration, segregation, urban spatial structure.

JEL Classification: N34, N94, R14.

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1. Introduction

Since the beginning of the 20th century, Barcelona (Spain) has been a preferred destination for internal and international migrants.[1] The city represents an interesting case in the Mediterranean Region given the availability of urban data on the presence of foreign communities since the early 20th century. Notably, an impressive immigration arrival rate was recorded for the period from 1991 to 2008, when the share of foreign immigrants surpassed 20% of the population (Figure 1).

The longstanding tradition of Barcelona as a migration destination makes this city a particularly good laboratory for understanding how important events have both impacted the socio-economic composition of the population and influenced the city's urban spatial structure, resulting in the possible rise or consolidation of segregation and shaping the urban socioeconomic equilibrium.[2]

A number of historical studies have highlighted the ways that socioeconomic events affect both the spatial structure and the social and demographic makeup of an urban population. Lévêque and Saleh (2018), for example, show that state industrialization in Cairo around the 1850s attracted rural migration inflows, but observe that this event deepened spatial segregation between Muslims and non-Muslims. In the case of Berlin, Hornung (2019) shows that the heterogeneous composition of migrant inflows (above all skilled immigrants) to Berlin's newly developed city quarters had beneficial results in economic terms by nurturing the creation of job-complementarities with natives.

Hence, while urban migration inflows do not seem to produce negative effects in economic terms, immigrants still often suffer from segregation when settling in their host destination, especially due to cultural diversity with respect to natives.

In efforts to better understand segregation effects from a historical perspective, the case of Barcelona proves valuable thanks to the (unique) availability of spatial data for different ethnic communities. Such information allows to study changes in the degree of segregation of different resident communities, within the analytical framework proposed by urban theory.

Identifying the determinants of the distribution of an urban population (and in turn factors driving spatial segregation) requires relating individual location decisions to the urban structure and the corresponding land organization. Crucially, this means determining whether population heterogeneity encompasses different location preferences on the basis of individual priorities, like accessibility to central places or proximity to other members of the to the same community. Such an approach also implies managing heterogeneity issues associated with the coexistence of various communities

[1] Statistically, we organize resident communities in Barcelona according to the individuals'place of birth. The main community consists of *Catalan* natives (born and living in Barcelona or Catalunya). We identify as *Spaniards* individuals born in the rest of Spain and migrating to Barcelona. Final, *Immigrants* are individuals born abroad and migrating to Barcelona.

[2] Migration flows provide evidence that (urban) communities change, and differ in terms of cultural, social and, potentially, economic background.

and different types of people (e.g., workers, retirees, etc.) that may share similar or different preferences jointly.[3]

One strategy is to consider location decisions as dependent on accessibility. Individuals decide where to reside in accordance with available options for traveling to their place for work or for leisure purposes. A monocentric model allows to deliver reasonable, if sometimes incomplete, predictions (Duranton and Puga, 2015). This strategy involves associating the idea of accessibility with ease (for individuals) of reaching the central business district (CBD), which is expected to be the centripetal urban point for work and leisure. Therefore, the idea of accessibility shapes the study of the importance of distance from the CBD as a determinant in location choice. The model in this paper builds on the Von Thünian orthodox framework as applied in the Alonso-Mill-Muth version. In the framework of a linear city, individuals maximize their utility function that depends on the consumption of land and a composite good for which they need to commute daily to the CBD, paying transport costs. In addition, they also travel to the CBD to supply labor and to obtain income (Fujita and Thisse, 2013). The reading proposed by Duranton and Puga (2015) of this setting indicates that this model is able to accommodate several features of the real world, particularly the coexistence of heterogeneous agents in the same place, but also recurrent improvements in the urban transport system over time. In fact, changes in a transportation system directly influence the degree of accessibility, and this in turn has an impact on housing and land prices. Yet the increasing heterogeneity of residents makes it more complicated for the CBD to accommodate employment for everybody, making the land structure less monocentric.

Our analysis aims to understand the ways that the spatial urban structure of Barcelona changed from 1902 to 2011 and, potentially, exacerbated a segregation tendency among the different communities in the city. To this end, we track the impact of the progressive entry of important immigration flows (initially from elsewhere in Spain, and then from abroad) jointly with an important feature influencing individual location decisions: the implementation of an administrative urban decentralization process from the late 1980s onward.

From a technical perspective, we seek to identify shifts in the urban spatial structure resulting in the creation of (spatially) segregated enclaves. To this regard, we focus on the effects of changes in population and composition, which both increased the city's size and progressively reduced the centrality and attractiveness of the CBD.

Generally, and in line with the predictions of Muth (1969), small population size typically sees a negative value of elasticities between population density and CBD distance. Empirical evidence presented in the literature confirms this finding for US and Canadian cities, where CBD attractiveness declines when population size increases (see, for example, Edmonson et al., 1985; Bunting et al., 2002). Such change is often due to improvements in the transport system, which favors the decentralization process.

Similarly, changes in Barcelona's urban spatial structure reduced the attractiveness of the CDB up until the 1960s and there existed a certain degree of segregation among communities. Yet this tendency later reversed. In the 1980s, the city sought to limit the creation of segregation spaces through the implementation of an urban development plan.

[3] For instance, different income profiles.

The political aim was to elaborate a well-formulated urban organization that would improve living conditions in all districts by physically remodeling their structure, creating cultural spaces and other accessible amenities, and endowing each area with local public services. The idea of a "new centrality"[4] of the city aspired to make the urban periphery attractive. An important push in this direction was the implementation of a program for the requalification of the city plan in view of the Olympic Games (1992), whose primary target was to eradicate the existing ghettos (Ferrer and Nel·lo, 1998).

This study relies on an original database constructed by merging historical statistics released by township administrative services and differentiating between communities. Using this data, we run a number of quantitative exercises. Our results highlight the strength of the CBD in attracting rich or qualified people, as aspect that differentiates European from US cities, where in the latter the wealthy are more likely to live far from the center so as to enjoy larger dwellings but pay for commuting costs (Duranton and Puga, 2015). In Barcelona, the combination of novel urban governance and population inflow enhanced rather than dampened the attractiveness of the CBD. In addition to reinforcing the role of the CBD, it was effective in endowing the peripheral areas with amenities and services that favored the spread of the population, but also limited the consolidation of spatial segregation.

The remainder of the paper is organized as follows. Section 2 provides an overview of Barcelona as a destination for migrants from an historical viewpoint. Section 3 introduces our database and some preliminary statistics, while Section 4 presents and discusses the quantitative results of the econometric exercise. Finally, Section 5 concludes.

2. Barcelona: migration at a crossroads

Barcelona has been an important trading center since Roman times. The strategic position in the Mediterranean area made this city a crossroads for trade and migration flows. On the one hand, industrialization experienced by the city (and its surroundings) in the nineteenth century, based mostly on the textile industry, attracted a significant number of immigrants from the rest of Spain, mostly from the southern regions. In fact, in 1930 about 56% of the residents were not born in Barcelona. The biggest group was made up of Valencians, living in the Barceloneta neighborhood, close to the port (Silvestre et al., 2011). On the other hand, the port itself made Barcelona an important stopover for maritime transit towards South America. Indeed, Barcelona has long been a place of transit and host to foreign migration flows (Ibarz, 2010). The works of Silvestre et al. (2011) and Ibarz (2010) show the salience of the abovementioned national immigration. Migrants were attracted by employment opportunities and high wages in the greater Barcelona area. Vacancies in the non-agricultural sector were especially important, an alternative option to the agricultural and mining sectors in the southern Spanish provinces of Almeria or Murcia. According to Silvestre et al. (2011), the

[4] This notion of "new centrality" is discussed in Salet and Salvini (2015). The so-called Barcelona model is well developed in Marshall (2004).

considerable migration flows of the 1930s occurred simultaneously with a consolidation of Catalan identity that caused self-selection into non-Catalan groups, similar to that observed among cross-border migrants in other European Countries (e.g., the Irish in Great Britain or Italians in Belgium, France, or Germany).

To these numbers, it is important to add immigration from abroad. According to Barcelona's Statistical Yearbook, which records the transit of individuals through the ports, in 1902 approximately 1,670 foreign individuals entered Barcelona from different places around the world, but only 1,140 left to move to other destinations. In their study of migration in Spain, Bover and Velilla (1999) show that up until the 1980s, migration in Spain accounted, on average, for 0.02% of population, while statistics for the city of Barcelona reveal that the share of immigrants had already reached about 2% of the population in 1902 (see Figure 1).

Figure 1: Share of foreign immigrants in Barcelona (1902-2011) (Source: our database)

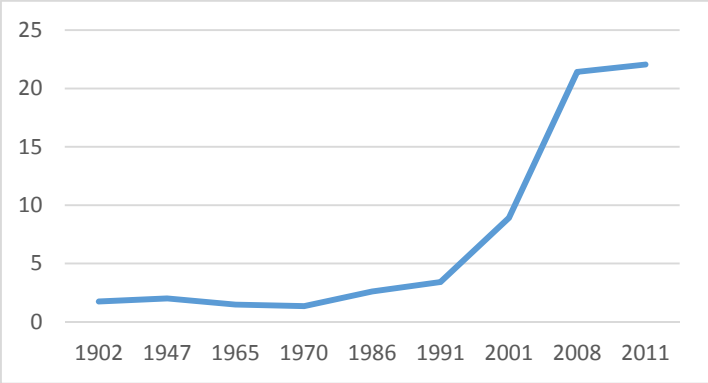


Figure 1 refers to international migration in Barcelona only, and shows that for most of a century it held constant, with an impressive rise from 1986 onward.

While these migration inflows had an important impact on the local labor market, our focus here is on the influence of the latter on the urban spatial structure of Barcelona, with particular interest in the issue of segregation.

According to Busquets (2004), all southern European cities that have experienced important changes in population composition (not just associated with birth rates) share the characteristic of complex urban development, and particularly, a distinctive pattern of residential development. Barcelona is no different. In the 1950s and 1960s, massive migrant inflows from the rest of Spain fueled the clustering of the immigrant community in peripheral areas of the city. Such migration gave rise to "shantyism," or the creation of informal satellite communities that adjoined the established core of the city (i.e., today's Eixample district),[5] among other forms of peripheral growth. Shantyism was a direct consequence of the arrival of thousands of job seekers, which Barcelona's formal real estate system was unable to accommodate, allowing the amount of substandard housing to skyrocket.[6] Spreading from the hills surrounding the city up to Montjuïc, along the seafront, and some spaces in Eixample, Barcelona's shanty communities were the first

[5] Refer to Figure A.1 in the Appendix for a visual representation of Barcelona and its principal urban districts.

[6] Interesting material referring to this particular historical period is available at http://ajuntament.barcelona.cat/museuhistoria/ca/barraques-la-ciutat-informal, provided by the Museo d'Història de Barcelona.

enclaves in which immigrants began to cluster, thus marking the starting point of our analysis.

Using data on dwelling properties, we are able to draw a general picture of the urban change that occurred in Barcelona (Figure A.2 in the Appendix). With reference to the city's urban structure in 2011, consisting of 73 neighborhoods, for each selected year we mapped the percentage distribution of the stock of residences across the various neighborhoods.

Although we can produce maps from 1900 to 2011 according to available data, we focus our discussion in particular on three milestone years:

- 1940, the end of the Spanish Civil War and the beginning of the Francoist regime;
- 1970, the end of the high internal migration period; and
- 2011, a representative year of the current situation, following both the 1979 introduction of democratic municipal governments for the implementation of urban planning and the real estate bubble during Spain's profound internationalization.

The changing distribution of the stock of residences indicates that Barcelona enlarged its urban territory over time, spreading inland. The urban core — the place with the highest concentration of dwellings — has similarly expanded. In 1920, the inner core was El Raval,[7] which now corresponds to part of the historical center of the city. The construction of new properties progressively displaced the residential barycenter away from the Roman perimeter outward. By 1940, the core residential neighborhood was Eixample, whereas in recent decades it has shifted upwards towards the neighborhood of Gràcia.

Along with this movement, the construction of residential dwellings in peripheral areas belonging to the city's external belt increased; a trend clearly aligned with an urban transformation spurred by the need to accommodate more national and international immigrants in these areas.

The degree of spatial integration among the three different communities — Catalans, Spaniards and Immigrants — in Barcelona can be assessed by means of a dissimilarity index (D-index) (Duncan and Duncan, 1955). The computation of this index allows to discern the degree of spatial integration of the two immigrant communities (Spanish and Foreign) with respect to the Catalan one.

The D-index is the most common measure of segregation when referring to an urban environment. Its principal advantages are that it is independent of population composition and is quite reliable for comparisons over time. For a selected city at time *t* for any pair of communities (*M, N)* in a territorial unit *i* (for *n* units), the D-index is constructed as follows:

$$D_t = \frac{1}{2}\sum_{i=1}^{n}\left|\frac{M_{it}}{M_t} - \frac{N_{it}}{N_t}\right| \qquad (1)$$

[7] The map depicting 1900 data is not so different from the current one. For example, the core place of concentration (El Raval) remains unchanged. A settlement dating back to the Roman origins of the city, El Raval has been an active part of the commercial and civil life of Barcelona for centuries (Busquest, 2004).

As presented in Equation 1, the D-index assumes continuous values in (0, 1), with 0 being the most equal situation and 1 the most dissimilar. The index provides a measure of the proportion of the population of community *N* that needs to be displaced in order to negate the degree of dissimilarity between *M* and *N* in neighborhood *i*. A D-index greater than 0.6 usually indicates the presence of a high degree of segregation in a city, while a D-index below 0.3 reflects a low degree of segregation.

In Table 1 we compute the D-index for the three major communities (Catalans, Spaniards and Immigrants) according to available data.

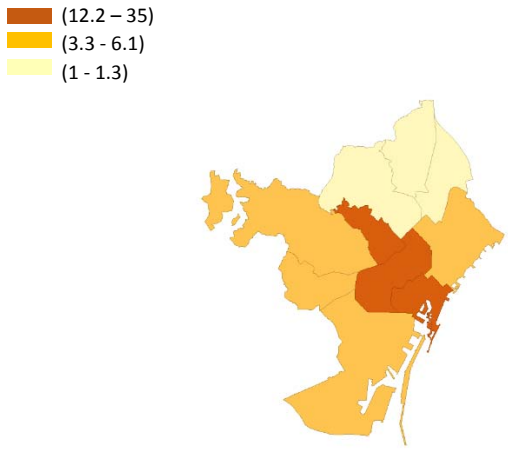
Table 1: Index of dissimilarity (Duncan, 1955)

	Catalans		**Spaniards**
	Spaniards	**Immigrants**	**Immigrants**
1902		0.11	
1947	0.05		
1965	0.10		
1970	0.12	0.34	0.43
1986	0.15		
1991	0.15	0.30	0.40
2001	0.15	0.19	0.26
2008	0.14	0.22	0.13
2011	0.14	0.22	0.22

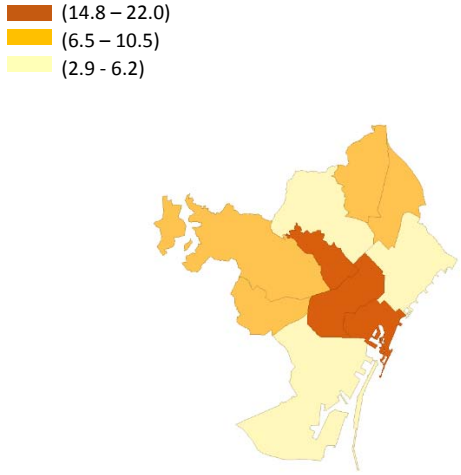
The results confirm the progressive consolidation of segregation in Barcelona up until the 1970s. Immigrants in particular suffered from segregation, especially with respect to Spaniards, likely linked to competition for the same jobs. Of no less importance, however, were discriminatory attitudes of Catalans towards Spanish-born residents, which strengthened during the most important period of in-land migration and held constant over time.

Figure 2: Spatial distribution of foreign immigrant share over total population (%) (Source: our database)

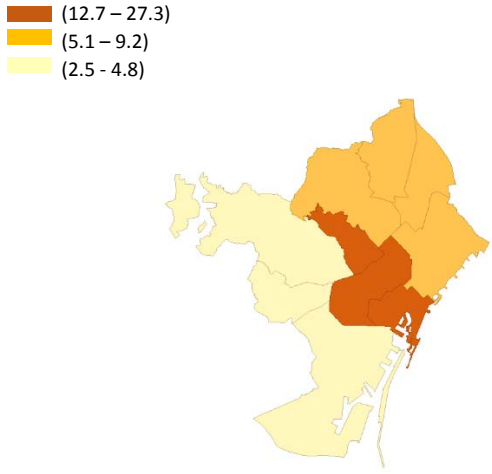
1902



1986



2008



Note that, in reference to foreign immigrants, the changes in the D-index are somewhat associated with shifts in the spatial distribution of this community. Figure 2 presents the spatial distribution of the share of foreign migrants over the total population. We focus on three salient historical moments when this share dramatically changed (as in Figure 1). First, 1902, the year our analysis begins. Then 1986, the year Spain joined the European Union and saw both an important degree of free circulation of people across the member states and the highest stock of immigrants, up until the 2008 financial crisis (the last year in the figure).

Figure 2 shows a slow but constant spreading of foreign migrants across the different districts of Barcelona. Those with the highest shares of immigrants consolidate over time, while we observe changes in the distribution for second-rank districts, moving south to north.

These results confirm a constant increase of foreign immigrants in Barcelona, their progressive spatial spreading within the urban area, and the persistence of discrimination. In what follows, we aim to identify the features that might drive these dynamics, and are potentially responsible for the consolidation of segregation patterns within the city.

3. Data and descriptive statistics

Our empirical analysis relies on an original database, which gathers relevant information on factors shaping the population distribution in Barcelona. Our principal source consists of the Annual Statistical Yearbooks published by the township administration, which contain relevant data on the demographic composition of Barcelona since 1902. However, historical events (namely the Civil War, and then the Francoist dictatorship period) hinder the collection of complete information. One of our preliminary tasks was thus to elaborate the available information so as to make it consistent at the territorial level over time.

To this end, we refer to the geographical urban structure of 2011 (at the district level, as in Figure A.1 in the Appendix) and create the fit of the pre-2011 urban territorial organization to the former. Applying the same criterion, we also elaborate an ad-hoc neighborhood structure for each of the pre-2011 maps, allowing to run comparable estimations for each period and community. It was, however, necessary to introduce a conversion criterion due to the unavailability of relationship/conversion files. Exploiting the technique adopted by the US Census Bureau for the TIGER/Line program, and using geographical points of reference, we identified an equivalence criterion for the matching of district boundaries and land surfaces. We use these shares to convert all pre-2011 district areas (and associated variables) to the 2011 district boundaries as a weighted sum. As a result, we obtain a pseudo panel of comparable observations at the urban level for the period 1902-2011.

In what follows, we provide a few preliminary comments about our data. Despite the expansion of the urban territory, population density continually increased up until 1965, mostly due to immigration from the rest of Spain (Table 2). Then, up until 2001, the density dropped, while in the last years of the period of analysis there occurred an upturn in population density caused by the high inflow of international migrants.

Table 2: Descriptive statistics

	Variables	Mean	Std deviation	Min	Max
1902	Population density	21744.21	19399.42	1691.3	64536.41
	Catalan density	13588.57	12515.07	1345.58	41751.86
	Spanish density	na			
	Immigrant density	399.75	392.82	11.27	1267.46
	# Bus lines per spat. unit	1.3	1.059	0	3
1912	Population density	21864.14	17764.83	1524.42	58392.27
	# Bus lines per spat. unit	2.7	1.828	1	6
1920	Population density	25316.15	19708.21	1875.6	64802.38
	# Bus lines per spat. unit	3.8	1.751	1	6
1947	Population density	32435.3	30459.4	3718.3	105036.2
	Catalan density	20158.54	17862.29	2416.125	61053.34
	Spanish density	11444.96	12143.3	1150.77	42248.57
	Immigrant density	625.29	571.79	95.08	1727.7
	# Bus lines per spat. unit	9.3	4.595	4	20
1965	Population density	30860.86	24242.79	6244.761	95114.23
	Catalan density	18289.5	13878.42	3866.109	52940.73
	Spanish density	12194.18	10335.82	2122.405	41232.76
	Immigrant density	377.18	264.54	67.7	940.73
	# Bus lines per spat. unit	15	6.1938	6	29
1970	Population density	29461.22	19413.46	6496.107	78182.12
	Catalan density	16365.44	10277.12	3639.27	40330.82
	Spanish density	10771.99	7963.62	1737.793	32537.72
	Immigrant density	374.44	227.99	80.99	848.06
	# Bus lines per spat. unit	17.25	6.312	7	31
1986	Population density	26039.04	15926	189.66	52523.81
	Catalan density	17096.18	11019.37	129.569	37517.29
	Spanish density	8340.07	5078.27	51.96	16321.62
	Immigrant density	512.75	311.10	165.87	1140.8
	# Bus lines per spat. unit	9.71	5.73	1	29
1991	Population density	25056.7	15281.19	225.55	50151.43
	Catalan density	16629.99	10677.62	163.35	35291.36
	Spanish density	7657.69	4673.95	50.14	14912.89
	Immigrant density	643.29	395.73	212.59	1339.73
	# Bus lines per spat. unit	9.5	6.09	1	30
2001	Population density	23469.06	14988.18	33.954	56885.65
	Catalan density	15191.92	9903.66	25.483	37750.7
	Spanish density	6421.87	4623.88	7.77	20451.48
	Immigrant density	1664.88	1353.04	517.72	4726.00
	# Bus lines per spat. unit	7.507	4.952	1	28
2008	Population density	25186.4	15673.6	77.57	59024.3
	Catalan density	14466.7	9225.4	57.97	36253.3
	Spanish density	10719.76	7337.75	19.60	29206.36
	Immigrant density	4472.80	3352.25	1125.03	12283.29
	# Bus lines per spat. unit	8.342	4.969	1	29
2011	Population density	24956.64	15467.52	74.558	59442.82
	Catalan density	14448.05	9116.32	56.007	35713.85
	Spanish density	5163.304	3582.03	10.361	15455.7
	Immigrant density	4521.75	3113.65	1121.05	11223.9
	# Bus lines per spat. unit	8.245	4.832	1	29

The massive migrant inflows, first from the rest of Spain and then from abroad, fueled a clustering of immigrants in peripheral areas of the city (Busquets, 2004).

Simultaneously, the construction of residential dwellings in areas belonging to the city's external belt increased. This trend clearly aligned with an urban transformation driven by the need to accommodate more national and international immigrants in these areas.

In one of the first empirical studies on the location determinants of population density, Guest (1973) identifies the quality of the urban transport system and dwelling supply as the most relevant features defining population location choices and, consequently, shaping the urban spatial structure, or "urban gradient."[8]

From our data, we observe that in 1902, Barcelona hosted small foreign communities, undoubtedly related to the intense shipping activities associated with its commercial port. Note, however, that in combining Figure 2 with Table 2, differences among communities — in terms of location — nearly disappear. A possible explanation relates to the progressive movement of households outside Barcelona's urban core to the larger metropolitan area. Another relates to the real estate market. In Barcelona, the creation flow of buildings shows a stable downward trend. A joint reading of both pieces of evidence suggests that the movement of people away from Barcelona's urban area aligns with arguments presented at the beginning of this section: people move from municipalities to improve their real estate properties, typically preferring individual dwellings. In turn, one should expect a reduction in the attractiveness of the CBD (and a downsizing of the urban gradient).

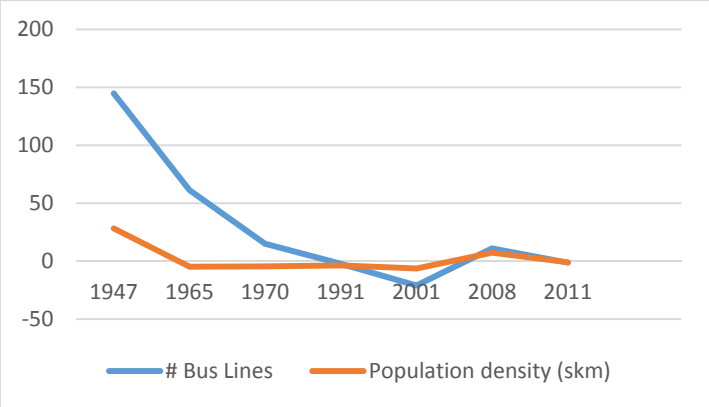
Finally, it is also of interest to analyze the evolution of the urban public transport system, which plays a relevant role in shaping population distribution. As we anticipated in Section 1, the urban transport system is crucial for guaranteeing the degree of accessibility to the CBD. Among the various modes of public transport in Barcelona, public bus lines enjoy the reputation of being an easily accessible service (Fernández i Valentí, 2006). In order to obtain data on bus-line density at the spatial level for each year of our period of study, we rely on raw information on urban public transport in Barcelona available online.[9] We first selected urban bus lines that have been operating for at least more than a year (hence, excluding experimental or summer lines). Then, for every line, we tracked the corresponding bus route on a map for each year to identify the districts or neighborhood served by each bus line. Finally, we aggregated the number of bus lines by district (or neighborhood) and year, and computed the correspondent spatial density. With this information, we expect to observe that a shifting density of bus services parallels a shifting density of the city's population.[10] As shown in Figure 3, we quantify this idea by depicting the trends in population and bus line densities. Despite the perfect collinearity in the final years of the considered period, the two trends are for the most part independent, with only a single instance of parallel movement, where change in the density of public bus transport overcomes that of population density. These results confirm that a general strategy was adopted by the public administration to improve the degree of accessibility of urban locations through a more efficient transport system only in the last years of the study period. Put differently, accessible means of transport did not represent a principal discriminatory feature in determining individuals' location choices for the overall period.

[8] The urban gradient is the (estimated) elasticity between population density and distance from the CDB. As discussed in Duranton and Puga (2015), the same types of variables have been confirmed in other research as relevant for study of the gradient of population distribution.

[9] This information is available at: at http://www.autobusesbcn.es/.

[10] It is worth mentioning that while Barcelona implemented urban train and metro networks as well, the development plan favored uniform full accessibility across all districts and, hence, these means are less likely to be discriminatory, compared to the bus service, in terms of location choices. We have tested this conclusion and the results are available upon request.

Figure 3 Percentage changes in public bus line density versus changes in population density
(Source: our database)



Overall, the empirical evidence discussed in this section emphasizes that the creation of dwellings in the peripheral areas of the city (and surrounding villages or towns), together with a progressively more efficient public transport system, favored the relocation of the urban population to outside areas. However, the entry of huge waves of immigrants also helped the urban population to return to levels of the previous decades, albeit with a different spatial structure shaping population distribution. Our empirical analysis endeavors to quantify this spatial change.

4. Empirical strategy and results

In order to perform the empirical analysis, we rely on an augmented version of the population density distribution function for a monocentric urban structure inspired by the negative exponential function introduced by Clark (1951). The standard population function identifies that the gross population density at a distance x from the CBD is negatively proportional to the size of the distance itself. The CBD is generally recognized as the center of interest for labor or leisure purposes for all citizens. Garcia et al. (2017) identify two specific places of interest known to have been important in the civil and economic life of Barcelona. Given the historical perspective of this analysis, we similarly selected two places that merit attention over the decades: Plaça Catalunya, labeled as the CBD, and a historical building in the old commercial port, labelled as the Port. Plaça Catalunya has long represented the core of the city's urban life in all dimensions, as reflected by the real estate market. In contrast, the old commercial port of Barcelona was originally the economic center for the city's trade industry but later developed into a tourism and leisure area. The Port is also not far from one of the city's major train stations, which has long served as a point of reference for Spanish-born immigrants arriving in Barcelona in search of work (Busquets, 2004). This analytical strategy is not new in the literature. Other empirical work has exploited the existence of sub-centers in identifying the gradient. The expected outcome is still a negative gradient, but flatter (see, for example, Garcia (2007) or, for a review of existing results, Duraton and Puga (2015)).

Given our working hypothesis, we select the following density function for a community h[11]

$$D_{hj}(x) = D_{hj0}e^{[\alpha_0 ln(x_{j0})+\alpha_1 ln(x_{j1})]} \quad (2)$$

in which $D_{hj}(x)$ is the gross population density at the centroid x of district (or neighborhood) j,[12] x_{j0} the distance (in km) between point x and the CBD, and x_{j1} the distance from x to the historical building in the old port of Barcelona. In the spirit of Mills and Tang (1980), we considered D_{hj0} as a constant.

By log-linearizing equation (1) we finally estimate

$$LnD_{hjt}(x) = \alpha_0+\alpha_{h1}Ln(x_{j0t}) + \alpha_{h2}ln(x_{j1t}) + \alpha_{h3}X_{jt} + \mu_t + \delta_s + \varepsilon_{htj} \quad (3)$$

in which α_0 is a constant, and x_{j0t} and x_{j1t} preserve the meaning previously described.[13] It is, however, important to note that the distance from any location in Barcelona to Plaça Catalunya and to the Port are time-dependent due to changes in the definition of the centroids of each spatial-plot, a consequence of the progressive expansion of the city. The variable X_{jt} refers to bus-line density in location j at time t. The rationale for including this variable is based on the argument that the efficiency of the public transport network is an important determinant in shaping location choices. That said, there is a potential endogeneity problem between the bus-line density and the population density of the same urban parcel j. In order to overcome this limitation, we implement an IV estimation strategy in which we assess bus-line density using an index of the relative importance of the bus-line density in all spatial units $i \neq j$ over the total density of the broader Barcelona public transport system (namely bus, train, and metro lines). This instrument builds on a similar idea introduced by Card et al. (2014). The population density in a district is expected to be proportional to the quality of the transport service of the own spatial unit, but not directly to that of the other spatial units. The Montiel-Pflueguer statistics confirm that this index can be exploited as instrument in the IV estimations. Finally μ_t and δ_s are time and spatial fixed effects, respectively.

Our empirical exercise is built in two steps. The first examines the sample of original data (i.e., an unbalanced panel) in order to assess the average effect of the gradient across years and for all communities in Barcelona. The second exploits the pseudo panel and produces point estimates for the temporal evolution of the urban gradient, differentiating between communities.

The selection criterion for communities distinguishes between the two broad waves of migrants arriving in Barcelona: those from elsewhere in Spain and those from abroad. This classification guarantees statistical representativeness of these individuals in all urban neighborhoods.[14] We also aim to capture the effect of income in defining location preferences. While we do not have sufficient information to identify the income of individuals belonging to the various communities across the decades, we explore this issue for both the community of high-skilled individuals (likely to represent the wealthy)

[11] Gueroïs and Pumain (2008) argue that the negative exponential function is the best fit (among several other options) for examining population density in Barcelona.
[12] We refer to point x as the centroid of either the district or neighborhood.
[13] This research strategy is in line with that proposed by Adhvaryu (2011).
[14] A concern for representativeness prevents us from separately considering different subgroups of nationals that make up the immigrant community in each district.

and, similarly, the low-skilled (likely to capture individuals belonging to the lower end of the income distribution).[15]

The results of the first step of our empirical strategy for the unbalanced panel are presented in Table 2 for the period 1902-2011.

We consider the overall population (mostly composed of native Catalans), Spanish-born citizens, immigrants, the illiterate (i.e., low-skilled workers among both natives and immigrants), and the high-skilled (both immigrants and natives). For our econometric analysis, we follow the usual strategy. We begin by performing OLS benchmarking estimations and then, on the basis of the F-test results we first conduct the fixed effects estimations (FE) and then the IV (FE). Given the limited available number of control variables at the territorial level, the choice of the fixed effects is important. To define a representative measure of the features of the districts that remain constant over time, we introduce ad-hoc spatial fixed effects (δ_s) by identifying the urban districts that survived over time (*H-District*). This allows to preserve the time invariant condition, valuable for two reasons. First, we must keep track of the spatial units that were part of the urban territory of Barcelona for the entire period of analysis and that consolidated over time. This allows to identify a sort of reputation effect that these spatial units enjoy, as they became important references for individual location choices.

Second, the introduction of this type of spatial fixed effect takes into consideration all the policies for decentralized governance that were implemented by local administrations at the district level. These mostly refer to education or health care facilities, which are provided on a district basis, and can differ across areas.

The results of the FE estimations emphasize a clear difference between the determinants of location decisions for Spaniards and those for immigrants (more similar to the larger population, namely Catalan natives). For the former, the urban gradient is not statistically significant while for the latter it is negative. Immigrants and natives thus follow the standard behavior established in the literature when considering the CBD as a centripetal point. For Spaniards, the location decision seems not to be sensitive to the CBD. A simple argument to explain these results could be differing priorities among these communities. If one considers that Spaniards principally moved to Barcelona in search of employment, it is plausible they were more prone to relocate closer to available jobs, mostly found near the Port (Silvestre et al., 2011 or Ibarz, 2010) and relatively far from the CBD.

[15] Note that information on the skill levels of the population is available only for the year in which we exploit census data. To overcome this problem, we introduce an ad-hoc criterion to define the high-skilled community. When data on education is available, we consider as highly-skilled those individuals with a university degree or more. In contrast, when this information is not available, we proxy with profession. We consider as members of the high-skilled community lawyers, doctors, professors, engineers, architects, priests, and all other professions that require university-level studies.

Table 2: Unbalanced panel (1902-2011)

	Log population density			Log Catalan density			Log Spanish-born density			Log Immigrant density			Log high-skilled density			Log illiterate density		
	FE	**IV**	**IV (FE)**	**FE**	**IV**	**IV(FE)**	**FE**	**IV**	**IV (FE)**	**FE**	**IV**	**IV (FE)**	**FE**	**OLS**	**FE**	**FE**	**OLS**	**FE**
Constant	17.5*** (4.02)	14.8*** (1.18)		-61.4*** (11.05)	13.7*** (1.21)	21.1*** (2.42)	-41.62*** (13.05)	16.41*** (2.21)		-22.44 (16.06)	-3.76* (2.15)		-393.23*** (44.45)	9.17*** (2.04)	-30.04** (12.40)	-77.96* (38.84)	1.66 (1.37)	61.60*** (10.36)
Log_Distance_CBD	-1.3*** (0.412)	-0.4*** (0.104)	-1.16*** (0.41)	-1.02** (0.44)	-0.45*** (0.11)	-0.60*** (0.22)	-1.39 (1.086)	-0.39** (0.17)	-1.72* (0.95)	-1.23* (0.66)	0.73*** (0.18)	0.46 (0.73)	23.16*** (1.89)	-0.91*** (0.21)	4.49*** (1.54)	2.08 (1.64)	0.72*** (0.13)	-6.70*** (1.29)
Log_Distance_Port	0.40* (0.20)	-0.23** (0.09)	0.37* (0.19)	9.6*** (1.23)	-0.11 (0.11)	-0.83*** (0.24)	7.40*** (1.75)	-0.52*** (0.15)	8.36*** (1.27)	5.00*** (1.79)	0.31* (0.16)	-8.84*** (1.89)	25.29*** (3.61)	0.62*** (0.11)	Dropped	8.20** (3.16)	-0.27*** (0.06)	Dropped
Log_BusLine_density		0.26*** (0.08)	0.006 (0.12)		0.19**	0.07 (0.15)		-0.18 (0.17)	-0.07 (0.10)		1.60*** (0.17)	1.54*** (0.15)		0.73*** (0.13)	0.59*** (0.18)		0.94*** (0.07)	0.568*** (0.15)
- Robust Durbin-Wu-Hausman test		36.90***			48.8***			135.08***			88.59***			0.67			1.51	
Instrument:		Ind_pub_transp_others	Ind_pub_transp_others		Ind_pub_transp_others	Ind_pub_transp_others		Ind_pub_transp_others	Ind_pub_transp_others		Ind_pub_transp_others	Ind_pub_transp_others							
Montiel-Pflueger test (α= 5%)			43.56			41.63			43.96			41.38						
TIME DUMMIES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Fixed effects	H-District		H-District	H-District		H-District	H-District		H-District	H-District		H-District	H-District		H-District	H-District		H-District
F-test FE vs OLS	8.4***			11.8***			15.9***			5.2***			39.34***			19.78***		33.50***
Errors	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust	Robust
R-squared	0.53	0.65	0.46	0.81	0.62	0.46	0.63	0.12	0.60	0.90	0.65	0.84	0.91	0.80	0.91	0.96	0.94	0.97
Obs	114	111	106	93	90	106	84	84	77	94	91	83	50	47	47	50	47	47

*Legend: *** 1%, ** 5%, *10% degree of significance*

Estimations that also include public transport facilities (represented by the *bus-line density*) provide additional evidence. Before discussing the estimation results, it is important to stress that the introduction of the *bus-line density* variable may create endogeneity problems. That is, more individuals may choose to reside in districts with abundant transport facilities, but the presence of a relatively important number of people may induce improvements in the public transport offer. To test for potential endogeneity, we instrument the *bus-line density* in each spatial unit by the density of the public transport facilities (bus, tram, and metro) in the neighboring spatial units. The Montiel-Pflueguer statistics, run to assess the validity of this instrument, confirm that our choice allows to control for this issue. The results of the IV (FE) models reveal that while the quality of the transport system is not statistically relevant for Spaniards (confirming, for instance, their preference to settle close to their place of work), it is significant for foreign migrants. Furthermore, the introduction of this variable makes the urban gradient for this community statistically insignificant; in our reading, this result emphasizes the importance of the quality of public transport for moving around the city and getting to points of interest.

In addition, the (IV) FE estimations highlight another difference between immigrants and the others. The former value the Port as a centripetal point (hence with a negative estimated elasticity) while for the others it is a centrifugal location point with a positive elasticity coefficient estimate. As discussed in Sections 1 and 2, this result can be associated with the type of foreign immigration flows into Barcelona, which found an important source of employment in the commercial activities surrounding the port (mostly relating to tourism like hotels, restaurants, etc.), above all for low-skilled individuals. The other two communities instead display a clear preference for settling far from the Port (the estimated elasticity is positive), as shown by the FE or IV (FE) estimations. It is plausible to think that for these two communities a district reputation effect plays a role in rendering this location less attractive. Quality of life or services provided in this district may be not be as appealing (or inferior to that offered in other parts of the city), and being native could help in obtaining such uncodified information and ultimately drive the decision to settle in a different district.[16] In addition, when considering the previous results, it is also possible that employment options for these communities, particularly for Spaniards, are found elsewhere; since the estimations suggest that the public transport system is not a relevant determinant in their location choice, they prefer to settle elsewhere, ideally close to their jobs.

Table 2 also presents the results for high-skilled and illiterate population density. As data are not always available for these two communities, our sample is necessarily smaller. Preliminary statistical tests show that there are no endogeneity problems associated with the log-bus-density variable, and that fixed-effect estimations are preferred. Due to collinearity with H-district effects, the variable referring to the distance to the Port is dropped. Both communities record a positive and statistically significant elasticity between their respective population density and bus-line density. In other words, the public urban transport system matters for both the high-skilled and illiterate populations. Instead, a different behavior appears when considering the urban gradient. While the community of illiterate citizens displays a negative elasticity with respect to Plaça Catalunya, the community of high-skilled citizens records a positive (and

[16] For instance, evidence suggests that illegal activities are usually more concentrated close to ports.

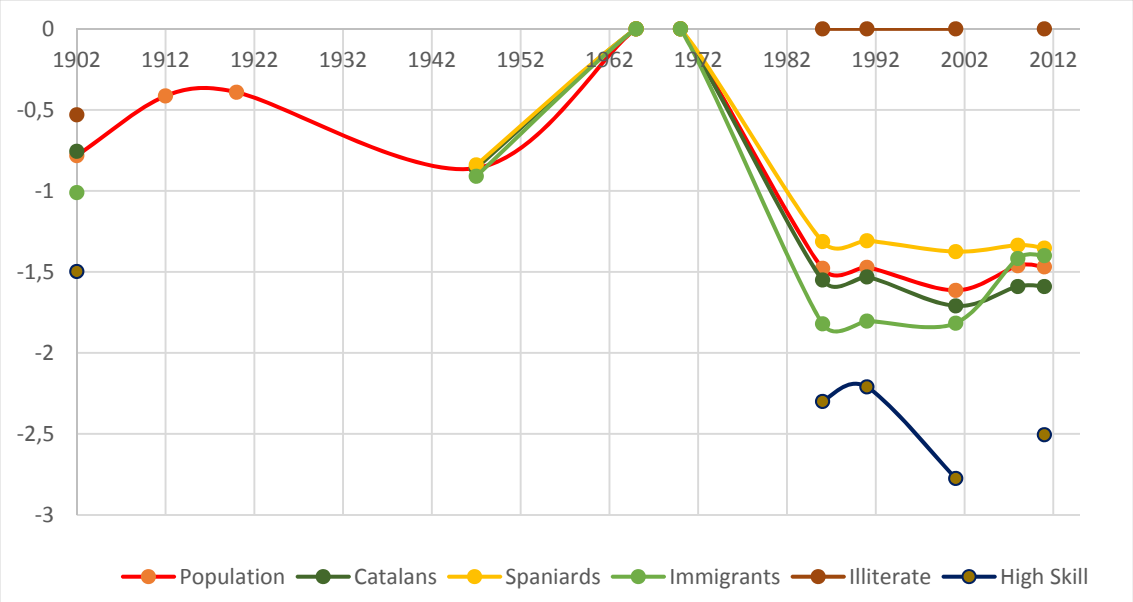
statistically significant) elasticity. Once more, high-skilled citizens are more likely to settle in high-rent areas on the periphery of the city, where they enjoy the possibility of living in individual dwellings. The urban gradient is the backbone of the urban spatial structure and represents the attractiveness of the CBD. A low urban gradient signifies a less appealing CBD. This finding may result from either the replacement of the selected CBD by another point of interest or an insufficient urban development plan, making the urban structure blurred and complicated to model. Indeed, in this case the latter can mask overlapping spatial layouts (e.g., the existence of ghetto areas) that cannot be properly identified.

The second step of our empirical analysis aims to identify the urban gradient for all selected communities across time. In order to perform this exercise, we exploit the pseudo panel created for the period 1902-2011 jointly with the ad-hoc identification of urban neighborhoods for each point in time. In this way, we are able to produce and then plot point estimates for the urban gradient (i.e., the elasticity between density and distance from the CBD). This allows to obtain comparable estimates and map their evolution so as to establish whether the urban gradient declines with increases in population size.

The estimations are run using a reduced form of Equation 2 in which we include as control variables the distance from the CBD and the Port only.

We gather estimates by decade and plot the elasticity of the distance to the CBD in Figure 4.[17] All estimates are run according to the OLS method with robust-error correction.

Figure 4: The urban gradient: mapping estimations for elasticity-distance to Plaça Catalunya



It is important to emphasize several common tendencies across the different communities. A first look reveals that from the beginning of the 20th century up until the 1960s the urban gradient was either not statistically significant or was less than one. During this span of time, Barcelona did not have a well-structured urban development

[17] Recall that data referring to the different communities are not available for every single decade. Estimate outputs are included in Appendix.

plan and the spatial structure of the city saw the existence of ghetto areas (linked to shantyism), making Plaça Catalunya less and less attractive in citizens' location decisions. Indeed, after the Spanish transition to democracy (roughly from 1980 onward), the urban development plan first targeted the physical elimination of any residual of shantyism, followed by a partial administrative decentralization at the district level ("new centrality"). These actions reinforced the attractiveness of the CBD by making it more relevant in individual location decisions. The shift allowed to avoid the creation of ghetto areas not only in the CBD (as often happens in US cities experiencing important population size increases) but also in the other urban districts. Indeed, the latter gained their own attractiveness thanks to the implementation of social or public services for local residents, helping to control (and possibly deter) such ghetto areas.[18] These initiatives continued to be effective, from 2000 onward, in inhibiting ghettoization of impressive foreign immigration inflows.

Before the democratic period, we do not observe large differences between the estimated elasticities of the various communities; they seem to share the same priorities. In contrast, in the most recent decade, the behavior of the different communities varies considerably. First, immigrants and the community of high-skilled citizens seem to have a preference for living close to the CBD (their urban gradient is highest). Returning to the argument discussed above, the evolution of the urban gradient for the remaining communities may be principally associated with a preference to reside close to their place of work, rather than the CBD. To this regard, the size of the urban gradient for the Spaniards is the lowest and is often not statistically significant, while for the illiterate community the CBD is almost never significant, meaning that it is irrelevant in their location choices. In line with this interpretation, Busquets (2004) shows that a part of the Spanish community moved to cities close to Barcelona in a search of more affordable rental or buying opportunities.

Therefore, changes in the urban gradient corresponding to increasing population size in recent years is mostly driven by the location decisions of immigrants and Catalans (the largest portion of the urban population). The cross-community of high-skilled individuals shows a similar pattern. The attractiveness of the CBD for the high-skilled community is likely associated with the available services (in particular financial), as well as leisure opportunities.[19] Relatedly, data at hand confirms that the portion of educated individuals in the overall population increased, but we have no tangible evidence for immigrants. Nevertheless, general evidence suggests that highly educated individuals make up a relatively important share of the last waves of (foreign) immigrants, above all among those from other EU countries and the US (Sanromà et al. 2015).

Finally, again in reference to changes in the skill composition of the communities, the Port of Barcelona merits further discussion. In our analysis, we used the latter as an additional point of interest for location choices. Estimation results confirm the relevance of the latter for the total urban population and its communities up until 1920. After this year, the Port remains statistically significant only for the high-skilled community in the period right before and after the Olympic Games (1992), but with a different implication. The elasticity is positive, meaning that this location is a truly centrifugal, rather than

[18] In addition, this reinforced attractiveness of the CBD, jointly with the corresponding (statistical) loss of attractiveness of the Port (refer to the Appendix) is in line with the theoretical predictions underlining this econometric strategy (as discussed in Duranton and Puga (2015) for the case of the urban gradient in the presence of potential secondary sub-centers).

[19] Assuming that high-skilled individuals are also likely to be able to devote a consistent part of their rent to this type of consumption.

centripetal, point for this community. This behavior is likely associated with the deep structural transformation that took place in seaside neighborhoods (like Barceloneta) close to the old Port of Barcelona as a part of the urban intervention plan to prepare the city to host the Games. The work-in-progress situation may have made these urban plots uncomfortable to live in, pushing people away. To test this argument, in Table 3 we run the same estimations as those for Figure 4 for the high-skilled community, but exclude the Barceloneta neighborhood (the area most affected by urban requalification for the Olympic Games). The idea seems to hold: in the new regressions the estimation of the elasticity from the Port is not statistically significant. It may also be that this situation affected the location decisions of natives more than immigrants. In Table 3, we replicate the same model by splitting the immigrant sample(s) between high and low-skilled immigrants, according to the criterion introduced in Sanromà et al. (2015).[20] Referring to the distance to the Port, the estimation for elasticity is not significant, as for the other communities.

Table 3: Pseudo panel for high skilled and select immigrant communities
Estimation method: Robust OLS

		ldist_CBD	**ldist_Port**	**Const**	**R-squared**	Obs
1986	High Skilled	-2.30 *** (0.94)	1.44 (1.11)	12.87*** (3.70)	0.33	39
1991	High Skilled	-2.24** (0.89)	1.61 (1.07)	9.64** (3.99)	0.25	39
2001	High Skilled	-2.62** (1.12)	1.26 (1.06)	13.85*** (2.66)	0.33	69
2001	Log(High_skill_imm)	-2.53 *** (0.81)	0.66 (0.68)	14.96*** (1.78)	0.50	71
	Log (Low_skill_imm)	-1.97* (1.09)	0.47 (0.94)	13.32*** (2.60)	0.24	73
2008	Log(High_skill_imm)	-2.34*** (0.85)	0.27 (0.73)	18.09*** (1.84)	0.54	73
	Log (Low_skill_imm)	-1.06 (0.76)	-0.008 (0.66)	11.35*** (2.41)	0.17	73
2011	Log(High_skill_imm)	-2.42*** (0.90)	0.33 (0.77)	18.17*** (1.80)	0.53	73
	Log (Low_skill_imm)	-1.03 (0.77)	0.05 (0.68)	10.56*** (2.50)	0.14	73
Average (2001-2011)	Log(High_skill_imm)	-2.43*** (0.52)	0.43 (0.46)	16.99*** (1.30)	0.45	217
	Log (Low_skill_imm)	-1.35** (0.53)	0.17 (0.47)	11.74*** (1.59)	0.16	219

Legend:
**** 1%, ** 5%, *10% degree of significance*
Log(High_skill_imm): Immigrants born in France, Germany, Italy, UK, USA
Log (Low_skill_imm): Immigrants born in Bolivia, Brazil, China, Colombia, Ecuador, Filipinas, India, Morocco, Mexico, Pakistan, Peru, Uruguay, Venezuela.

[20] Most immigrants from EU countries and North America are assumed to be high-skill individuals. Immigrants arriving from a sample of low income (or developing) countries in Latin America or Asia are assumed to be low-skilled.

Overall, this set of estimations allows us to conclude that the development of structured urban planning led to a reinforcement of the historical CBD as a crucial centripetal point for almost all communities in Barcelona. Nevertheless, the point estimates allow to observe the urban distribution of the different communities, as in a typical monocentric urban style model, from 1986 onward. High-skilled citizens are those with the greatest likelihood of locating near the CBD, while the Spanish-born community are the least likely, and the illiterate community seems to remain outside the competition.

5. Conclusion

In this study we track changes in the population distribution of Barcelona over the 20th century, when the city experienced important migration inflows and a potential rise in segregation. We assess the effectiveness of "new centrality" policies in deterring urban ghettos and the loss of attractiveness of the CBD when population size increases. In contrast with the general tendency in the literature, our estimates confirm the reinforcing centripetal effect of the CBD (Plaça Catalunya) for almost all of the analyzed communities. The effectiveness of these policies became evident from 1986 onward. A clear differentiation in terms of urban gradient appears across communities and makes the CBD more attractive for high-skilled citizens during the period of intense immigration inflows. From an urban theory perspective, this result can be associated with the outcomes of policies supporting the centrality of the CBD through increased land value, which translated into higher levels of rent to live in this area. As a result of new centrality policies, Barcelona avoided the consolidation of a low-income segregation area in the city center (unlike that which has happened in some US cities). This occurred not only by enhancing CBD features and emphasizing accessibility, but also by limiting the creation of segregation spaces in the rest of the urban territory and heightening the attractiveness of the remaining districts through a combination of political and socio-economic initiatives. The other selected point of attraction (the Port of Barcelona), was also a determinant in shaping location decisions before the Civil War. Afterwards, however, it loses any (statistically significant) relevance in citizen location choices.

From a policy perspective, the implementation of an integrated urban development plan, focused on administrative decentralization and accessibility, helped to manage the challenges of a sudden urban population increase.

The CBD was able to adapt and reinvent its attractiveness by transforming and supplying valuable services for an increasingly important share of the population (e.g., high-skilled individuals). Furthermore, this effect has held even in the presence of a constantly improving public transport service, which might be expected to temper the CDB's attractiveness.

Further research could replicate this analysis with more detailed data. This would allow to better qualify the high/low skill features of the different communities in Barcelona. It would also favor more precise and conclusive quantitative estimations, as well as improve predictions that could aid policy decisions relative to urban planning.

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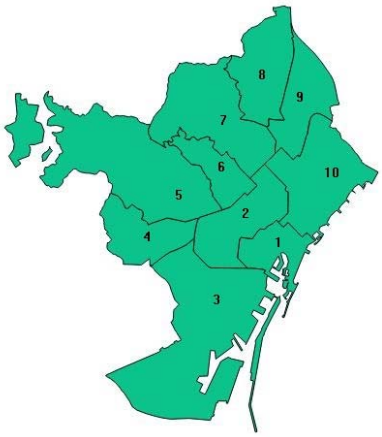
Urban spatial structure in Barcelona over time (1902-2011): Immigration, segregation and new centrality governance.

Appendix

Figure A.1 : Map of Barcelona by district (as of 2011)



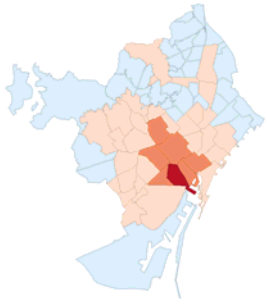
Legend:

1: Ciudad Vella
2: Eixample
3: Sants-Montjuic
4: Les Corts
5: Sarrià- San Gervasi
6: Gràcia
7: Horta-Guinardó
8: Nou Barris
9: San Andreu
10: San Martí

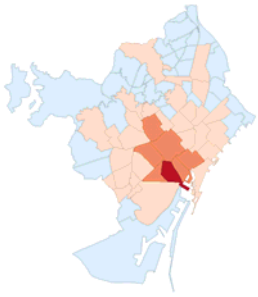
Figure A.2: Stock of dwellings

Legend. Highly concentrated areas: red-shadow areas; Low-concentrated (or empty) areas: light blue areas (Source: our database)

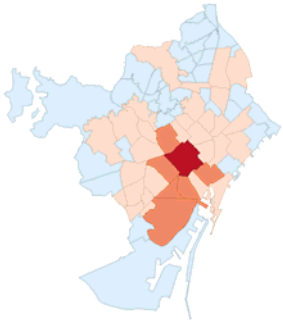
1900



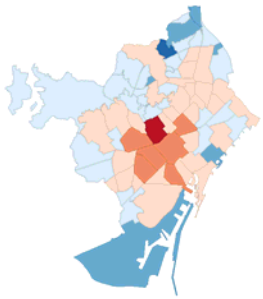
1920



1940



1970



2011

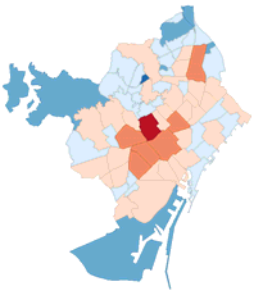


Table 2a: Pseudo panel by decades: 1902 -1970 (*Legend: *** 1%, ** 5%, *10% degree of significance*)

	(Average 1902 -2011)			
	ldist_CBD	ldist_Port	Const	R-squared
	-0,64***	-0,39***	18,34***	
Population	(0,14)	(0,11)	(1,04)	0,47
	-0,42***	-0,29***	15,03***	
Catalans	(0,09)	(0,11)	(1,05)	0,23
	-0,22*	-0,43***	13,50***	
Spaniards	(0,12)	(0,11)	(1,23)	0,38
	-0,68***	-0,37***	17,05***	
Immigrants	(0,15)	(0,12)	(1,11)	0,78
	0,05	-0,5**	10,98***	
Illiterate	(0,28)	(0,19)	(2,30)	0,84
	-1,27***	0,32*	16,1***	
High-skill	(0,26)	(0,18)	(1,81)	0,75

	1902			
Obs: 35	ldist_CBD	ldist_Port	Const	R-squared
	-0.78***	-0.72***	21,04***	
Population	(0,20)	(0,25)	(1,05)	0,67
	-0.76***	-0,91***	21,24***	
Catalans	(0,22)	(0,27)	(1,32)	0,67
Spaniards				
	-1.01***	-0.76**	18,9***	
Immigrants	(0,30)	(0,36)	(1,64)	0,62
	-0.53***	-0.75***	18,67***	
Illiterate	(0,15)	(0,19)	(0,84)	0,69
	-1.50***	-0.27	18,19***	
High-skill	(0,35)	(0,46)	(2,11)	0,49

	1912			
Obs: 35	ldist_CBD	ldist_Port	Const	R-squared
	-0,41**	-0,99***	20,47 ***	
Population	(0,15)	(0,23)	(1,36)	0,64
Catalans				
Spaniards				
Immigrants				
Illiterate				
High-skill				

	1920			
Obs: 35	ldist_CBD	ldist_Port	Const	R-squared
	-0,39**	-0,97 ***	20,30***	
Population	(0,15)	(0,22)	(1,33)	0,64
Catalans				
Spaniards				
Immigrants				
Illiterate				
High-skill				

	1947			
Obs: 36	ldist_CBD	ldist_Port	Const	R-squared
	-0,86***	0,03	16,11 ***	
Population	(0,29)	(0,45)	(2,23)	0,37
	-0,86***	-0,11	16,55 ***	
Catalans	(0,29)	(0,45)	(2,3)	0,42
	-0,84***	-0,07	15,64***	
Spaniards	(0,30)	(0,46)	(2,29)	0,40
	-0,91***	0,23	10,91 ***	
Immigrants	(0,31)	(0,43)	(2,09)	0,32
Illiterate				
High-skill				

	1965			
Obs: 43	ldist_CBD	ldist_Port	Const	R-squared
	-0,29	-0,16	13,51***	
Population	(0,20)	(0,36)	(1,98)	0,23
	-0,42	-0,36	15,16***	
Catalans	(0,25)	(0,46)	(2,4)	0,39
	-0,27	-0,19	12,70***	
Spaniards	(0,18)	(0,36)	(2,02)	0,22
	-0,29	0,08	7,22***	
Immigrants	(0,27)	(0,36)	(1,87)	0,11
Illiterate				
High-skill				

	1970			
Obs: 43	ldist_CBD	ldist_Port	Const	R-squared
	-0,26	-0,06	12,50 ***	
Population	(0,19)	(0,34)	(1,85)	0,15
	-0,42	-0,36	15,06 ***	
Catalans	(0,25)	(0,46)	(2,4)	0,39
	-0,24	-0,11	11,69***	
Spaniards	(0,17)	(0,35)	(1,98)	0,13
	-0,30	0,03	7,74 ***	
Immigrants	(0,21)	(0,32)	(1,69)	0,18
Illiterate				
High-skill				

Table 2b: Pseudo panel by decades: 1986 -2011 (*Legend: *** 1%, ** 5%, *10% degree of significance*)

	(Average 1902 -2011)			
	ldist_CBD	ldist_Port	Const	R-squared
	-0,64***	-0,39***	18,34***	
Population	(0,14)	(0,11)	(1,04)	0,47
	-0,42***	-0,29***	15,03***	
Catalans	(0,09)	(0,11)	(1,05)	0,23
	-0,22*	-0,43***	13,50***	
Spaniards	(0,12)	(0,11)	(1,23)	0,38
	-0,68***	-0,37***	17,05***	
Immigrants	(0,15)	(0,12)	(1,11)	0,78
	0,05	-0,5**	10,98***	
Illiterate	(0,28)	(0,19)	(2,30)	0,84
	-1,27***	0,32*	16,1***	
High-skill	(0,26)	(0,18)	(1,81)	0,75

Obs: 38	1986			
	ldist_CBD	ldist_Port	Const	R-squared
	-1,48**	0,82	14,79 ***	
Population	(0,70)	(0,74)	(2,85)	0,22
	-1,55**	0,84	14,77***	
Catalans	(0,70)	(0,73)	(2,85)	0,24
	-1,31*	0,74	13,04 ***	
Spaniards	(0,72)	(0,75)	(2,94)	0,17
	-1,82**	0,96	12,58***	
Immigrants	(0,76)	(0,82)	(2,62)	0,32
	-0,30	-0,27	10,08 ***	
Illiterate	(0,55)	(0,572)	(2,44)	0,11
	-2,30***	1,44*	12,77	
High-skill	(0,74)	(0,78)	(3,03)	0,33

Obs: 38	1991			
	ldist_CBD	ldist_Port	Const	R-squared
	-1,47**	0,86	14,40***	
Population	(0,71)	(0,75)	(2,8)	0,22
	-1,53**	0,88	14,30***	
Catalans	(0,70)	(0,74)	(2,8)	0,24
	-1,31*	0,77	12,60 ***	
Spaniards	(0,73)	(0,76)	(2,94)	0,16
	-1,80**	0,92	13,07***	
Immigrants	(0,75)	(0,81)	(2,56)	0,34
	-0,79	0,16	8,80 **	
Illiterate	(1,04)	(1,17)	(3,82)	0,07
	-2,21***	1,57**	9,67 ***	
High-skill	(0,71)	(0,74)	(3,34)	0,26

Obs: 73	2001			
	ldist_CBD	ldist_Port	Const	R-squared
	-1,61**	0,88	10,80***	
Population	(0,79)	(0,68)	(2,01)	0,17
	-1,71**	0,96	10,40***	
Catalans	(0,77)	(0,66)	(2,05)	0.19
	-1,37*	0,90	7,39***	
Spaniards	(0,81)	(0,70)	(2,11)	0,10
	-1,82*	0,43	13,63 ***	
Immigrants	(0,92)	(0,79)	(1,99)	0,31
	-0,47	0,17	2,99	
Illiterate	(0,67)	(0,59)	(2,15)	0,02
	-2,78***	1,46*	13,10 ***	
High-skill	(0,98)	(0,84)	(2,47)	0,33

Obs: 73	2008			
	ldist_CBD	ldist_Port	Const	R-squared
	-1,46**	0,69	11,25***	
Population	(0,72)	(0,61)	(1,87)	0,19
	-1,59**	0,90	10,03***	
Catalans	(0,69)	(0,59)	(1,92)	0,2
	-1,34*	0,49	11,00 ***	
Spaniards	(0,76)	(0,65)	(1,98)	0,17
	-1,42*	0,23	13,14***	
Immigrants	(0,78)	(0,67)	(2,06)	0,25
Illiterate				
High-skill				

Obs: 73	2011			
	ldist_CBD	ldist_Port	Const	R-squared
	-1,47**	0,73	10,99***	
Population	(0,72)	(0,61)	(1,89)	0,19
	-1,59**	0,92	9.82***	
Catalans	(0,70)	(0,60)	(1,89)	0,19
	-1,35*	0,87	7,27***	
Spaniards	(0,76)	(0,65)	(1,96)	0,11
	-1,40*	0,28	12,63***	
Immigrants	(0,76)	(0,66)	(2,05)	0,24
	-0,79	0,46	5,28***	
Illiterate	(0,64)	(0,55)	(1,93)	0,34
	-2,51***	1,02	15,16***	
High-skill	(0,93)	(0,80)	(2,15)	0,38