THERE IS ROOM FOR GROWTH: LAND USE AND URBAN STRUCTURE

Chapter 2

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Introduction

Latin American cities have significantly higher population densities than the cities of Europe and North America.[2] The average density in the region is 90 inhabitants per hectare, which is 80% higher than that of Europe (51 inhabitants per hectare) and more than four times that of North America (21 inhabitants per hectare). This relatively high population concentration is mostly due to the higher density of the larger cities (cities with more than 3 million inhabitants), which reach 120 inhabitants per hectare on average. In contrast, cities of Europe and North America with the same population range, show density levels about half and one-fifth, respectively, of that observed in Latin American megacities. For example, while in 2014 the metropolitan areas of New York and Mexico City had almost the same population (18 million inhabitants), the density of Mexico City (110 inhabitants per hectare) exceeded that of New York (25 inhabitants per hectare) by a factor of more than 4.

How does the region benefit from (or find itself affected by) high population concentrations? It is difficult to make normative arguments in favor of high or low densities, or more or less compact cities. As discussed in Chapter 1, more populated and denser cities foster agglomeration economies and productivity, but they also increase travel congestion, housing prices, and environmental pollution. The balance between these forces determines the productivity of a city's businesses and the wellbeing of its inhabitants. The net gains of the agglomeration forces are greater if intensive land use is combined with an adequate infrastructure for mobility, housing, water and sanitation. However, as will be seen throughout this chapter, this does not appear to be the case of most cities in the region. On the contrary, relatively high densities are due in part to the fragile mobility infrastructure, among other services, which has not allowed an orderly growth of the urban extension making more difficult the absorption of migrants who are attracted by the greater opportunities of the city. This has forced a high concentration of the population into central areas, where employment is generally located.

The high demand for housing in these central areas and restrictive land use regulations have led to an increase in housing prices, pushing many low and

1. This chapter was written by Cynthia Goytia and Pablo Sanguinetti, with research assistance from Jonathan Cohen and Matías Italia.

2. In this report, the term North America encompasses the United States and Canada, while Mexico is included in Latin America.

The "triple informality" (in housing, transport and work) that characterizes the cities of Latin America significantly reduces their productivity.

middle-income families out of the formal market. This phenomenon has boosted the informal housing market, with the emergence of new slums, and the growth and densification of existing ones. In these settlements, or neighborhoods, located on public (often occupied illegally) or on squatered private land, in both central and peripheral areas of the cities, livebetween 20% and 30% of the population of large metropolitan areas in Latin America. Furthermore, many of these settlements, especially those located in central areas, have very high densities, which explains to a large extent the high population concentration in the region's major cities.

Likewise, the lack of access to public transport, especially in suburban areas, has led to the emergence of a wide range of informal travel services that lack regulation, are low-quality, and prone to high accident rates.[3] Deficiencies in access to transport and housing, in turn, hinder access to employment, which strengthens the labor informality phenomenon so prevalent in the region's labor markets. Thus, cities in Latin America (and generally in developing countries) are characterized by a "triple informality" (in housing, transport and work) that significantly reduces the cities' productivity and, thereby, affects the economic performance and wellbeing of countries.

The unplanned growth of Latin American cities has resulted not only in high densities but also in an inadequate land use pattern, understood as the allocation of urban space to different activities. This chapter seeks to document this pattern by describing the structure of the cities of the region in terms of location of economic activity and employment, as well as households. Studying this pattern, understanding the forces that generate it and observing its evolution over time is a fundamental input for the design of urban land use policies.

As established throughout this chapter, cities can take on different shapes, which require different policy approaches. For example, the dynamics of firm and household location can follow a "monocentric" model, characterized by a strong concentration of employment and housing in the central areas. In this model, as the distance to the center increases, employment and housing density decreases sharply, which is reflected in lower land prices. Alternatively, the structure of land use could be better explained by a model where economic activity is located in several subcenters, distributed throughout the urban geography. This more decentralized pattern of economic activity implies a more dispersed pattern for the population's location. In this type of "polycentric" cities, with much larger suburban areas, population density is lower and decreases much more slowly as distance to the center increases. Available evidence for the metropolitan areas of Latin America shows that, in general, the urban structure is consistent with a monocentric model.

3. Chapter 3 describes the evidence on these informal transportation services in detail.

There are economic forces and aspects of the mobility infrastructure and technology that determine the urban form. Agglomeration economies tend to offer strong incentives for firms to concentrate on certain locations. As the availability of jobs decreases with distance to such locations, housing prices, and construction density declines. The high population density in downtown areas favors the development of mass public transport (metro, buses and train services) with a radial orientation towards the center, further consolidating the concentration of business activity in these locations. Alternatively, technological advances such as those permitting the mass-production of automobiles and its complementing road infrastructure (for example, highway construction), along with virtual connectivity and truck transportation, could favor greater decentralization of employment and population in the cities.

The relatively high densities of Latin American cities suggest that, in the future, many cities may face a greater demand for growth in urban extension.

Furthermore, the extent to which land use regulations favor agglomeration economies and reduce the costs or the negative congestion externalities is a critical aspect influencing city productivity. For example, the promotion of industrial activities can contribute to the creation of high income jobs but, at the same time, increase pollution. However, regulations may pursue different objectives than resolving externalities (or "market failures"). In that sense, the interplay of interests may lead to inadequate policies or "governance failures", as in the case of regulations that set minimum limits for plots that are too large for residential single-family use. These regulations can generate fractures or discontinuities in the urban structure and, at the same time, directly affect the families' possibilities to access housing in the formal sector, a subject that is explained in detail in Chapter 4.

The relatively high densities of Latin American cities suggest that, in the future, many cities in the region may face a greater demand for growth in urban extension, a process that will be reinforced further by the increase in household income, massification of automobile use, technological change, the construction of roadways and improvements in public transport.

What can be learned from the growth of cities in the region in recent years? What have been the consequences of this growth in terms of density and population distribution throughout the urban territory? To what extent has this growth led to a greater decentralization of residential and employment uses? What is the relationship between these urban growth patterns and the indicators of urban segregation and inequality? This chapter will seek to answer these questions by focusing on aspects of public policy related to land use regulations and planning. As will be seen in these pages, land use policies cannot be dissociated from those that focus on improving mobility and access to housing. However, the analysis of the specific issues associated with the diagnosis and the policies in mobility and housing is developed in Chapters 3 and 4, respectively.

A comparative perspective of land use dynamics in Latin American cities

To analyze land use patterns, we must be able to access disaggregated and georeferenced information from within the urban conglomerates. The scarce availability of this type of data for variables such as population and employment densities, built-up area, land prices, etc. in Latin America has made it difficult to carry out empirical studies that lead to a deeper understanding of the determinants and effects of different urban growth patterns in the region.[4] However, geographic information systems (GIS), new spatial analysis technologies and high-definition satellite imagery provide alternative sources of innovative data that are now used to produce indicators of urban structure and extension in a wide sample of cities. Satellite imagery, for example, allows the consistent measurement of a set of spatial attributes that can be compared between cities and over time.

Chapter 1 presents an example of this methodology by using satellite imagery of nighttime luminosity to measure the extension of metropolitan areas in all cities in the world (see Text box 1.3, p. 37). This section uses an alternative database, the Urban Expansion Atlas (AEU for its acronym in Spanish), developed by UN-HABITAT (the United Nations agency for human settlements), the Lincoln Institute for Land Policies, and the University of New York (AEU, 2016).[5] This database uses daytime satellite images as the basic input to identify contiguous built-up areas, with the goal of measuring the extension of urban areas, the density of their construction, the incidence of suburban areas and the extension of unbuilt intra-urban spaces. As mentioned in Chapter 1, the problem with this database is that it only contains a small sample of cities of the world (around 200), of which only 26 belong to Latin America. However, one of its advantages is that it allows estimations of the density in terms of built-up area and understanding in detail the cities' growth patterns through the differentiation of central and suburban areas.

The analysis presented in this section classifies the cities included in the AEU into three categories, corresponding to the three terciles of the distribution of the cities by population: i) small cities, of up to 500,000 inhabitants; ii) intermediate cities, from 500,000 to about 3 million inhabitants; and iii) large metropolises and megacities, with more than 3 million inhabitants. For comparative purposes, information is presented for both Latin America and North America (excluding Mexico) and Europe.[6]

4. In contrast, in the countries belonging to the Organisation for Economic Co-operation and Development (OECD) these issues have been widely studied.

5. Angel et al. (2016a, 2016b) present the data from the Atlas of Urban Expansion (AEU).

6. The Appendix to this chapter lists the 26 cities in Latin America, the 16 cities in North America, and the 16 cities in Europe that make up the sample.

Population density

The average population density of Latin American cities in 2015 is significantly higher than that of cities in North America and Europe.

There are two complementary definitions of population density. The first measures the population concentration in the total urban area (including open spaces) and the second is restricted to built-up areas. Total density, used to compare the entire region with other regions of the world (see Chapter 1), is always lower than density over the constructed area. Furthermore, by including urbanized open space, this measurement is affected by the city's level of fragmentation.[7]

As noted in this chapter's introduction, the average population density (over the constructed area) of Latin American cities is higher than that of cities in North America and Europe. Graph 2.1 (see p. 76) shows the average density levels for the three city categories, classified by size, in the three indicated regions. We see that the average density of cities in Latin America in 2015 (90 inhabitants per hectare) is significantly higher than the average of North America (21 inhabitants per hectare) and Europe (51 inhabitants per hectare). These differences remain for the three city sizes, although they are greater for larger metropolises (with more than 3 million inhabitants): 120 inhabitants per hectare in Latin America versus 25 inhabitants per hectare in North America and 60 inhabitants per hectare in Europe.[8]

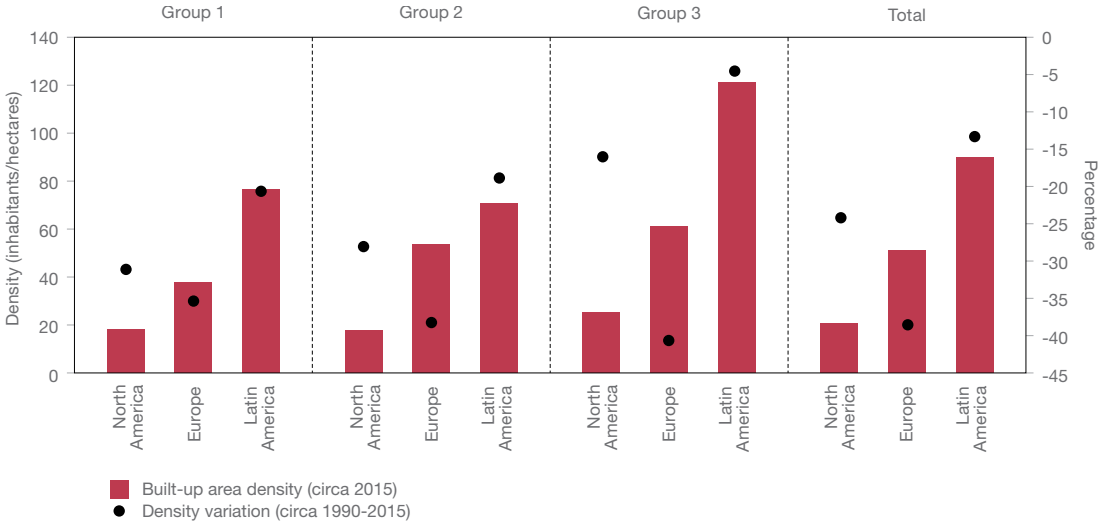
The density comparison between cities in Latin America and developed countries for a given year is illustrative and seems to confirm the hypothesis of a more intensive use of urban land in the region. However, we must also evaluate the variation of this indicator over time, since it could reveal dynamics capable of changing, in the long run, the general picture observed in the most recent period. In that sense, Graph 2.1 (see p. 76) shows information on density changes for the period circa 1990-2015. We may observe that in all three regions there is a tendency towards decreasing densities in the last decades. However, there is significant heterogeneity in the magnitude of the changes: while for the whole set of Latin American cities density fell by 13% on average, in North America the drop was almost twice that figure and in Europe it was about three times. In the case of the larger cities, in those 25 years, density in Latin America fell only by 4%, while in Europe the drop in density is very similar for all size categories. Within Latin America, the case of Bogota stands out, where the density

7. The concept of "fragmentation" refers to the degree of discontinuity in the urban structure due to the existence of open spaces (e.g., parks, empty floor-space, etc.). The available fragmentation indicators, such as the saturation indicator (proportion of built-up space over extension) or the open space indicator (open space available within a 1 km radius around each constructed pixel), suggest that Latin America does not behave very differently to cities in Europe or North America, which indicates that the aggregate density patterns established in Chapter 1 would be robust using density over built-up area.

8. Within this category of large metropolis, in Latin America the cities of Bogota (245), Caracas (190), Sao Paulo (113), Mexico City (109), and Santiago de Chile (107) stand out for their greater density, expressed in inhabitants per hectare. In the case of the great metropolis of Europe, among those with greater density Madrid (93), London (63), Berlin (56) and Paris (55) stand out; while in North America densities drop significantly for cities of comparable size such as Montreal (34) and Los Angeles (32), New York (24), Portland (21), Houston (19) and Chicago (17).

over built-up area increased by 35% (from 180 inhabitants per hectare to 245 inhabitants per hectare) during that period.

Graph 2.1 Average population density over built-up area and its variation over the period circa 1990-2015, for selected cities in North America, Europe and Latin America [a/ b/]



a/ The graph shows, on the left axis, built-up area density for the total of cities and the average for the three city categories in North America, Europe and Latin America. The right axis exhibits the percentage variation of density over the period circa 1990-2015..
b/ Group 1 includes cities with up to 500,000 inhabitants; group 2, between 500,000 and 3,000,000 inhabitants approximately, and group 3, with more than 3,000,000 inhabitants. See the Appendix for the complete list of cities.

Source: Authors' elaboration using data from the AUE, Angel et al. (2016a).

In conclusion, population density in Latin America is not only much higher than in the developed world, but it is also decreasing at much lower rates, meaning that if the trend continues, density gaps will increase.

Urban sprawl and city growth: Central and suburban areas

Urban sprawl or the physical extension of Latin American cities is smaller than that of its peers in North America and Europe (see Chapter 1). Table 2.1 complements the evidence provided in Chapter 1 based on the AEU, which shows the total urban extension of the cities, the percentage of the land occupied by built-up areas, by open space, and the proportion of constructed space in central or suburban areas for all three regions.[9] According to this

9. The AEU defines suburban areas as those areas of the city with less constructive density. In particular, those areas where only between 25% and 50% of the pixels show buildings (see note b/ in Table 2.1).

source of information, there is a significant difference in the extension of the built-up area, reaching 34,543 hectares on average in Latin America[10], a figure equivalent to almost 63% of the average area in European cities (55,000 ha) and about one-fifth of the urban built-up area in North America (169,000 ha). This difference holds for larger metropolises, although there are considerable variations within the group. For example, Santiago de Chile has a built-up area equal to a third of Milan, Italy (60,000 hectares versus 180,000 hectares), while the population of both cities is similar (6.5 million inhabitants). Another interesting comparison involves Caracas and Montreal, both with a little more than 3 million inhabitants and an urban extension difference of approximately 6 to 1 (in favor of Montreal).

The extension of the built-up area in Latin America represents approximately one-fifth of the urban built-up area in North America.

The smaller size of the built-up area in Latin American cities is not because they have larger unbuilt urban open spaces (such as large parks, forests or just empty spaces). On the contrary, as shown in Table 2.1, these cities have a comparatively low proportion of undeveloped urban areas (28% in Latin America compared to 34% in Europe and 36% in North America).

Table 2.1 Total urban extension and average built-up area for selected cities in North America, Europe and Latin America, circa 2015 [a/ b/]

		Total urban extension (hectares)	Total urban extension		Built-up area		
			Built-up area (%)	Urbanized open space (%)	Urban (%)	Suburban (%)	Rural (%)
North American average	Group 1	37,121	59	41	69	29	2
	Group 2	182,716	59	41	71	27	2
	Group 3	544,308	72	28	85	14	1
	Total	263,715	64	36	75	23	2
European average	Group 1	7,751	68	32	78	20	2
	Group 2	48,094	63	37	75	23	2
	Group 3	199,846	67	33	81	18	1
	Total	82,909	66	34	78	21	1
Latin American average	Group 1	6,288	71	29	80	19	1
	Group 2	27,150	69	31	82	17	1
	Group 3	105,861	76	24	88	11	1
	Total	47,977	72	28	84	15	1

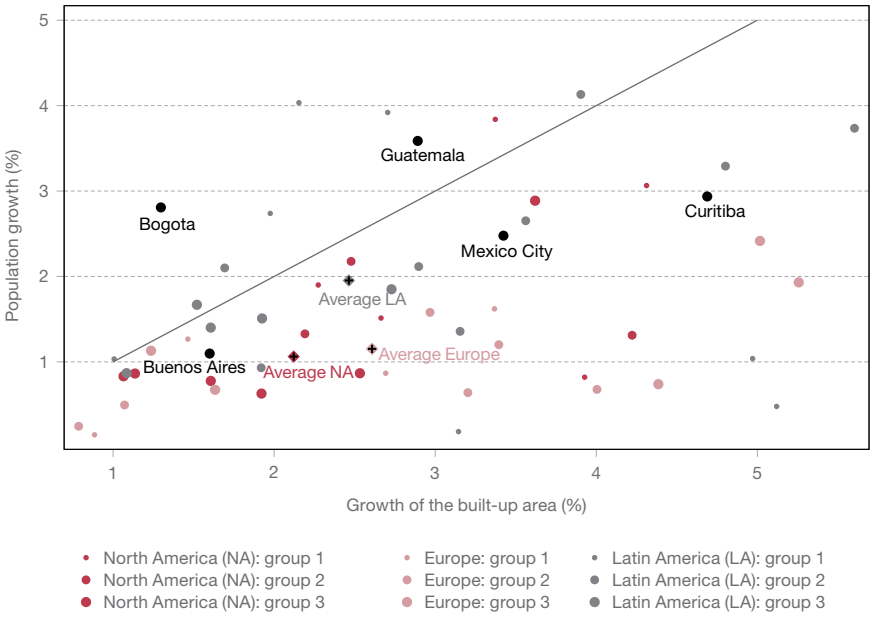
a/ Group 1 includes cities of up to 500,000 inhabitants; group 2, between 500,000 and 3,000,000 inhabitants approximately, and group 3, with more than 3,000,000 inhabitants. See the Appendix for the complete list of cities.
b/ The urban extension is made up of built-up area and urbanized open space. Likewise, based on satellite images, each constructed pixel is classified into three types depending on the "walking distance circle" (defined as a circle of 1 km² equivalent to a 10-minute walk) surrounding it: urban (if more than 50% of the circle's pixels are built), suburban (when between 25% and 50% of the pixels are built) and rural (with less than 25% of built-up pixels).

Source: Authors' elaboration using data from the AUE, Angel et al. (2016a).

10. This figure arises from the multiplication of the percentage of constructed area for the average of all the cities of Latin America (72%) by its total urban extension in hectares (48,000 hectares). The other figures follow the same logic based on the data in Table 2.1.

On the other hand, Graph 2.2 shows the evolution of the built-up area in the cities of the AEU sample during the period circa 1990-2015 and compares it with the evolution of the population in the same period. The 45° line indicates equal growth in both variables, which implies that density should remain the same. However, in all three regions, on average, cities grew more in terms of built-up surface than population (which accounts for the decreases in density reported in Graph 2.1, p. 76). However, while this is true individually for cities in Europe and North America, in Latin America this average hides a much greater heterogeneity among cities. For example, while Bogota and Curitiba (Brazil) had approximately the same population growth between 1990 and 2015 (close to 3% per year), the growth of the built-up area in Bogota was between 3 and 4 times lower than in Curitiba (1.4% versus 4.8% per year).

Graph 2.2 Relationship between population growth and built-up area growth during the period 1990-2015 for selected cities in North America, Europe and Latin America [a/ b/]



a/ The annual growth rates for the population and the built-up area are used. The 45 ° line indicates that the population growth coincides with that of the built-up area.
b/ El grupo 1 incluye ciudades de hasta 500.000 habitantes; el grupo 2, de entre 500.000 y 3.000.000
b/ Group 1 includes cities of up to 500,000 inhabitants; group 2, between approximately 500,000 and 3,000,000 inhabitants, and group 3, with more than 3,000,000 inhabitants. Due to scale issues, the extreme values of the cities Halle (Germany), Palmas (Brazil), Raleigh and Springfield MA (United States) are not shown. See the appendix for the complete list of cities.

Source: Authors' elaboration using data from the AUE, Angel et al. (2016a).

The smaller built-up surface of Latin American cities is due in part to the fact that built-up suburban areas are smaller compared to North America

and Europe, both in terms of absolute extension and in proportion to the total built-up surface of the cities. As reported in Table 2.1 (see p. 77), the built-up suburban area in Latin America occupies, on average, 15% of the constructed area, while in North America and Europe it is 23% and 21% respectively.

The smaller urban extension of the built-up area in Latin America is due to the fact that the suburban areas are not as large as in North America and Europe.

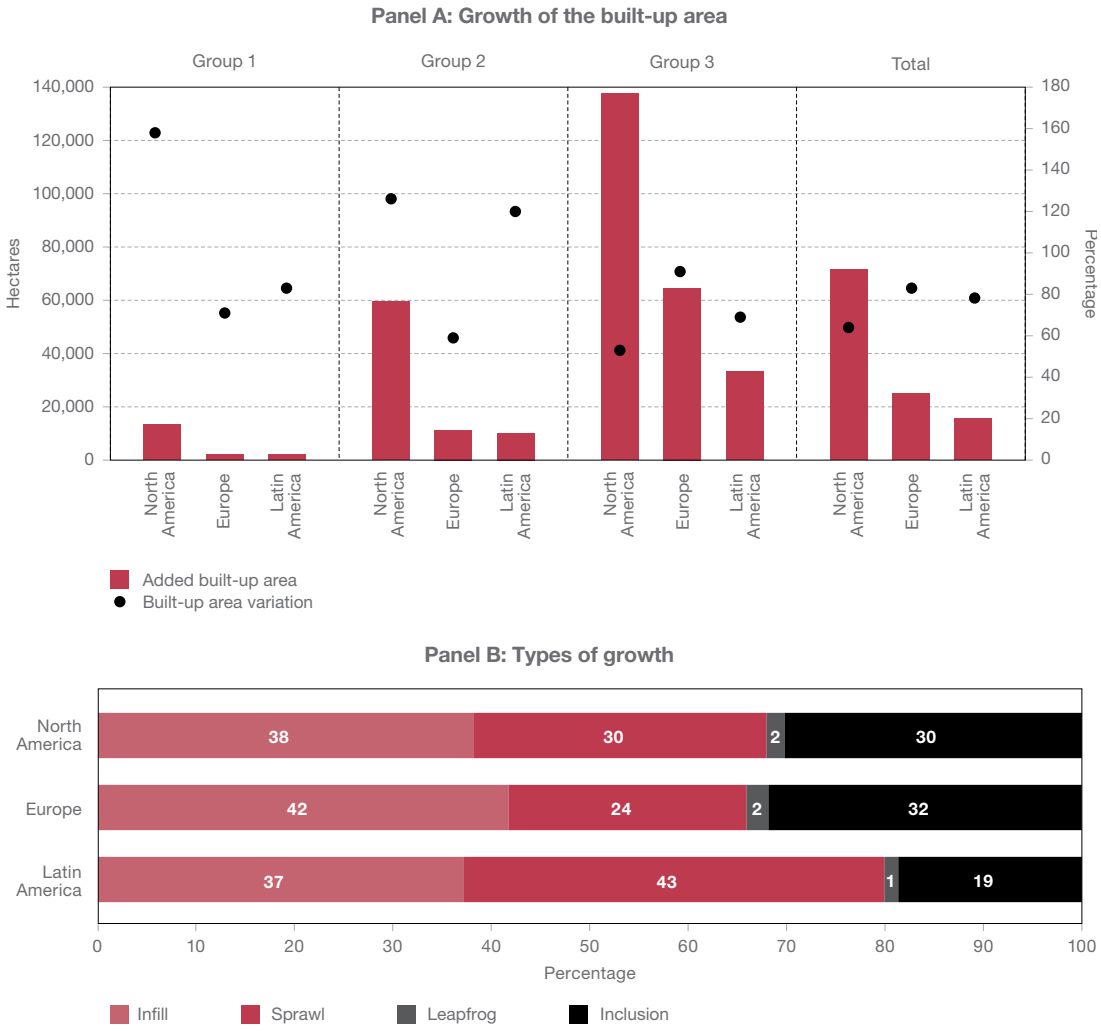
The high densities observed in several Latin American cities suggest that, in the future, they may face an increasing demand for built-up land. The AEU distinguishes four different sources of urban extension growth, depending on the location of the new areas that are incorporated to the city: i) infill growth, whereby newly built-up areas occupy previously vacant areas within the existing urban borders; ii) sprawl or growth in extension, which occurs when the urban boundaries continuously extend beyond existing constructions; iii) leapfrog growth, which occurs when newly built-up areas are separated from the preexisting urban area; and iv) growth by inclusion, which occurs when urban areas that were not previously contiguous merge through the urbanization of the intermediate zones that separated them. Together, these four categories make up the whole of a city's growth in its physical extension.

Panel A of Graph 2.3 (see p. 80) describes the growth pattern of the built-up area in the cities of the AEU sample. Although the percentage growth of the total built-up area between 1990 and 2015 in all three regions is not very different (Latin America, with 77% growth, is in between North America, with 64%, and Europe, with 83%), absolute growth is quite different: while cities in Latin America grew by an average of 15,000 hectares, in North America it was approximately 72,000 hectares, and in Europe, 25,000 hectares. As for the growth's breakdown, panel B of Graph 2.3 (see p. 80) suggests that cities in Latin America saw an increase in their built-up land through a sprawl of the urban space, while in the cities of the other two regions, growth was due mostly to the infill of the existing area and the inclusion of other previously non-contiguous metropolitan regions.[11] As always, averages hide an interesting variation. In Bogota, for example, the already documented strong growth in population density for the period 1990-2015 (from 180 inhabitants per hectare to 245 inhabitants per hectare) is mainly explained by an infill in of its urban area. In contrast, in Guadalajara (Mexico), growth through urban sprawl was favored over urban infill, thereby decreasing the density of the built-up area from 105 inhabitants per hectare to 85 inhabitants per hectare.[12]

11. This phenomenon described by the AEU, and which is especially pronounced in European cities, is also pinted out in the analysis conducted in Chapter 1 based on CAF's Database on the Extension of Mteropolitan Areas (BEAM).

12. In comparative terms, while cities such as Berlin, Madrid and Milan incorporated 48,000 hectares of constructed area between 1990 and 2015, in the same period cities of similar population in Latin America only incorporated 8,000 hectares.

Graph 2.3 Growth of the built-up area and types of growth over the period 1990-2015 for selected cities in North America, Europe and Latin America [a/ b/ c/]



a/ The graph in panel A shows the added area in hectares for all the cities and the average for the three city categories in North America, Europe and Latin America. The right axis shows the percentage variation of the built-up area.
b/ The graph in panel B shows the percentage of each type of growth for the average of the cities in North America, Europe and Latin America.
c/ Group 1 includes cities of up to 500,000 inhabitants; group 2, between 500,000 and 3,000,000 inhabitants approximately, and group 3, with more than 3,000,000 inhabitants. See the Appendix for the complete list of cities.

Source: Authors' elaboration using data from the AUE, Angel et al. (2016a).

Informal land use

In addition to the quantitative growth of cities, both in population and in the expansion of the built-up area, it is relevant to describe some of the characteristics that can help determine the quality of that growth. In particular, one of the characteristics to be considered is the extent to which cities have planned their

urban expansion, or if it responds instead to informal processes of territorial development. Generally, cities that expand their constructed area in an orderly way can allocate land for road networks (main and secondary),[13] define an appropriate mix of uses (with residential amenities and good allocation of public spaces), and preserve vulnerable environmental areas by protecting them from urbanization.

Measuring the incidence of slums in Latin American cities poses significant challenges in terms of methodology and data availability.

On the other hand, when urban growth occurs through the illegal occupation of public or private land (by families and companies), the State loses the capacity to allocate land to different urban needs (such as streets or parks), hindering the provision of basic services (such as water, sanitation and energy) in these neighborhoods. It is also difficult for families located in these areas to invest in their home, given the irregular land tenure and lack of services.[14] In this sense, the quality of urban habitats in slums is much lower than in the formal city. Nonetheless, as discussed in more detail in Chapter 4, these precarious housing solutions are the only housing alternatives for many low-income households that cannot access housing in the formal market.

The incidence of slums in Latin American cities is evident. However, the rigorous measurement of this phenomenon poses considerable challenges in terms of methodology and data availability. For its part, the AEU defines as "informal development areas" spaces that present irregularities in the urban structure (for example, very small lots, narrow streets, lack of sidewalks and public lighting). However, this methodology relies exclusively on satellite images, and does not contrast areas that are detected as informal with complementary information coming from censuses or surveys.[15]

Notwithstanding these limitations, the estimation of the incidence of "informal development areas" provided by the AEU constitutes a good starting point for analyzing such visible phenomena as is the impact and evolution of slums in Latin American cities. Graph 2.4 (see p. 82) shows both the incidence of slums before 1990, and the growth of these areas in the period circa 1990-2015.[16] It can be observed that since 1990 the incidence of this phenomenon has increased significantly in Latin American cities (from 16% to 36%), while it is practically non-existent in North America and very low in Europe (5% in the most recent period). This city growth, defined by a significant informality that affects the cities of all three considered size ranges, highlights the difficulties that all cities in the region have faced when planning their growth in an orderly manner.

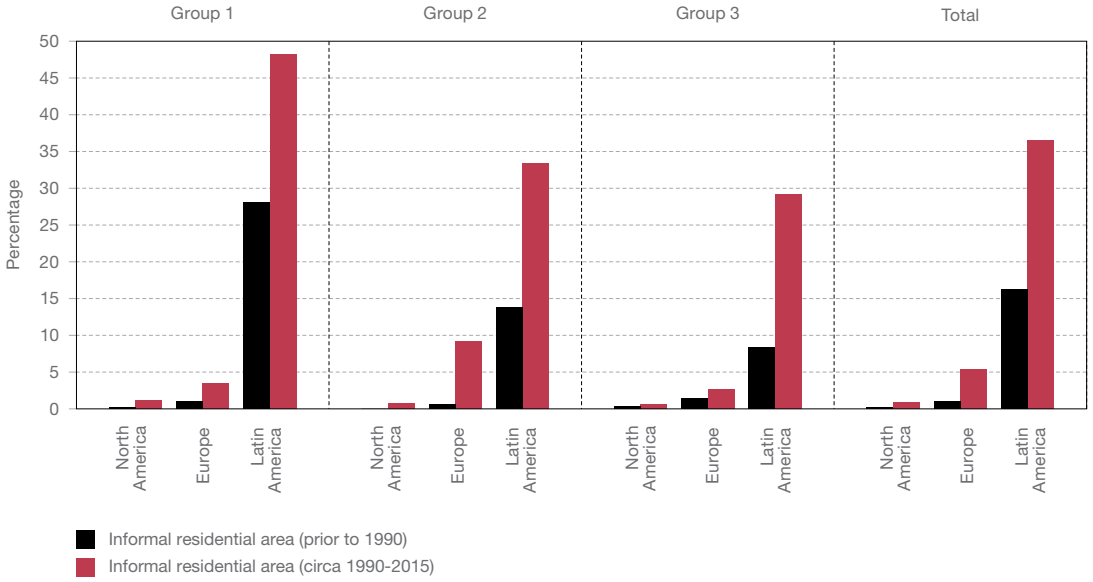
13. The information provided by the AEU on the allocation of space for roadways shows that in recent decades (1990-2014) the proportion of land destined for streets and avenues fell on average from 25% to 20% of the urban built-up area in the large metropolitan areas of the region.

14. See Chapter 4 for a more detailed discussion of this aspect.

15. This comparison is important because the existing definitions of slums, such as that of UN-Habitat, highlight housing characteristics that are not detectable from satellite images, such as connection to basic services and ownership of the land or property. This, however, does not imply that the precarious access to services and the informality of tenure are not correlated with certain urban patterns that are indeed detectable through satellite imagery. However, the predictive capacity of the physical characteristics that are captured by satellites must be documented in order to evaluate the accuracy of these estimates.

16. The estimations made for both periods are not entirely comparable since the one made until 1990 is an indicator of slum incidence within the total built-up area until that date, whereas the one made for the period circa 1990-2015 is valid for the newly built surface area in this period.

Graph 2.4 Average evolution of areas of informal development, in different periods, for selected cities in North America, Europe and Latin America [a/ b/]



a/ Based on satellite images, areas with irregularities in the urban structure (eg very small lots, narrow streets, absence of sidewalks and lack of public lighting) are defined as areas of informal development.
b/ Group 1 includes cities of up to 500,000 inhabitants; group 2, between approximately 500,000 and 3,000,000 inhabitants, and group 3, with more than 3,000,000 inhabitants. See the Appendix for the complete list of cities.

Source: Authors' elaboration using data from the AUE, Angel et al. (2016a).

The evidence described throughout this section suggests that Latin American cities are characterized by high population densities that, despite having decreased in recent years, are still significantly higher than those observed in developed countries (where, in addition, density has been falling at much higher rates). In comparative terms, the region's relatively high densities are due in part to the weak growth of the cities' physical span, explained in turn by a low development of suburban areas. This weak growth in span has created pressure in terms of housing demand that, not having been properly addressed, has led to the emergence of slums, both in central and peripheral urban areas. This informal land use phenomenon has intensified in recent years to such an extent that today it represents more than a third of the urban territory of the region.

This analysis, although aggregated, points towards the need to promote the development of suburban areas in Latin American cities, through the provision of mobility infrastructure and other services in peripheral areas. However, policy design requires a better understanding of the relationships between land use and urban development, for which a rigorous analysis of more disaggregated information from within the cities is essential, describing the evolution of population density, employment, land use and prices, among others. Before presenting this analysis, a brief conceptual framework must be introduced to

understand how market forces and public policies (such as those involving mobility infrastructure, other services and land use regulations) determine the internal structure of cities. This conceptual framework will make it possible to derive a series of hypotheses that can later be contrasted with disaggregated information from within the cities.

Conceptual framework: Determinants of land use and the internal structure of cities

Just as agglomeration economies and congestion costs are important determinants of rural-urban migration and the balance of system of cities (see Chapter 1), these same forces also affect population distribution, densities and the price and use of land within the cities.

The presence of agglomeration economies means that firms producing goods and services tend to settle close to one another, clustering on specific areas within the cities' geography, and thereby forming a central business district (CBD). Initially, the exact location where the firms cluster and the CBD is established may be determined by historical or institutional issues or geographical accidents. However, workers and their families must choose their place of residence and the size of their home by considering the fact that employment is located in the CBD. For example, although land prices are lower at a greater distance from the CBD, and therefore larger housing is available, it is also true that, at a greater distance, commuting costs to the CBD, where employment is located, will be greater (both in terms of money and time).

This simple monocentric model produces very intuitive predictions that can be studied using available information:[17] i) the prices of housing and land (per square meter, m^2) decrease with distance to the center or to the area with the greatest concentration of economic activity; ii) construction density also decreases with distance to the CBD, while housing consumption increases; iii) population density decreases with distance to the CBD.

The evolution of these variables throughout the city's geography can be represented by curves or gradients. The slopes of these curves are determined by the cost of moving between the place of residence and the workplace, and, therefore, by the mobility infrastructure.[18] In particular, if transport costs fall as a result of public investments (for example, in new highways) or due to technological

17. Seminal studies that develop the monocentric model of urban economics are Alonso (1964), Mills (1967), and Muth (1969). Brueckner (1987) develops a graphic and intuitive explanation of the model. See also Fujita (1989) for a classic reference. Duranton and Puga (2015) present a version of the model that incorporates several extensions.

18. Although the classical model of urban economy is based on transport costs and their reduction through efficient infrastructure, similar conclusions can be drawn for other network services such as water and sanitation.

Evidence for the United States shows how the emergence of the automobile and the massification of its use may explain the decentralization that these cities underwent.

development (e.g. mass-use of the automobile), the gradients flatten (the curve shifts downwards, and its slope is reduced). This means, for example, that land prices drop (more significantly in central areas) and that they fall on average at a lower rate as distance to the CBD increases. Mobility infrastructure and technological development, therefore, make cities grow in terms of their physical size due to growing suburban areas (i.e., suburbanization), and in terms of their population (congestion costs are reduced and, consequently, the net wage increases, bringing more migrants to the city).[19] In general, growth in urban extension is greater than that of the population, which is why densities decrease across the cities' entire geography.[20]

Another implication of the model is that increases in income triggered by causes different from agglomeration forces (such as technological advances that improve the aggregate productive structure or increased access to credit) generate a greater demand for housing space by households, who prefer larger spaces as their income rises. Because the price of housing is lower with greater distance to the CBD, the population moves away from the center, which results in a physical expansion of the city and a decrease in population density.[21] In other words, the long-term development process and policies that reduce credit barriers (especially with regard to mortgage credit) have implications for the structure of cities in terms of their size and density.

The empirical validity of the monocentric model has been studied in the United States, where it has been demonstrated that the emergence of the automobile and the massification of its use was one of the main forces behind the strong decentralization that these cities underwent since the second half of the 20th century (Glaeser and Kahn, 2004). Duranton and Turner (2012) find similar results for interstate highway construction, while Margo (1992) finds evidence consistent with the hypothesis that income growth in the United States between 1950 and 1980 was accompanied by increases in the urban footprint and reductions in density. Furthermore, Glaeser and Shapiro (2002) and Voith (1999) show that greater access to mortgage credit (for example, through a reduction in interest rates) increased the demand for suburban housing in this country.[22] In Latin America, however, rigorous studies of the model's implications are scarce. As we wil see below some descriptive evidence for the Metropolitan Area of Buenos Aires suggests that the development of interurban highways (especially those leading to the north and west of the city) promoted the suburbanization of the city.

19. See the conceptual framework in Chapter 1.

20. For the derivation details of these results see Duranton and Puga (2015).

21. If the increase in income occurs for all cities (and for the rural sector) because of an aggregate technological change, the population will not increase in any city and the expansion of urban boundaries will generate a drop in density.

22. In Latin America, however, the mortgage loan market is incipient (with the exception, perhaps, of Chile), which constitutes an obstacle for the demand for housing with greater space and therefore for the extension of the city. Chapter 4 discusses in detail the functioning of this market in the region.

Decentralization of employment

The monocentric model is not the only one that accounts for the observed land use patterns and urban structures. For example, the assumption that cities have a single business center, where all employment is concentrated, is a simplification that bears little resemblance with the actual structure of modern urban agglomerations. In fact, although most cities have a CBD with a strong concentration of firms, businesses and jobs, they also develop other subcenters that are located throughout their geography.[23] This suggests that a more realistic framework for studying job and housing locations across the city's geography should contemplate the fact that the location choices of firms and households are jointly determined. On the one hand, companies want to be close to other companies to take advantage of agglomeration economies and the associated productivity increases; however, high land prices in the CBD can more than offset gains in productivity, inducing them to locate in other areas. On the other hand, workers want to be close to jobs to reduce transportation costs, but high property prices in the CBD lead many workers to relocate to other areas. Therefore, the interaction between firms and families can lead to much more varied land use configurations than suggested by the monocentric model.[24] In particular, subcenters may arise with a lower density of firms and jobs in relative terms (Henderson and Mitra 1996, Glaeser and Kahn 2004).[25]

The number and size of subcenter depends largely on the mobility infrastructure and other services. In fact, for a subcenters to be economically attractive to firms, it must be connected to the rest of the city and to the CBD, and must have digital connectivity and communications services. To the extent that the fixed costs of providing this infrastructure are low, a greater number of subcenters may arise throughout the city (Glaeser and Kahn, 2004).

This more general model allows to explain some facts regarding the changes in the internal structure of cities in the last decades. In particular, the automobile massification that has driven residential decentralization in many developed countries, coupled with the development of freight transportation by truck, has reduced the fixed costs for establishing productive subcenters. This factor, in turn, has also favored the decentralization of employment (Glaeser and Kahn, 2004).

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23. For example, Sao Paulo (Brazil), which is one of the largest cities in Latin America, has 33 subcenters with a certain concentration of jobs and firms, in addition to the main CBD (Garcia-López and Moreno-Monroy, 2016).

24. Ogawa and Fujita (1980) and Imai (1982) develop the model with endogenous location decisions of firms and families. Lucas and Rossi-Hansberg (2002) generalize the results found in these previous papers. See also Fujita and Thisse (2013). In the version of the model developed by Duranton and Puga (2015), it is shown that under a certain configuration of parameters mixed use -residential and commercial- areas emerge close to the CBD, a bit further exclusive commercial subcenters come up, and finally, further away, lower density residential areas arise.

25. The firms' decisions to locate close to families or other firms will depend on the characteristics of these firms in terms of sectors of activity, production technology, input requirements, etc. Some firms will want to be closer to input suppliers or infrastructure critical to their operation (such as highways, in the case of distribution companies), while others will prefer to be closer to final consumers (such as retailers).

The presence of amenities throughout the city's geographical span seems to play a central role in the spatial patterns of economic segregation.

Income differences and socioeconomic segregation

Another element that the basic monocentric model does not consider is that families differ in terms of their income (as well as in relation to other sociodemographic variables, and their preferences). This difference in households's characteristics gives rise to a series of questions that the basic model cannot answer, such as, where would the richest families and the poorest families be located and under what circumstances can socioeconomic segregation occur within the city. Answering these questions requires an understanding of how the demand for housing and the transportation costs vary with changes in income. As already mentioned, as household incomes increase, their housing consumption also increases (both in terms of quantity and quality). This encourages higher income households to move to suburban areas, where the price per square meter is lower. However, gains in housing space and quality coexist with higher transportation costs, which are higher for high-income families given their greater opportunity cost of time. Thus, if the first effect more than compensates for the second, a perfect segregation should be observed: poor families living in more central areas and high-income families living in suburbs.

According to Glaeser et al. (2008), this is the pattern of socioeconomic segregation that can be observed in several cities in the United States, supporting the argument that for North American high-income families the benefits of living in larger houses more than offset the higher travel costs. However, this phenomenon is not evident for all cities within the United States (for example, in New York and San Francisco) or Europe. In the latter, in fact, the opposite phenomenon predominates: high-income families live in relatively central areas. Furthermore, this type of segregation has not been widely observed in Latin American cities either.

This contrasting evidence suggests that it is difficult to justify the spatial patterns of socioeconomic segregation in cities by appealing only to travel costs and to the demand for land as a function of income. Other determinants, such as the presence of amenities across the city's geography, also seem to play a central role.

Amenities and congestion costs

Basically, the monocentric model and the extensions discussed so far conceive cities as labor markets where the families' location choices are made by weighing accessibility to employment against cost of land and house size. However, a more realistic view should incorporate the fact that cities offer other things besides jobs. As described in Chapter 1, amenities (and negative externalities) are also key determinants in families' (and businesses') decisions to locate in a city. The incorporation of these elements can give rise to more varied urban structures (uses, land prices, densities), while opening a wider menu of options for public policies. If, for example, the high density of productive activities in

the CBD produce some level of environmental degradation, noise pollution and traffic congestion, this could give relatively wealthy families more reasons to settle in peripheral areas of the city. Meanwhile, lower-income workers remain in the center, where environmental pollution and poor quality of life reduce the price of housing, which adds to the savings in transportation costs.[26]

Land use regulations may respond to a need for resolving market failures.

On the other hand, intensive land use in central areas increases the costs of providing amenities such as parks and open spaces, shopping centers and cultural spaces. To the extent that higher-income sectors value these amenities relatively more, the disparity in their supply deepens the possible segregation process.

As mentioned earlier, in some cities in the United States, relocation and segregation by income, partly associated with the deterioration of traditional urban centers, was very important in the 1970s and 1980s (Cullen and Levitt, 1999 Baum-Snow and Lutz, 2011). On the other hand, the fact that the historic centers of European cities hold valuable cultural and touristic assets maintained the appeal for high-income families to be located in the center. Therefore, in European cities there is a mixed use (commercial and residential) of CBD land. In this sense, as will be seen later in the section "Regulation of land use and the growth of cities", initiatives to revitalize and recover historic centers in Latin American cities could play a relevant role in combating urban deterioration processes and socioeconomic segmentation.

Land use regulations

The monocentric model (and the additional elements that have been incorporated in this section) assumes that land is regulation-free and that, therefore, its use is exclusively allocated through a competitive process (like an auction) whereby families or firms that are willing to pay more obtain ownership of the land and are free to decide its use (commercial, residential, industrial, etc.), and with what intensity. Clearly, this does not happen in reality. The regulations that affect land use are broad, and can take on the form of minimum lot sizes, minimum buffer zones, maximum limits for the built surface area per unit of land, restrictions on the types of activity or uses in each of the city's areas (residential, industrial, commercial, mixed), among others.

These regulations may respond to a need for resolving market failures. For example, when certain uses (such as industrial use) generate negative externalities (such as pollution), or when the market allocates little land to uses that produce positive externalities (because social benefits are significantly higher than private profits), such as parks and public transportation. However, regulations may also respond to other motives, such as historical considerations

26. Aspects related to crime incidence and the low quality of public services in downtown areas can be addressed as congestion costs. These two elements derive from the erosion of tax revenues generated by the relocation of high-income families (Inman, 1995). Chapter 5 deepens the analysis of city governance and financing aspects.

or political or economic interests. This is evident in the case of regulations that generate new negative externalities or amplify existing ones. This is the case when setting too large minimum limits for single-family residential lots increase housing prices by reducing the supply of land. This dynamic can result in a greater city extension, or even in a growth pattern that produces discontinuities in the urban structure (Mills, 2002).[27]

These regulations are also responsible for the fact that a significant portion of low-income families are kept outside the formal real estate market (see Chapter 4). Rising prices incite families to move far away from employment centers to access formal housing, but this greatly increases their commuting budget. Living in slums in the periphery compensates for the higher transportation costs with lower housing costs. Alternatively, these families could locate themselves in relatively central slum areas, with much higher savings in transportation and housing.

In summary, the conceptual framework presented in this section identifies four main forces that determine the structure and expansion of cities: population growth, income dynamics, mobility infrastructure and technological improvements that reduce the costs of intra-urban travel, and land use regulations. By increasing the demand for housing and its cost, population growth stretches the edges of the city, transforming rural land into urban land. The increase in income promotes a greater consumption of space and favors suburbanization due to the negative price gradient from the CBD towards the periphery. Meanwhile, investment in mobility infrastructure (such as highways) and technological advances that reduce the cost of travel (such as the automobile) also encourage suburbanization. Land use regulations can accompany or limit the urban growth process according to the previously mentioned dynamics.

A fifth factor that determines the form of cities, and which has not been thoroughly analyzed until now, is geography. According to Burchfield et al. (2006), almost one-third of changes in physical size across US metropolitan areas is due to geographic factors. One of the most important is the presence of underground aquifers, which reduce the costs associated with the installation of aqueduct networks because they allow water to be obtained through alternative methods (such as well drilling). Terrain irregularities are also relevant: while relatively low hills lead to dispersal, high mountains act as barriers that favor more compact urban development patterns. This partially explains the fact that cities in the Andean Region of Latin America are relatively less extensive and denser. Consequently, urban development is not only affected by the general dynamics analyzed in this section, but also by a variety of factors associated with local geographical characteristics.

27. In the province of Buenos Aires, in Argentina, there is a regulation which was introduced in 1977 that requires a minimum lot of 300 m2 for single family housing. Clearly, if this regulation is compared with that of other Latin American countries (and even that of developed countries), it is very restrictive.

Urban form and land use in Latin American cities

The conceptual framework proposed in the previous section helps to understand the economic forces that underlie the urban structure and, in particular, to understand the determinants of more or less centralized employment and population structures. This section analyzes the shape of some Latin American cities, as well as the relative importance of the studied forces in determining this structure.

The monocentric model hypothesis and the case of the Metropolitan Area of Buenos Aires

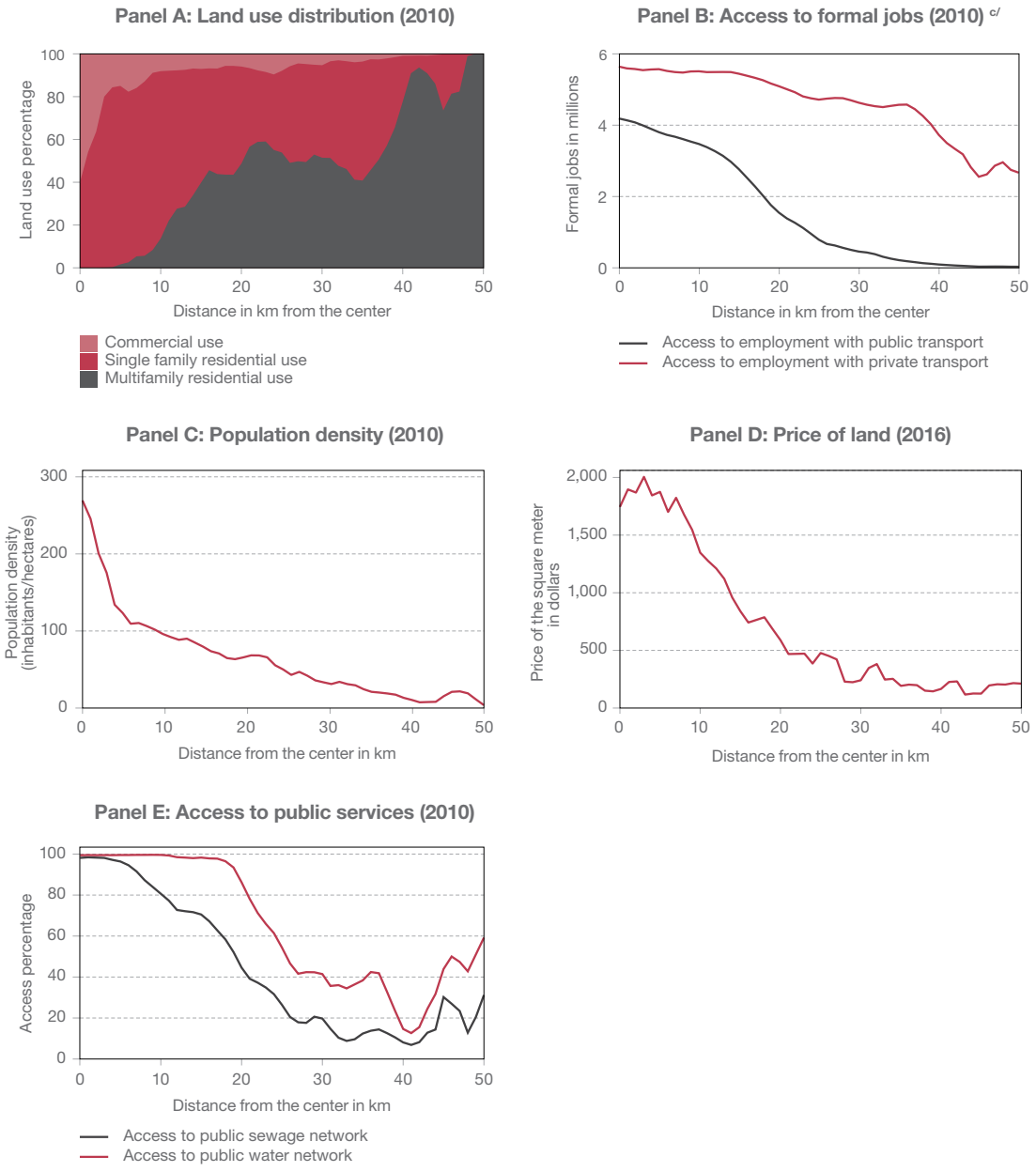
To what extent do the monocentric model's predictions developed in the previous section apply to the internal structure of Latin American cities? Unfortunately, the lack of disaggregated information on employment location, construction and population density, and land prices prevent a comprehensive diagnosis for the entire region. There is only information for a few cities, such as the Metropolitan Area of Buenos Aires. The Center for Research on Urban Policies and Housing (CIPUV, for its acronym in Spanish) of the Torcuato Di Tella University together with the World Bank have produced a database that allows the analysis of some key variables in the city's urban geography.

Graph 2.5 (see p. 90) shows the estimation of curves (gradients) for land use (panel A), access to formal employment (panel B),[28] population density (panel C), land price (panel D) and access to water and sewer services (panel E), from the CBD of Buenos Aires towards the periphery of its metropolitan area. In general, the behavior of all the variables is quite compatible with the monocentric model: near the CBD of Buenos Aires there is a greater proportion of land devoted to business and commercial activities (panel A), which is congruent with the higher density of (access to) jobs observed in that area (panel B). In addition, given the savings in commuting costs that are generated through proximity to labor sources and the competition of commercial land use, the cost of land for residential use reaches its maximum values in this central area (panel D), which is why housing is only available in a multifamily housing modality, producing high levels of population density (panel C). As distance to the CBD increases, commercial and business land use decreases, while residential multifamily and single-family residential land use increase. Also population density and land prices drop.

Beyond these general tendencies, the gradients' behavior does not always maintain a decreasing trend with the same rate. In other words, at certain distances from the CBD, significant changes can be seen in the slopes of the curves, suggesting the existence of subcenters with a certain degree of employment and population concentration. For example, an increase in land use for multifamily housing (panel A) can be detected at 20 km-25 km from the CBD, which partially explains the flattening of the population density curve at that distance from the center (panel C).

28. The access to formal employment variable measures, for a given distance, the number of jobs that households can potentially reach within a maximum transfer time of one hour using public or private transportation.

Graph 2.5 Estimation of gradients for the Metropolitan Area of Buenos Aires [a/ b/]



a/ Estimates arise from averaging the observations of each variable per kilometer. For example, in the case of the density gradient, the population of the census radiuses located at each distance (km) from the center (in all directions) is added up and then divided by the total area of the census radiuses. Then, in a second stage, the curve is tempered through the calculation of moving averages within a 3 km (-1 km to +1 km) window.
b/ In all cases the Congress of the Nation was taken as the center of the city.
c/ The graph shows, in the ordinate axis, the formal workplaces that can be reached within a commute of less than one hour..

Source: Authors' elaboration using data from the National Population, Household and Housing Census of the INDEC (2010), processed with Redatam + Sp, for land use gradients, population density and access to services; Quirós, T.P. and Mehndiratta, S.R. (2015), for the access to employment gradient; and CIPUV-UTDT (2016), for the land prices gradient.

On the other hand, an interesting fact which is highlighted by panel B regarding access to employment is that although the number of jobs that can be reached by traveling one hour or less, in both public and private transport, decreases as the distance to the CBD rises, this fall is much more significant in the case of jobs that can be reached through public transport. This underlines the aforementioned fact that, in general, in many Latin American cities, public transit services are available in central areas and their coverage is substantially reduced in suburban and more peripheral areas. As for the access to employment by private transport, the gradient is fairly flat up to a distance of almost 40 km from the center of the city. This suggests that, in Buenos Aires, automobile use, combined with the highway supply heading south, north and west, has improved access to jobs, which partially explains the great expansion of this city's metropolitan area in recent years.[29] However, not only does access to public transport services diminish significantly in the peripheral areas of the city, but the same occurs with other network services such as water and sewage, as documented in panel E of Graph 2.5.

In many Latin American cities, public transport coverage is substantially reduced in suburban and more peripheral areas.

Employment concentration in Brazilian cities

As has been pointed out, the existence of agglomeration economies implies a tendency towards high employment concentration. Therefore, a central aspect for the study of the internal structure of a city is defining the location of the CBD, which brings together most of the city's economic activity (industrial, services, commercial, etc.). The main difficulty in identifying the CBD in Latin American cities is the lack of good georeferenced information on the location of firms (and on the type of employment they require). In the few cases where such information exists, a second aspect must be resolved, which is to determine a methodology for identifying the location of the CBD and its limits. Some studies use qualitative information (such as historical milestones, official definitions or informed opinions) and then corroborate to what extent these locations have high job densities.[30] Others studies locate the CBD using a quantitative methodology by comparing employment densities at the census radius level (or in smaller spaces when the information allows it) and grouping the contiguous radiuses that stand out with high levels of concentration. The study by García-López and Moreno-Monroy (2016) uses the second methodology to identify the CBD and the main employment subcenters in 35 metropolitan areas in Brazil with more than 500,000 inhabitants. The authors combine the data from the Relación Anual de Informaciones Sociales (RAIS, which constitutes an administrative record of social security) and the location information of firms to

29. The increase in access to jobs at a distance of 50 km-55 km can be explained by the important development of the municipality of Pilar, in the northern suburb of the city of Buenos Aires. Thanks to a successful industrial park (and regulations that inhibits new companies to locate near the center of the city of Buenos Aires), many companies have been moving into this area. The creation of this business subcenter led to an increase in housing around that area, where gated residential neighborhoods abound, as well as commercial and office activities.

30. This methodology, however, is far from perfect. Glaeser and Khan (2004) study the location of employment in 300 metropolitan areas of the United States and find that in only 180 of them the census radius that includes the historical center of the city holds the highest job density.

estimate the employment level of each census radius in each city and, thereby, the concentration of economic activity in that space.[31]

Table 2.2 presents a summary of the estimations of García-López and Moreno-Monroy (2016), dividing cities into three terciles of their population distribution.[32] For each group of cities, different indicators for the distribution and density of formal employment for 2000 and 2010 are shown.

Table 2.2 Employment distribution and densities for selected Brazilian cities in 2000 and 2010 a/ b/

	Group 1	Group 2	Group 3	Total
Population (2010)	676,599	1,136,580	5,462,582	2,475,21
Total employment (2010)	165,879	270,035	1,494,239	657,027
Employment percentage variation (2000-10) %	50	67	38	42
Proportion of employment over population (2010) %	25	24	27	27
Number of subcenters (2000)	1	1	6	3
Number of subcenters (2010)	1	2	9	4
Employment density in the CBD (2010) c/	10,859	18,453	52,933	27,888
Employment density in subcenters (2010) c/	4,487	7,488	13,420	8,579
Average distance of workplaces from the CBD (2010), in km	8.5	22.7	15.0	15.6
Proportion of employment in the CBD (2000) %	24	17	10	17
Proportion of employment in subcenters (2000) %	19	21	40	27
Proportion of employment in the CBD (2010) %	23	22	11	19
Proportion of employment in subcenters (2010) %	21	22	34	26

a/ Employment data corresponds to formal employment.
b/ Group 1 includes cities of up to 500,000 and 850,000 inhabitants; group 2, between approximately 850,000 and 2,000,000 inhabitants, and group 3, with more than 2,000,000 inhabitants. See the Appendix for the complete list of cities.
c/ It refers to the number of jobs per square kilometer.

Source: Authors' elaboration using data from García-López and Moreno-Monroy (2016).Source: Authors' elaboration using data from García-López and Moreno-Monroy (2016).

Several interesting stylized facts emerge from the information provided in Table 2.2. First, the larger the size of the cities, the greater the proportion of formal employment. This is compatible with the idea that agglomeration economies, which partially explain the growth of cities, generate productivity profits that are reflected in the creation of greater quality jobs (O'Clery and Lora, 2016).[33] Second, the CBD concentrates on average a high proportion of urban employment, reaching almost a fifth in 2010. Furthermore, employment

31. In the study by García-López and Moreno-Monroy (2016), employment density is defined as the number of formal jobs per square kilometer.

32. Group 1 includes cities of between 500,000 and 850,000 inhabitants; group 2, between 850,000 and 2,000,000 inhabitants, and group 3, with more than 2,000,000 inhabitants (see the complete list of cities in the chapter's Appendix).

33. This relationship is more significant when larger cities are considered.

density in the CBD grows with the size of the city, even though its share in the city's total employment falls. The latter is because the number of subcenters where economic activity is concentrated increases in larger cities, although the average density in these subcenters is generally significantly lower than that of the CBD. For example, in the case of Sao Paulo, employment density in the CBD in 2010 was almost 158,000 workers per square kilometer, while the average of the city's 33 subcenters was approximately 30,000 workers per square kilometer. Third, employment rises between 2000 and 2010 in most cities (that is, in 19 of 35 cities), as well as the number of subcenters. However, the share of the CBD and subcenters in the city's total employment during this period is relatively constant. Thus, a clear pattern of change in centralization/ decentralization levels cannot be discerned.

In 2010, in Brazil there are very few cities that are strictly "monocentric" (only 3 of 35).[34] This finding could be extrapolated to other cities in Latin America (and developed countries). However, this does not mean that employment shows a strong decentralization pattern, since, as indicated above, employment concentration in the CBD is high and relatively stable, and jobs are relatively close to the center: the average distance indicator is 15.6 km.

An alternative way of evaluating employment concentration and the urban form is through the estimation of curves that describe the spatial evolution of densities, from the center towards the city's periphery (see section "Conceptual framework: Determinants of land use and the internal structure of cities"). Text box 2.1 presents this exercise for a subset of three Brazilian cities. This exercise confirms the previous conclusion regarding the existence of a rather heterogeneous behavior among cities, with cities where employment has decentralized, others where there are no changes, and some in which concentration actually increases.

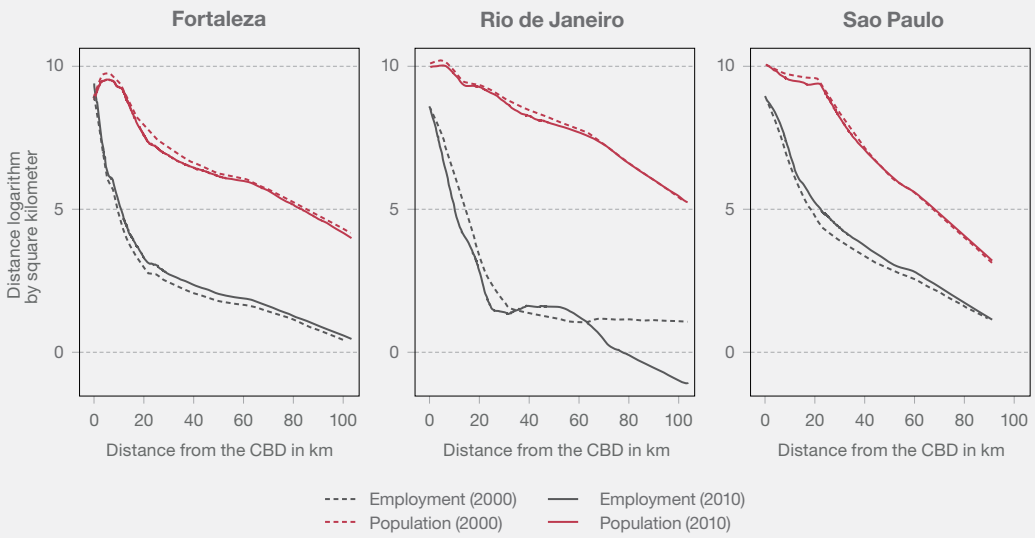
Text box 2.1 The estimation of employment density curves for a selection of Brazilian cities

The estimation of curves (or gradients) that describe the spatial evolution of densities from the center towards the periphery is a widely-used exercise in urban economics literature to evaluate the structure of cities.[a] The monocentric model, described in the conceptual framework, predicts a higher level of employment concentration than residential concentration. Figure 1 confirms this prediction by comparing the employment and population density gradients in three Brazilian cities (Fortaleza, Rio de Janeiro and Sao Paulo) for 2000 and 2010. Indeed, in all cases it is observed that the slope of the curve describing the spatial evolution of employment density is steeper than the slope of the residential density curve.[b] Employment density curves also reflect the existence of subcenters with a concentration of economic activity. The most striking case is that of Rio de Janeiro, where the employment curve has a pronounced break in

34. See the chapter's Appendix.

its slope revealing an increase in employment density at the 30-km mark from the CBD, which suggests the existence of a subcenter that is very important economically.

Graph 1 Employment and population gradients for selected Brazilian cities in 2000 and 2010 a/



a/ The graph shows the estimation of employment and population density as a function of distance from the CBD, using the nonparametric method of Local Regression (Logically Weighted Regression), for the cities of Fortaleza, Rio de Janeiro and Sao Paulo, in 2000 and 2010.

Source: García-López y Moreno-Monroy, based on García-López and Moreno-Monroy (2016)

Table 1 Employment and population gradients for selected Brazilian cities in 2000 and 2010 a/ b/

Fortaleza				
	Employment density		Population Density	
Years	2000	2010	2000	2010
Logarithm of the density in the CBD	6.019***	6.332***	9.591***	9.687***
	(0.047)	(0.05)	(0,042)	(0.033)
Density gradient	-0.088***	-0.089***	-0.049***	-0.068***
	(0.002)	(0.002)	(0.004)	(0.002)
Adjusted R^2	0.3	0.27	0.16	0.3
Rio de Janeiro				
	Employment density		Population Density	
Years	2000	2010	2000	2010
Logarithm of the density in the CBD	6.646***	5.461***	10.385***	8.539***
	(0.044)	(0.052)	(0.027)	(0.068)
Density gradient	-0.084***	-0.101***	-0.046***	-0.015***
	(0.002)	(0.002)	(0.001)	(0.002)
Adjusted R^2	0.15	0.16	0.15	0.15

Continued ›

Sao Paulo				
	Employment density		Population Density	
Years	2000	2010	2000	2010
Logarithm of the density in the CBD	7.603***	7.958***	10.065***	9.172***
	(0.033)	(0.033)	(0.023)	(0.041)
Density gradient	-0.128***	-0.124***	-0.038***	-0.022***
	(0.002)	(0.002)	(0.001)	(0.002)
Adjusted R^2	0.18	0.17	0.05	0.09

a/ The table shows the coefficients estimated by ordinary least squares. The dependent variable is the logarithm of employment and population density, and the independent variable is the distance from the CBD in kilometers.
b/ Robust standard errors in parentheses. *, ** and *** indicate statistical significance at 1%, 5% and 10%, respectively.

Source: García-López and Moreno-Monroy (2016).

The comparison of the econometric estimations of the employment and population density gradients for 2000 and 2010 (see Table 1) allows us to evaluate the changes in the urban form during this period. The results show that, during this period, all three considered cities experienced growth in formal employment densities. In the case of Fortaleza, growth is widespread throughout the city, with increasing central and peripheral densities in equal proportions.[c] This means that there was no significant change in the employment distribution across the city's geography. In the case of Sao Paulo, growth is decentralized, since peripheral densities increase proportionally more than central ones (the curve becomes flatter). Finally, Rio de Janeiro is part of a centralized growth process in formal employment, showing an increase in central densities and a reduction in peripheral ones (the curve becomes steeper in 2010 compared to a decade earlier). As a consequence, the city has become more monocentric in terms of employment concentration.

As for the population density, results show that in the first decade of this century Rio de Janeiro and Sao Paulo experienced a suburbanization process with decreasing central densities and an increase in peripheral ones (the curve flattens) while in Fortaleza the opposite phenomenon is observed.

In conclusion, the analysis of these three cases suggests that, potentially, there is a high degree of heterogeneity, at least in the case of Brazil, in the evolution of the urban structure that accompanies the city's growth in terms of employment and population. This highlights the need to study the evolution of urban structure on a case-by-case basis, evaluating the relevance of possible determinants and the consequences for urban public policies.

a. See, for example, Bertaud and Malpezzi (2003, 2014) and Bertaud (2004).
b. This result is corroborated by the econometric estimation of the slopes presented in Table 1.
c. The curve moves upwards in a parallel manner: the estimated coefficient of the constant rises and that of the slope remains constant

Patterns of population decentralization in cities in Latin America, the United States and Europe

Job location is a fundamental determinant in the residential decisions of families. That is why an urban structure where jobs are highly concentrated

In general, cities in the United States show higher levels of decentralization of the urban population than those of Latin America and Europe.

in a few locations, may induce a strong concentration of the population to avoid commuting costs. This implies high housing prices and a lower consumption of residential space. However, as indicated in the conceptual framework, factors such as increasing family incomes, improvements in access to mortgage loans, investments in public transport networks (e.g. suburban train network) and the technological changes associated with cheaper car use can drive suburbanization processes. In such a case, a much more decentralized residential distribution can be observed compared to employment (see Text box 2.1, page 93).

This subsection studies population decentralization processes in more detail. For this purpose, CAF's Database on the Extension of Metropolitan Areas (BEAM by its acronym in Spanish), described in Chapter 1, is used to analyze the population's share living in the cities' central areas and compare it with that of the remaining urban area.[35] This analysis is presented in Table 2.3, where "central area" is defined as the urban space within a 5 or 10 km radius around the city's central point.[36]

In general, cities in the United States show higher levels of decentralization of the urban population than those of Latin America and Europe. If the center is considered as an area of up to 5 km around each city's central point, all considered cities in the United States have less than 10% of their inhabitants residing in this central area, both in 2000 and in 2010. In cities like Madrid and Rome, however, this percentage is 22% and 28%, respectively, in 2010, while in Caracas that same year it reached 37%. Only Buenos Aires and Mexico City are below 10% in Latin America, and London, in Europe.

If the center is considered as the area within a 10 km radius around the city's central point, population concentration in this zone does not exceed 14% in the United States (except New York, where it almost reaches 20%), and reaches values as high as 58% in Rome and 55% in Madrid for 2010. According to this definition, the percentage of urban inhabitants living in central areas in Latin America in all cases exceeds 50% in 2010, except in Buenos Aires (19%) and Mexico City (26%). The fact that metropolises located in Andean countries exhibit this pattern is unsurprising, given the restrictions that geographical accidents impose on urban expansion.

35. In Ch et al. (2017) details regarding BEAM are described.

36. In note b/ of Table 2.3 the geographical reference point which was used as the center for each city is indicated. It was generally chosen in regard to an administrative/political landmark (for example, the seat of government).

Table 2.3 Changes in population density patterns during 2000-10 for selected cities in North America, Europe and Latin America [a/ b/]

			5 km distance from city center			10 km distance from city center		
City	**Population (2000)**	**Population (2010)**	**Population in central area (2000) %**	**Population in central area (2010) %**	**Difference between 2000 and 2010 in p.p.**	**Population in central area (2000) %**	**Population in central area (2010) %**	**Difference between 2000 and 2010 in p.p.**
North America								
Atlanta	2,981,331	4,527,711	5.5	6.5	1.0	15.5	13.4	-2.1
Chicago	8,336,630	10,623,020	3.0	5.7	2.7	13.0	12.4	-0.6
Los Angeles	13,289,918	15,803,291	4.1	4.2	0.1	13.6	11.5	-2.0
New York	15,613,956	15,598,063	7.3	9.8	2.5	19.7	19.5	-0.3
Europe								
London	9,501,808	12,132,310	7.8	7.9	0.1	25.0	24.2	-0.8
Madrid	4,439,990	5,525,552	31.6	22.3	-9.3	75.2	54.7	-20.5
Paris	9,575,634	10,552,397	15.8	17.9	2.0	39.9	40.4	0.6
Rome	3,240,829	3,398,718	33.1	28.1	-5.1	75.5	57.6	-18.0
Latin America								
Bogota	5,781,236	7,717,989	20.3	18.2	-2.0	61.6	53.7	-7.9
Buenos Aires	10,757,883	14,127,009	10.3	7.0	-3.2	23.4	18.9	-4.5
Caracas	4,078,695	3,821,912	42.5	37.0	-5.5	81.9	66.6	-15.2
Lima	7,254,642	8,836,417	25.5	33.1	7.7	68.0	74.0	6.0
Mexico City	16,428,409	20,529,656	9.3	7.5	-1.8	30.4	26.1	-4.3
Montevideo	1,416,941	1,604,885	25.0	24.0	-1.0	72.0	67.8	-4.3
Quito	941,117	2,031,086	37.7	26.6	-11.1	85.8	60.3	-25.5
Santiago de Chile	5,015,025	5,897,845	23.4	16.4	-7.0	64.8	51.0	-13.8

a/ The table shows the percentage of population within a radius of 5 km and 10 km from the geographical center of the city compared to the total population for 2000 and 2010.
b/ The following geographical references were considered for each city. For Latin America: Bogota (Bolivar Square), Buenos Aires (Obelisk), Caracas (Bolivar Square), Lima (Mayor Square), Mexico City (Zocalo), Montevideo (Intendencia), Quito (Alcaldia) and Santiago de Chile (La Moneda Palace). For Europe: London (Charles Statue), Madrid (Mayor Square), Paris (Notre Dame) and Rome (Republic Square). For North America, the references are US cities: Atlanta (Atlanta Central Library), Chicago (Cloud Gate), Los Angeles (Pershing S quare) and New York (Times Square).

Source: Authors' elaboration based on BEAM (CAF, 2016), Ch et al. (2017) and population data from Landsat 8 (USGS - NASA, 2010).

Lima has a strongly monocentric structure, while Mexico City has a more decentralized pattern, with multiple subcenters distributed across its geography.

When comparing the data for 2000 and 2010, Table 2.3 (see p. 97) also suggests that for most cities analyzed there has been a process of decentralization of the population, particularly when considering the area covered by a 10 km radius from the central point of the city.[37] The case of Quito, in Latin America, is worth noting as we observe a reduction in the share of population living in the center (defined by a 10 km radius) from 86% in 2000 to 60% in 2010. Caracas and Santiago de Chile also show substantial declines (around 14 percentage points). According to the most restrictive definition of central area, which considers a radius of 5 km, Latin American cities continue to undergo a process of decentralization. This contrasts with cities in the United States, London and Paris, where these zones are gaining a share of the total urban population. This phenomenon is partly associated with interventions that have sought to revitalize the historic center of these cities by promoting a mixed land use (both commercial and residential).[38]

A complementary approach to evaluating population distribution within cites is through "thermal mapping", which describes urban population density in two dimensions.[39] Graph 2.6 illustrates this representation for some of the previously studied cities: Bogota, Mexico City and Lima for Latin America; Chicago in the United States and Madrid and Paris in Europe. The maps show the circles representing a circular area of 5 and 10 km radiuses from the city center (as well as other projections with 10 km increments). For each city two panels are shown: to the left density distribution within a 30 km radius from the city center. The color intensity in the maps is directly proportional to density level. The panels to the right capture the complete city boundaries, as estimated by BEAM according to the methodology laid out in Chapter 1, for 2000 and 2010.

A city's shape can be evaluated through the representation of density levels. Examples for Latin America as exhibited in Graph 2.6 show a variety of situations. First there is Lima with a strongly monocentric structure, comprised of a central area with population density levels of up to 60,000 inhabitants per square meter in some segments (approximately 600 inhabitants per hectare). Second, in Bogota, a clear subcenter appears to the southwest in addition to the central business district (CBD).[40] Finally, Mexico City presents a higher decentralization pattern with multiple subcenters distributed throughout the city's geography. In contrast to the heterogeneity of the region, Madrid and Paris show a clearly monocentric structure, with density dropping sharply beyond the central area (defined as an area spanning a 10 km radius from the center). At the other end of the spectrum, in US cities such as Chicago, density distribution is more homogeneous throughout the territory.

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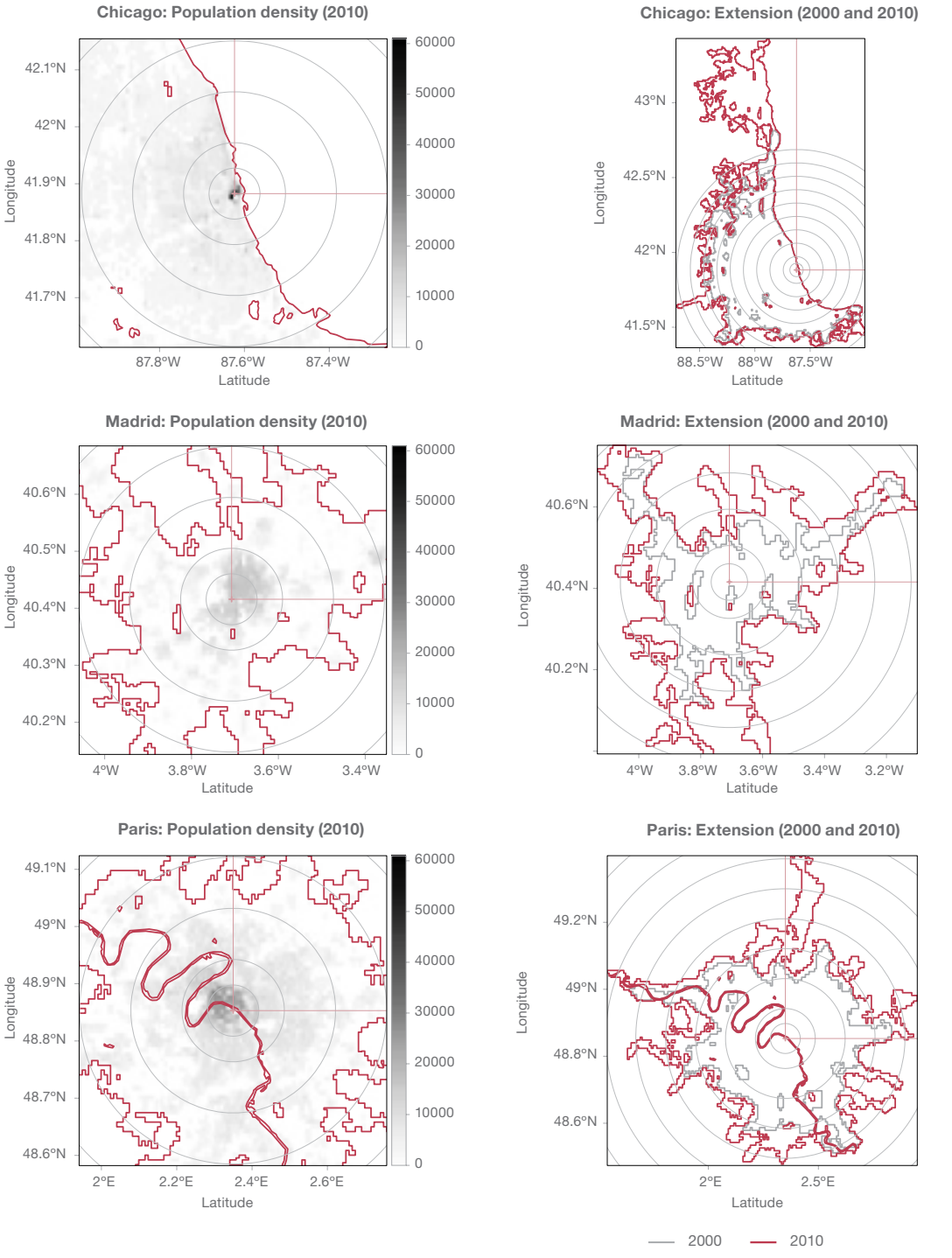
37. With Lima being the sole exception, showing a process of increased concentration both within the 5 km and the 10 km radius.

38. Redevelopment of vacant industrial buildings in central locations (brownfield development) is an active policy in most of these cities. This topic is developed in more detail in the section "Land use regulation and urban growth".

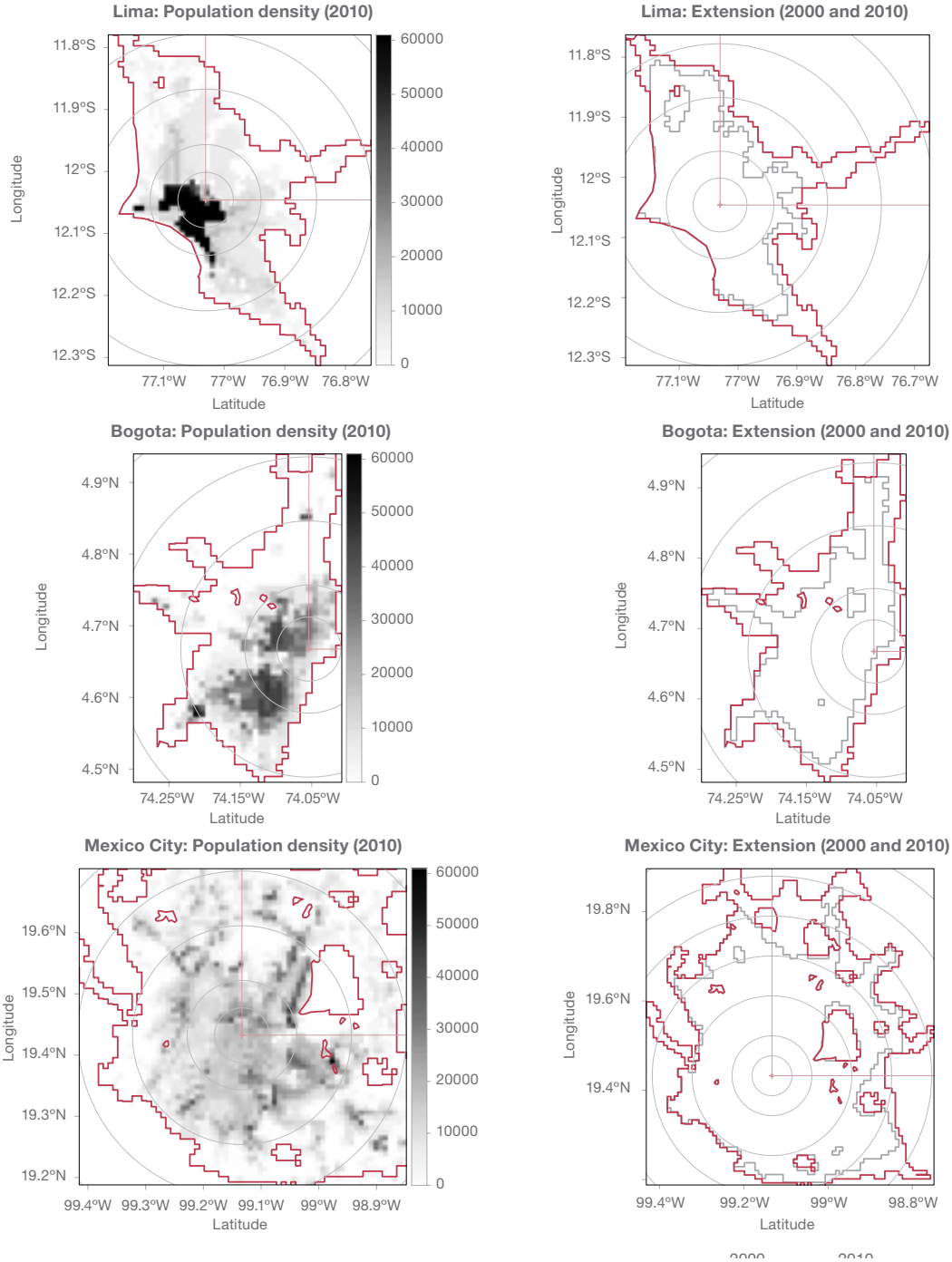
39. Population information is disaggregated into 1 km^2 segments (Ch et al., 2017).

40. Bogota's CBD overlaps with the financial district, with epicenter on Calle 72 and Carrera 7ª. The subcenter located to the southeast corresponds to the so-called "international center", which runs from Calle 32 to Calle 19.

Graph 2.6 Population density and extension for selected cities in the United States, Europe and Latin America [a/]



Continued ›



a/ The left-hand graphs identify the population density per square kilometer for 2010, using georeferenced population as estimated by Landsat 8 (USGS - NASA, 2010). The right-hand graphs identify the limits of urban extension for 2000 (grey) and 2010 (red). The following geographical references were considered for each city: Bogota (Zona T), Lima (Plaza Mayor), Mexico City (Zocalo), Chicago (Cloud Gate), Madrid (Plaza Mayor) and Paris (Notre Dame). Both for the population density graphs and for the extension graphs, the circles centered on the geographical centers mentioned above have a 5 km radius followed by a 10 km radius, with subsequent 10 km increments (i.e. they go from 10 km to 20 km, 30 km, 40 km and so on). The cities' latitude and longitude in degrees are included for geographical reference.

Source: Authors' elaboration based on BEAM (CAF, 2016), Ch et al. (2017) and population data from Landsat 8 (USGS - NASA, 2010).

A noteworthy fact illustrated in Graph 2.6 (see p. 99) is the contrast of the urban expansion of Latin American cities when compared with their European and especially with their US counterparts. This phenomenon has already been pointed out in Chapter 1 and in the section "A comparative perspective of growth and land use dynamics in Latin American cities" of this chapter. In Lima and Bogota, for example, a radius of 20 km from the city center encompasses a considerable area of the city (on average, no less than 70%), and there is no significant growth of the urban area extension for these two cities between 2000 and 2010. Mexico City, meanwhile, stands out within the region for its relatively wide extension (along with Buenos Aires and Sao Paulo), with suburban areas that can be identified even at a distance of 40 km from the center. The extension of Mexico City and Buenos Aires are comparable to certain European cities such as Madrid and Paris, which show important suburban developments 50 km away from the center, some of which have consolidated during the last 10 years (Madrid to the South and Paris to the North). Chicago, in the United States, is a classic example of a city with extended suburban areas, which in some directions reaching as far out as 60 km from the city center.

Slum incidence has increased in the last few years, with few examples of reconversion and integration of these neighborhoods into the formal urban structure.

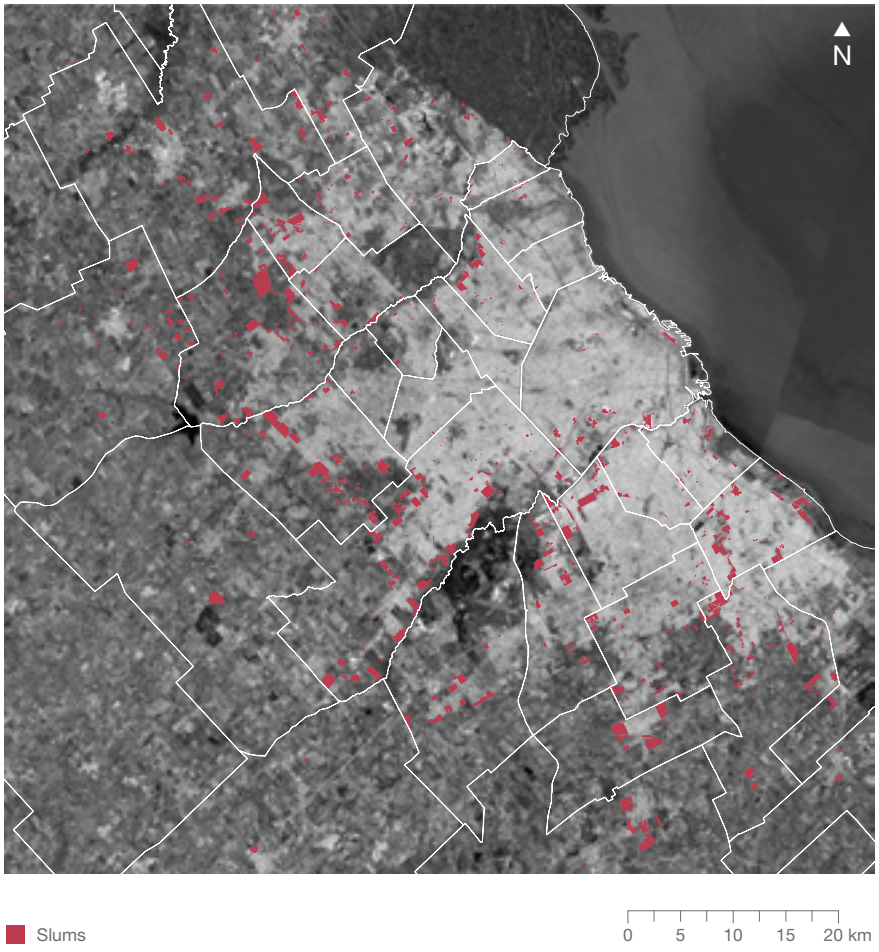
Distribution of slums in urban geography: The case of the Metropolitan Area of Buenos Aires

As mentioned earlier, Latin American cities (as well as cities from other developing countries) are characterized by a high level of informality, reflected in the coexistence of formal urban developments and slums, where low-income families occupy land that is generally government property. This type of dwelling constitutes a "solution" to the problem of housing for many families, allowing them access to better jobs (and services such as education and health) than those available in their place of origin, without having to pay for the elevated market value of formal housing (see Chapter 4). Slum incidence has increased in the last few years, with few examples of reconversion and integration of these neighborhoods into the formal urban structure despite government efforts to change this reality.[41]

Analysis of the location, size, dynamics and other aspects related to slums in Latin America faces the problem of lack of systematic and reliable information. The recent availability of data from satellite photos has allowed for partial progress in the quantification of this phenomenon for some cities (Duque et al., 2016). Graph 2.7 (see p. 102) shows the case of the Metropolitan Area of Buenos Aires, based on the survey of slums made by the Techo Argentina Foundation in 2016 (Techo, 2016). The graph shows how these neighborhoods are distributed throughout the entire urban geography, including very central areas. The so-called "Villa 31", for example, with an estimated population of over 30,000 people and a density of 800 inhabitants per hectare, is located very close to the Buenos Aires CBD.

41. Henderson et al. (2016) analyzes the case of Africa, mentioning how institutional failures affect slums reconversion in the continent's cities.

Graph 2.7 Location of slums in the Metropolitan Area of Buenos Aires in 2016 a/



a/ A slum is defined as a group of at least eight grouped or contiguous families, where more than half does not have property title nor regular access to at least two of the basic services: tap water, electricity with home meter, and/or excreta disposal through the sewage network. The survey was carried out on-site, detecting slums and interviewing community representatives/key informants.

Source: Slums survey (Techo, 2016).

The job concentration in the central area provides advantages to those workers (in many cases informal) living in the slums located near the CBD. These advantages include minimization of transportation costs and accessibility advantages, not only to potential jobs but also to other services. This explains the higher market value of land and housing in centrally located slums, as well as their higher population density, which usually is comparatively higher than that of the formal city neighborhoods. The slums that sprout in the urban periphery, where land is cheaper, are in

contrast lower in density, with little to no infrastructure and even of poor environmental quality, such as river banks or floodplains unsuitable for urbanization. The process of slum proliferation in peripheral urban areas can contribute, as we will see in the next subsection, to a greater degree of urban segregation.

When coupled with the suburbanization of high-income households, urban expansion can contribute to the process of segregation.

Urban growth and segregation: Evidence for the Metropolitan Area of Buenos Aires

As mentioned in the conceptual framework, land value varies within a city as a function of its distance from the city's CBD, transportation costs and the presence of amenities. This phenomenon, coupled with the fact that families have varying income levels, can potentially lead to a process of segregation by income level. However, the specifics of urban segregation can take a variety of forms. For example, depending on the circumstances, wealthier families tend to locate in suburban areas or near the areas central to economic activity. As mentioned earlier, the same can be said of slums. The specifics of urban segregation are particularly relevant in relatively monocentric cities, as tends to be the case in Latin America. Housing segregation is in fact particularly problematic when employment opportunities are concentrated in one part of the city, since it reduces accessibility[42].

When coupled with the suburbanization of high-income households, urban expansion can contribute to the process of segregation, based on, for example, the demand for more space or fiscal incentives. This process encourages the creation of gated communities, with private security, green space and sports facilities. Thus, in the Metropolitan Area of Buenos Aires, 10% of the land that is zoned for urban use is destined to this type of urbanization, and in municipalities such as Tigre, 34% of the area is destined to private developments or country clubs (Goytia et al., 2015a).

Goytia and Dorna (2016) analyze the relationship between urban growth during the years 2000-10 and household socioeconomic segregation in the 31 Argentine metropolitan areas. The results confirm that low-income household segregation prevails in most metropolitan areas. Evidence also suggests that different urban growth patterns have various effects on segregation. Discontinuous growth is the biggest culprit of segregation, particularly of the poorest. One could explain this phenomenon by the location of social housing projects in peripheral areas removed from the cities, where land is cheaper and there is precarious access to basic services and transportation

42. Garrido and Vargas (2016) argue that as long as unskilled workers cannot access jobs in the city and there are complementarities between low and high-skilled workers, segregation will have negative effects on the city's aggregated productivity. If, however, urban activity is concentrated in productive hubs with no such complements, spatial concentration of skilled workers will lead to positive externalities what will compensate for the productivity losses associated with unskilled workers. The city's productivity will in this case be unaffected by segregation.

networks. In contrast, cities that grow by extension and through filling up open space within the urban borders result in a lower degree of segregation of the lower-income households, which are consequently distributed more homogeneously across the urban territory.

Land use regulation and urban growth

In most countries and cities in the world, land use and urban structure are not the result of the action of market forces alone. Territorial planning systems (such as urban codes) lay down regulations that condition land use, urban structure and growth possibilities. This section analyzes the impact of land use planning and its regulation.

Zoning and land use regulation: Background and purpose

Land use regulation and planning, or in other words, territorial organization through zoning and other measures that condition land use, are a common mechanism for controlling the externalities associated to certain land uses (such as industrial activities). In this sense, planning establishes requirements on lot size and buildings height, seeks to ensure adequate solar lighting conditions and determines the amount (and variety) of amenities in each urban area (through establishing not only the amount of public open space and parks but also the proportion of free areas in each plot). Regulation also determines the requirements that private developers must meet as contribution to public infrastructure, such as space destined for circulation routes and public equipment, or connections to water and sanitary networks. Potential benefits to urban territorial planning include the provision of public goods such as public spaces for roads or parks, or the safeguarding of environmentally protected areas. This is important, since public space would likely be underprovided by the market, calling for regulation on this matter. Finally, another group of regulations defines the minimum standards for construction quality and living conditions, together with the inspection regime.

Duranton (2007) conducts a taxonomical study of the origin of regulations depending on the type of public institution or, alternatively, private interest that promotes their establishment. A first approach indicates that zoning regulations are implemented in municipalities (that is, at the sub-metropolitan level) driven by benevolent local planners who seek to maximize local wellbeing. In this case, zoning regulations will be efficient, as long as the externalities they seek to correct occur exclusively in their jurisdiction. When externalities are not restricted to the municipal limits, a lack of municipal coordination will most likely promote suboptimal situations (for a more detailed discussion, see Chapter 5). The requirement of a minimum lot size in a neighborhood can, for example,

promote air quality, safety and property value, but can also negatively impact other territories as the unsatisfied housing demand will shift to other areas of the city, most likely increasing urban congestion in those zones. In the second approach, a body responsible for coordinating this regulatory role implements zoning regulations for the entire metropolitan area. Although this approach would appear more efficient than the first, by encompassing all externalities and the spillovers generated amongst municipalities within the metropolitan area, there are still very few cities in the region that adopt coordination mechanisms for land use planning (see Chapter 5). This could partly account for the inefficient expansion of some Latin American cities, especially those characterized by high administrative fragmentation (Lanfranchi and Bidart, 2016).

Land use limitations for urban development increase the price of land and, therefore, of housing.

The third approach recognizes that in many cases and particularly in developing countries, regulation is not justified in terms of correcting externalities but is rather associated to fiscal motivations or economic interests of certain groups. Zoning regulation, for example, can be the result of a process of local decision-making that, by restricting new developments, benefits local residents by increasing the value of their property. Fischel (2001) coins the term homevoters to describe homeowners who vote (or lobby) regulations that preserve or increase the value of their property, even to the detriment of general wellbeing. Many cities offer mechanisms for engaging citizen participation and public consultation with community members to carry out local zoning. This is the case in 60% of Argentine municipalities (Goytia et al., 2010). Although this kind of mechanism can be considered a form of direct democracy, it also encourages owners to promote more restrictive measures (Fischel, 1980, 1985; Quigley, 2007).

Opposition to new housing developments in many urban neighborhoods could be an indicator of this type of inefficiency, originated in the political economy of regulation. This is also the case with regulations that establish very high minimum requirements for lot size and strict limitations on developments. This type of initiative, which often seeks to mitigate the cost of urban congestion (caused by traffic, for example) by capping urban growth, discourages investment in housing and promotes social exclusion by increasing land prices. A paper by Combes et al. (2016) on French cities suggests that those cities that allow the extension of the urban area to adjust to population growth ultimately succeed in keeping the price of land under control. The authors demonstrate that the costs of a bigger city (requiring bigger investment in infrastructure) are modest and of the same magnitude as the gains in agglomeration economies, leaving no support to the imposition of development regulations which favor a strict restriction on urban extension growth.

Land use limitations for urban development increase the price of land and, therefore, of housing. Consequently, households and firms reduce their consumption of space. Resisting urban expansion could, therefore, result in denser cities, with smaller housing and more expensive land (Brueckner, 2001), but also with fewer firms, less capacity to attract workforce and lower productivity (Duranton and Puga, 2001). In conclusion, the social cost of restrictive zoning can be quite high.

There is an important variation in the way cities regulate land use within the region.

This evidence flags a warning on policies being applied in Latin America with the objective of restricting the growth of urban extension. Although there may be legitimate reasons to avoid a disorganized and discontinuous growth (without accompanying infrastructure) of the urban border, these restrictions could increase congestion costs and house prices. In Mexico City, for example, the construction of social housing has led, since the early 1990s, to a sustained urban growth in scattered areas located at great distance from the city center. By fostering residential developments in remote areas, with little accessibility to employment hubs, lack of coverage for basic services and inadequate mobility infrastructure, this process has generated major inefficiencies.[43] As a way of counteracting this phenomenon, the Mexican federal government recently launched the promotion, through the Plan Nacional de Desarrollo 2013-18 (National Development Plan) and the Programa Nacional de Desarrollo Urbano 2014-18 (National Program for Urban Development) of an urban policy agenda to contain extensive urban growth through the establishment of urban perimeters. Although this policy could be a justifiable response to the bad experience resulting from the social housing policy, these limits could eventually become restrictive by excessively driving up housing prices and congestion within the city. This could happen particularly if the economic and market conditions change, favoring the decentralization of employment and population.

Land use regulation in Latin American cities

There is an important variation in the way cities regulate land use within the region. This variability is partly due to the faculties that the high government levels in each country delegate to local administrations. But it is also a function of the instruments and capacities conferred to these local governments. Regrettably there is a lack of systematized and comparable information on the different characteristics of these regulatory frameworks for a large sample of Latin American cities.

The CIPUV Land Policy Index (CILP) is the most comprehensive action yet performed in a Latin American country to measure the regulatory environment at the municipal level (Goytia et al., 2012). Based on a survey targeted at the Directors of Planning for Argentine municipalities, this indicator provides a standardized measure that summarizes the conditions of the local regulatory environment, facilitating the comparison between jurisdictions. The index reproduces the methodology of the Wharton Residential Land Use Regulatory Index developed by Gyourko et al. (2008) and incorporates aspects specific to the problems relevant to Latin American cities: informality of the land and housing market, and weak enforcement of land use regulation compared to developed countries.

43. As a direct result of the suboptimal location of these social housing projects built with the financial support of the Instituto del Fondo Nacional de la Vivienda para los Trabajadores, roughly 390.000 to 487.000 housing units built between 2006 and 2010 are currently uninhabited (OECD, 2015).

This aggregated index comprises several subindexes with information that includes data on the existence of urban codes, the process and costs required for project approval, the characteristics of the provision and financing of infrastructure services, zoning and construction regulation, the existence of citizen participation mechanisms in defining regulations, and the application of instruments to recover the additional value generated by urbanization and public investment.

Results show that land use regulation is mostly heterogeneous across Argentine territory, presenting substantial differences amongst metropolitan areas, amongst the municipalities that compose them and between jurisdictions located within metropolitan areas and outside them. To illustrate the point: 95% of the municipalities in the metropolitan areas have local ordinances regulating land use, but only 73% have actually defined a code for land use. It is also interesting to analyze the extent to which the regulations are up to date. According to the index, the most updated ordinances belong either to the largest municipalities or those most densely populated. Low-density municipalities are, in average, more prone to have outdated land use regulation instruments when compared with medium- and high-density municipalities. As for the enforcement of local regulations, 63% of highly regulated jurisdictions (those with above-average CILP) report low levels of enforcement.

The municipalities of the Pampean region (center-east part of Argentina) and its large metropolitan areas, including Bahia Blanca, Buenos Aires and La Plata exhibit the most rigorous regulatory environment, with the Metropolitan Area of Buenos Aires being the most restrictive countrywide. The biggest differences between highly regulated and less regulated environments occur in terms of costs, project approval times, and public-sector participation in financing urban infrastructure. Jurisdictions with a higher level of regulation generally have two levels of regulation (local and provincial) and require the participation of more authorities to approve regular projects and zoning modifications.

Variations at intrametropolitan level suggest that municipalities with over 50,000 inhabitants, which form the peripheral ring around the main metropolitan areas, present the most stringent indicators with respect to various CILP components. In these municipalities, with relatively large vacant areas (as a percentage of total area) and a relatively lower density, there is less public financing of infrastructure expansion (as a percentage of total financing).

Interventions that incease city value: Renovation of deteriorated and underutilized areas

The presence of deteriorated or underutilized areas in the city center is, to different degrees, one of the shared characteristics amongst Latin American cities. As in many cities in developed countries, new standards in production, transportation and logistics stemming from new technologies and economic transformation have left a large number of empty warehouses, old train stations and industrial and port complexes in central areas of the cities underutilized or degraded. In other words, because constructions are very durable goods, the “creative destruction”

of economic development implies transformations and displacements that leave behind ample unoccupied spaces within cities (Duranton, 2007).

With the shift of economic activities and the associated implications for land use and value, new suburban areas compete with the old buildings of the central city for urban residents. As the older buildings require greater investment in maintenance, and the market tends to favor suburban locations, the combined factors could lead to an excessive development in extension, punishing the market value of property located in the city center and further undermining the incentives for its maintenance.

Systematic evidence on the amount of vacant or underutilized land in Latin American cities is very scarce, so building a database that accounts for this phenomenon should be a public policy priority. Currently it is only possible to base the discussion on specific urban experiences in the region, covering several types of interventions according to the specific problems they face. On one hand, there are programs for the recovery of deteriorated areas of historic importance, such as the recovery of Quito's Historic Center, in an attempt to turn around the tendency towards obsolescence and decline of these areas through the creation of new cultural amenities with heritage value.

There are other interventions that seek to harness development opportunities offered by railway or logistic infrastructure located in zones that have become urbanized. Exponents of this category can be found in renovated docking areas, airports, railway stations and other facilities that have lost their original vitality and purpose. These interventions aim to recycle these areas for complementary purposes, such as residential or commercial use and also for offices. Two iconic cases are the zone of Puerto Madero, in Buenos Aires, and the more recent Porto Maravilha, in Rio de Janeiro, which followed the steps of the London Docklands renovation. They stem from riverside docks and facilities located in the city center that fell into disuse, and both share the implementation of similar strategies of recuperation. These include an autarchic management institution that overcomes the coordination difficulties that usually plague intervention of this type, when the renovation is promoted by public and private partnerships. The defined land use regulations in these cases is also similar: mixed land use programs in which a services sector coexists with a large housing component, as well as equipment and services oriented to a young population with good urban connectivity.

A third type of intervention aims to modify the city's growth trend, focusing on repopulating underutilized sectors within the city through granting subsidies (for purchase or rent) and credit to promote the development of social housing. Examples of this kind of intervention can be found in the city center of Sao Paulo and the southern part of the city of Buenos Aires, and in the repopulation of the Barrio Poniente of Santiago de Chile.

Finally, with the purpose of discouraging large urban spaces of vacant land in urbanized areas, Bogota and some municipalities in the province of Buenos Aires, Argentina, to name some examples, specifically tax ownership of vacant lots in certain central areas.

Green space and its location

Green areas are highly valued when localized in densely populated areas.

The loss of open space to urban growth is an undesirable consequence of urban expansion. Faced with this reality, planners may feel the temptation to maintain green areas on the city perimeter. There is no evidence, however, that households value open spaces when located on the cities' periphery. In fact, green areas are highly valued when located in densely populated areas (Turner, 2005). The promotion of open spaces in the urban perimeter and the concept of green belts potentially increase the stress on the already densely populated central areas, when the actual necessity is to allocate green spaces within the central and suburban areas.

A wide range of empirical work has analyzed how households assign value to different types of green spaces. Open spaces provide positive externalities (amenities) in highly developed urban areas and negative ones (such as longer commute time) in areas that are not highly developed (Walsh, 2007). When choosing housing, families value the proximity to public parks, open space and private property gardens. Indeed, the evidence suggests that housing prices decline with distance to parks. However, the relationship between open space and price is not linear: beyond a 1 km distance, the price of housing decreases as a function of proximity to parks and open spaces, since it generally competes with the proximity to other complementary urban benefits, such as shops and other services that are sometimes valued higher than access to open space.

Open space is, therefore, a local public good, whose improvement in terms of quality, integration and maintenance will have positive social and economic impact. In terms of social impact it is worthwhile to mention the increase in household wellbeing, public health benefits and environmental benefits derived from improvements in air quality, and the mitigation of high climatic variations. Regarding economic impacts, a key factor is the appreciation of the properties that adjoin the green spaces. The inclusion of green space has the additional potential to revitalize high-density slums.

Financing instruments based on land revaluation

Public investment (in infrastructure or green space, to name a few) and regulations governing land use affect land and property value. These changes capitalized in property value can provide a potential source of income to finance the necessary investments required for urban development. However, this potential for generating fiscal resources, generically referred to as land based financial instruments is mostly untapped in the region. This contrasts with experiences in cities from developed countries, such as the UK betterments or the US windfalls. The few cases available in Latin America are based on local regulation or in regulations from higher government levels. An iconic case in the region is the great amount of urban renovation projects in Sao Paulo financed by the issuance of Certificate of Additional Building Potential (CEPAC) which are actioned through the Sao Paulo Stock Exchange.

The resulting revenues are invested to finance the entire infrastructure required by the project in the urban area where it operates.

Another innovative land policy instrument which allows municipalities to have the resources to plan and guide expansion is to readjust land plots, bringing about public-private participation by forcing landowners to share the costs of extending mobility and services infrastructure in suburban areas. In exchange for giving up a part of their land for streets and networks, landowners receive an urbanized plot (equipped with basic services and access to the newly built roads). This instrument enables public-private partnership and is used in Korea and Japan, and recently in the region, in several Colombian cities and in the province of Buenos Aires, Argentina. In the case of the Buenos Aires municipality of Trenque Launquen, the application of this mechanism in 2011 enabled the landowners to contribute to the financing of the infrastructure required for the expansion of the urban perimeter (Duarte and Baer, 2013).

Conclusions

Analyzing the determinants of land use and urban structure in Latin American cities is fundamental to guiding public policies that seek to promote the benefits of agglomeration, and at the same time, keep congestion costs under control. This chapter aims to contribute along these lines, by making a diagnosis of Latin American urban structure in a comparative context. This analysis is nevertheless limited by the lack of disaggregated information on population, employment, density, built-up areas, land cost and other factors that would enable a systematic study of internal urban structures in the region, and their evolution through time. This deficiency called for the generation of new evidence based on alternative sources such as the AEU, BEAM, information on employment distribution available for 35 metropolitan areas in Brazil, and data on land value, employment access and available land use for the metropolitan areas of Argentina.

In the past few years, urban growth and changes in city structure have become relevant issues for public policy in Latin America and around the globe. The debate on urban shape is often extremely oversimplified and reduced to the discussion of expansion versus compactness (increased density) of cities. This conceptual simplification has helped to root a generalized perception that urban growth in extension is undesirable, since it diminishes accessibility by increasing commuting time, causing environmental deterioration, reducing agglomeration economy and productivity. This explains why so many cities have adopted land use policies seeking to limit urban expansion.

However, this is not necessarily so. A growth in urban extension combined with an adequate land use regulation (opening new residential and business

areas in suburban and peripheral locations) and the necessary infrastructure (such as roads, public transport, tap water and sewer services) can facilitate the access to quality housing without necessarily compromising access to jobs and other services. This happens not only because improvements in transport infrastructure facilitates commuting, but also, because the decentralization of the population could boost the emergence of business and services subhubs in suburban areas. This process of suburbanization is also motivated by trends such as increasing households' income, and technological improvements that reduce commuting costs, which could explain the growth in urban extension occurring in developed countries.

Bearing in mind the significant differences within the region, evidence for Latin America suggests that urban expansion has been limited and mostly chaotic when compared to other regions. Population has concentrated in central areas that concentrate employment opportunities, while those living in peripheral areas suffer restricted accessibility due to the poor quality or the complete absence of public transport and the lack of adequate roads infrastructure. This has led to an increase in the demand for centrally located housing, driving up their market price, thanks to restrictive land use regulations. The high prices in turn prevent families of middle-low to low income to access the formal housing market, resulting in the emergence of slums and the growth and densification of existing ones. This process explains why cities in Latin America and other developing regions are characterized by relatively high population density and high levels of segregation coupled with informality.

The documentation of these dynamics is very relevant from a public policy perspective, since this information constitutes a fundamental input for planning an organized expansion and closing the infrastructure (transport, water and sewage network, etc.) gap between central and peripheral areas. This infrastructure investment must be complemented with a better land use planning and regulation that foster the supply of formal housing as well as provide space for mobility infrastructure and other critical facilities (shopping areas, amenities, etc.).

In short, urban policy needs to shift its focus. The goal should not be to have a larger or more compact city. The goal is to achieve higher accessibility, which can be obtained both in a monocentric city of relatively low extension and high density through a good quality of massive public transit system (i.e., trains and subways) as well as in a more extended, polycentric city, where highways, the use of cars and the decentralization of employment equally allow families access to jobs and other services.

Prioritizing accessibility is particularly important to transform Latin American cities into drivers of productivity growth. However, the scarcity of information and empirical knowledge limits the promotion of this approach. Hopefully the evidence discussed in this chapter would encourage carrying out more comparative studies that would allow evidence-based policies that promote urban development and wellbeing.

Appendix

Table A 2.1 Details about the data of the Atlas of Urban Expansion

	City	Country	Group	Period	Urban population (circa 2015)	Built-up area in hectares (circa 2015)	Population density over built area (circa 2015)
North America	Gainesville	United States	1	1990-2013	175,756	7,663	23
	Killeen	United States	1	1990-2013	225,248	17,686	13
	Victoria	Canada	1	1990-2013	318,267	13,351	24
	Modesto	United States	1	1992-2014	458,146	22,728	20
	Toledo	United States	1	1990-2014	489,974	33,057	15
	Springfield	United States	1	1991-2014	530,272	36,637	14
	Raleigh	United States	2	1990-2013	1,188,416	78,270	15
	Cleveland	United States	2	1990-2013	1,865,023	116,854	16
	Portland	United States	2	1990-2014	1,904,409	88,455	22
	Minneapolis	United States	2	1990-2014	2,626,920	142,874	18
	Montreal	Canada	3	1990-2013	3,317,850	89,185	37
	Houston	United States	3	1990-2014	5,399,338	272,394	20
	Philadelphia	United States	3	1990-2014	5,852,880	298,214	20
	Chicago	United States	3	1989-2014	8,913,778	510,972	17
	Los Angeles	United States	3	1990-2014	15,138,973	459,047	33
	New York	United States	3	1991-2011	18,412,093	747,852	25
Europe	Zwolle	Holland	1	1990-2014	108,237	3,197	34
	Oldenburg	Germany	1	1990-2013	158,329	3,781	42
	Le Mans	France	1	1992-2013	179,135	5,974	30
	Halle	Germany	1	1990-2010	235,706	6,721	35
	Lausanne	Switzerland	1	1987-2015	306,229	6,495	47
	Palermo	Italy	2	1987-2013	822,940	13,249	62
	Salonika	Greece	2	1990-2011	859,431	10,568	81
	Sheffield	England	2	1992-2013	1,166,836	27,394	43
	Ambers	Belgium	2	1990-2013	1,277,376	43,115	30
	Vienna	Austria	2	1991-2013	2,025,195	36,563	55
	Manchester	England	2	1989-2010	2,585,614	51,040	51
	Berlin	Germany	3	1990-2013	3,860,243	68,743	56
	Madrid	Spain	3	1991-2010	5,256,249	56,019	94
	Milan	Italy	3	1988-2013	6,402,051	178,364	36
	Paris	France	3	1987-2014	11,114,026	198,626	56
	London	England	3	1989-2013	11,197,941	177273	63

Continued ›

	City	Country	Group	Period	Urban population (circa 2015)	Built-up area in hectares (circa 2015)	Population density over built area (circa 2015)
Latin America	Ilheus	Brazil	1	1993-2013	97,888	1,513	65
	Jequie	Brazil	1	1992-2014	128,045	2,511	51
	Palmas	Brazil	1	1990-2013	154,873	4,228	37
	Leon	Nicaragua	1	1993-2010	160,355	1,544	104
	Holguin	Cuba	1	1987-2014	263,345	2,157	122
	Valledupar	Colombia	1	1989-2011	392,935	2,688	146
	Cabimas	Venezuela	1	1989-2014	460,894	9,488	49
	Reynosa	Mexico	1	1991-2013	479,078	12,028	40
	Florianopolis	Brazil	2	1990-2014	532,951	10,210	52
	Ribeirao Preto	Brazil	2	1990-2014	607,350	10,917	56
	Culiacan	Mexico	2	1990-2014	625,346	11,563	54
	Cochabamba	Bolivia	2	1990-2013	1,034,944	16,736	62
	Cordoba	Argentina	2	1991-2014	1,392,944	24,542	57
	San Salvador	El Salvador	2	1991-2014	1,693,748	16,889	100
	Tijuana	Mexico	2	1989-2014	1,706,084	28,626	60
	Quito	Ecuador	2	1988-2013	2,173,697	22,665	96
	Guatemala City	Guatemala	2	1990-2013	2,654,085	26,506	100
	Curitiba	Brazil	3	1990-2014	2,728,388	44,527	61
	Caracas	Venezuela	3	1991-2014	3,104,392	16,352	190
	Bello Horizonte	Brazil	3	1989-2013	4,038,047	48,701	83
	Guadalajara	Mexico	3	1990-2014	4,375,721	51,625	85
	Santiago de Chile	Chile	3	1990-2014	6,486,535	60,381	107
	Bogota	Colombia	3	1989-2010	7,801,693	31,895	245
	Buenos Aires	Argentina	3	1989-2014	13,879,006	147,306	94
	Mexico City	Mexico	3	1990-2014	17,765,121	161,821	110
	Sao Paulo	Brazil	3	1988-2014	19,609,222	172,428	114

Source: Authors' elaboration using data from the AUE, Angel et al. (2016a).

Table A 2.2 Details about the data on Brazilian metropolitan areas covered by García-López and Moreno-Monroy (2016)

City	Group	Population (2010)	Employment (2010)	Number of subcenters (2010)	CBD censity (2010)	Subcenter density (2010)
Juiz de Fora	1	507,706	122,960	1	17,666	2,685
Macapa	1	520,976	97,116	1	16,484	7,190
Blumenau	1	557,916	208,793	1	5,256	3,401
Feira de Santana	1	581,673	106,311	1	10,977	2,818
Jundiai	1	643,405	184,637	1	9,944	9,371
Limeira and Rio Claro	1	687,560	165,295	1	7,258	5,128
Barra Mansa and Volta Redonda	1	734,239	135,368	1	4,540	10,383
Joinville	1	751,921	250,244	2	10,514	2,613
Campo Grande	1	770,308	162,119	2	11,665	1,522
Ribeirao Preto	1	841,303	214,200	0	9,488	0
Aracaju	1	845,586	177,622	1	15,655	4,242
Florianopolis	2	854,379	318,313	2	37,088	5,221
Londrina	2	919,110	249,778	2	13,510	4,157
Uberlândia	2	971,015	252,706	2	13,990	9,075
João Pessoa	2	975,491	197,885	2	29,685	9,730
Teresina	2	976,974	203,802	1	20,890	6,999
Maceio	2	1,007,579	170,672	1	19,930	5,492
Cuiaba	2	1,091,538	218,276	0	5,884	0
Sorocaba	2	1,138,453	257,475	0	7,314	0
Natal	2	1,170,628	297,219	2	24,519	8,357
Sao Jose dos Campos	2	1,342,316	327,817	6	8,814	9,841
Grande Vitoria	2	1,538,470	436,177	2	22,798	16,057
Baixada Santista	2	1,653,007	310,296	3	17,015	14,925
Goiania	3	2,032,443	552,630	5	24,028	12,555
Manaos	3	2,108,576	414,005	3	13,569	7,251
Curitiba	3	2,868,201	1,031,859	4	38,494	8,311
Campiñas	3	2,907,717	763,146	3	25,067	10,787
Salvador	3	3,450,085	910,399	6	37,972	23,709
Fortaleza	3	3,457,399	699,056	4	24,439	4,829
Brasilia	3	3,494,740	727,784	6	28,284	5,705
Recife	3	3,613,199	819,317	5	38,411	14,316
Bello Horizonte	3	4,696,870	1,505,247	13	44,751	15,261
Puerto Alegre	3	5,945,448	1,472,610	7	31,156	7,968
Rio de Janeiro	3	11,591,159	2,350,702	15	171,061	20,679
Sao Paulo	3	19,385,152	6,684,113	33	157,961	29,674

Source: Authors' elaboration based on García-López and Moreno-Monroy (2016).