REAL ESTATE MARKETS AND URBAN NETWORK IN BRAZIL

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Abstract

Real estate markets reveal aspects regarding the urban-regional network of a country and the possibilities for the development of this network in a polycentric manner. Using an unprecedented database, this article investigates the real estate markets in second-, third- and fourth-tier metropolises in Brazil. It explores the variability and creates typologies of real estate markets in a group of selected metropolises – Brasília, Belo Horizonte, Salvador, Florianópolis and Vitória – using multivariate analysis methods. The results indicate high levels of market segmentation, shed light on the suburbanization processes versus the presence of strong city centers, and raise concerns regarding the affordability of housing in some municipalities. Within each agglomeration, real estate markets vary substantially, indicating a high level of social segregation; among them, there are intriguing similarities, indicating how the residential and commercial locations are (re)produced in a relatively generic manner in Brazil.

Keywords

Real Estate Markets; Urban Network; Urbanization; Human Settlements; Polycentricities; Brazil.

MERCADOS IMOBILIÁRIOS E REDE URBANA NO BRASIL

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Resumo

Mercados imobiliários revelam aspectos relativos à rede urbano-regional de um país e também às possibilidades para o desenvolvimento dessa rede de forma policêntrica. Usando uma base de dados inédita, este artigo investiga os mercados imobiliários em metrópoles de segundo, terceiro e quarto níveis no Brasil. Explora-se a variabilidade e criam-se tipologias de mercados imobiliários nas metrópoles selecionadas – Brasília, Belo Horizonte, Salvador, Florianópolis e Vitória – por meio de métodos multivariados. Os resultados indicam altos níveis de segmentação dos mercados, jogam luz sobre os processos de suburbanização em contraposição à presença de centros fortes e geram preocupações sobre a capacidade de pagamento dos residentes em alguns municípios. Dentro de cada metrópole, os mercados imobiliários variam substancialmente, evidenciando alto nível de segregação social; entre elas, há similaridades intrigantes, indicando como os locais residenciais e comerciais são (re)produzidos de maneira relativamente genérica no país.

Palavras-chave

Mercados Imobiliários; Rede Urbana; Urbanização; Assentamentos Humanos; Policentralidades; Brasil.

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Introduction

Real estate markets reveal aspects related both to the urban-regional network of a country and to the possibilities of developing this network in a polycentric manner, although these critical dimensions are sometimes either underestimated in the name of exclusively macroeconomic considerations (STORPER; SCOTT, 2003) or excessively focused on primary metropolises of each country (CASTRIOTA; TONUCCI, 2018; ZHANG et al., 2016). In this article, the expression "urban-regional" is used due to an understanding that the contemporary urbanization process is not restricted to the main centralities of each metropolis; it may only be apprehended on a scale that considers the surrounding region and its interrelationships. There is also an emphasis on the "urban network" because the growth of each of these agglomerations is interrelated. Thus, a few cities extend their tentacles over a huge, urbanized space (LEFEBVRE, 1999; MONTE-MÓR, 2006) and, of particular interest for this article, eventually the urban land in such centers becomes exceedingly valorized (ALMEIDA; MONTE-MÓR; AMARAL, 2017; CRONON, 1991). As urbanization progresses, primary centralities buy raw materials and sell advanced products and services to/from increasingly distant locations, and national integration, often guided by the state, connects the flows of products, people and information. The effects of de-agglomeration, such as congestion, high urban land costs and the politicization of the local working class, move a part of industry to other agglomerations, thereby forming new levels of metropolises. This dynamic, simply

put, leads to the formation of a national urban network (CAMPOLINA DINIZ; CROCCO, 2006; IBGE, 2008; PERROUX, 1967). It is assumed that the urbanization process carries with it processes of urban land valorization, and this is a key point to this article.

Thus, the characteristics and functioning of real estate markets are a fundamental aspect of urban networks and urbanization in terms of its process. As the empirical literature has recently observed for continental countries, such as China (ZHANG et al., 2016) and the United States (DEFUSCO et al., 2018), real estate dynamics vary significantly at different poles of the national urban network. In addition, real estate dynamics are key to enabling a more polycentric urban network, and, depending on the planning and intrinsic dynamics of each process, less unequal. One of the deleterious possibilities of urbanization is that secondary, tertiary, quaternary centers, and so forth in the urban hierarchy, become expensive, hindering deconcentration processes. Theoretically, second, third and fourth tier urban-regional agglomerations in the urban network are privileged spaces in these deconcentration processes, since they provide good levels of infrastructure, economies of scale, agglomeration and urbanization, and central services in the sense suggested by Christaller (1966). This perspective dialogues with an endogenous process of national development, in which the territorial dynamics are guided by the possibilities and compatibilities of the country itself, as proposed a few years ago in the *Brasil policêntrico* [Polycentric Brazil] project (BRASIL, 2008)[1].

Given this scenario, the objective of this article is to describe and analyze the real estate markets at different levels of the country's urban network – in Brasília, Belo Horizonte, Salvador, Florianópolis and Vitória – and in different macro-regions (South, Southeast, Northeast and Central-West), based on the new classification of the urban network undertaken by the Brazilian Institute of Geography and Statistics (IBGE, 2020). The article uses a new database built from one of the main real estate network companies for the selected agglomerations. From what may be achieved in the literature review, this is the first attempt to study the real estate markets of this group of metropolises, and the first to use the methodology used here to study real estate markets in general. This methodology enables the creation of typologies of real estate supply in selected agglomerations through the adoption of multivariate analysis methods (cluster analysis). Furthermore, this approach

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1. The then Ministry of Planning, Budget and Management (MP) together with the Center for Management and Strategic Studies (CGEE) contracted the undertaking of the Study of the Territorial Dimension of the PPA. Among the eight modules of this study, Module 3 (Reference Regions) presented a proposal for the regionalization for the Brazilian territory.

provides an understanding of the most relevant variables in order to differentiate these markets (principal component analysis - PCA) and indicates similarities and dissimilarities between them in the different agglomerations.

The results have indicated that the real estate markets are somewhat segmented and segregated[2] in the studied agglomerations. Within each of them, there are substantial variations plus some intriguing similarities. There is also evidence of processes of suburbanization[3] simultaneous to the presence of strong centers. Lastly, there are some preliminary indications, which raise concerns as to whether the housing is affordable for residents in some municipalities. These results may have significant implications for housing policies, for territorial planning, for debates on migration and on the recently studied relationship between macroeconomic cycles and real estate markets in metropolises from different positions in the urban network (DEFUSCO et al., 2018; ZHANG et al., 2016).

This article is structured into three sections in addition to this introduction. The following section presents a brief review of the specialized literature regarding the Brazilian urban network and the selected agglomerations. The second section details the analyzed data and the methodology. In the third part, the results of the PCA and cluster analysis are presented. Lastly, the final considerations are made, with a suggestion for future steps regarding this research.

1. The Brazilian Urban Network

Urbanization processes are anchored by urban agglomerations that organize the territory, concentrate values and centralities, and extend through the surrounding regions thereby connecting one another (CHRISTALLER, 1966; PERROUX, 1967). Each agglomeration represents a node in the urban network. In Brazil, since the 1960s, the Brazilian Institute of Geography and Statistics (IBGE) has conducted research on the urban network – currently called Areas of Influence of Cities (known as Regic) –, with publications in 1967, 1972, 1987, 2000, 2008, and 2018. This last survey was published in 2020 with data referring to 2018. The main objective of Regic is to identify and analyze the Brazilian urban network, establishing the hierarchy of urban centers

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2. By segregation we refer to the distribution of groups in the urban space. Urban studies generally analyze segregation into different groups (socioeconomic, racial, ethnic), defining it as the degree of separation between social groups in an urban space (RASSE, 2019).

3. Here, suburbanization signifies a process that combines population and economic growth and the expansion of the urban fabric beyond the main centrality of an urban agglomeration. This term has become increasingly diverse and complex, as indeed has the very process it describes (KEIL, 2018). For the purposes of this article, it should be noted that the process of suburbanization may result in a variety of real estate transformations, such as skyscrapers, informal occupations and subdivisions, gated communities, housing projects, shopping malls, among others.

and the areas of influence of the Cities. In this publication, as a unit of analysis, the IBGE adopts the set of municipalities and population arrangements – territorial sections that consist of groups of two or more strongly integrated municipalities – and the term "City", with a capital letter, to indicate the main centrality of a node in the urban network (IBGE, 2020). All definitions of levels in the Brazilian urban network in this article are based on Regic.

The deconcentration and extension of the national urban network, with the emergence and strengthening of metropolises and centers beyond a large single national metropolis, are a phenomenon that has been observed in several underdeveloped countries over recent decades. For Africa, see Turok (2016); for China, Zhang and Peck (2016); and, for Latin America, UN-Habitat (2012) and Moura and Pêgo (2016). For a data-based world viewpoint, see Angel et al. (2016). Figure 1 illustrates this dynamic in Latin America and the Caribbean. It demonstrates that national primary cities, such as Guatemala City, São Paulo, Asunción, Caracas, Montevideo and Mexico City, among others, have grown below the national average. On the other hand, of the twelve agglomerations that grew above the national average, eleven are not primary cities in their national urban networks: Valparaíso, Puebla, Medellín, Belo Horizonte, Córdoba, Guadalajara, San Miguel de Tucumán, Fortaleza, Mendonza, Guayaquil and Arequipa – San José, in Costa Rica, is the only exception. In Brazil, Rio de Janeiro (secondary) and São Paulo (primary) grew well below the national average, while the tertiary metropolises of Belo Horizonte, Fortaleza and Recife grew well above the average.
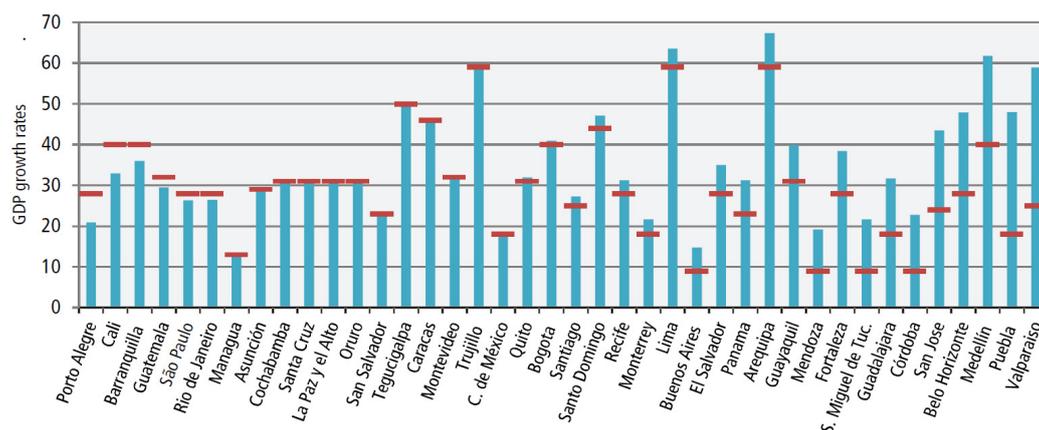

Figure 1. Agglomeration and Country GDP growth *per capita* – Latin America and the Caribbean (2000-2010)

Source: UN-Habitat (2012).

NB.: the blue columns represent the country's GDP per capita growth rate and red lines represent the city's GDP per capita growth rates.

With regard to the Brazilian case, as the literature has described, the decline in urban primacy in São Paulo since the 1970s has not been associated with a continuous process of concentration, nor with complete dispersion. Indeed, Brazilian urbanization, particularly when the industrial production dimension is emphasized, led to the formation of a "polygon", the central position of which was occupied by São Paulo, with the vertices formed by urban-regional agglomerations (CAMPOLINA DINIZ, 1993; 1994).

The agglomerations selected for this study either form some of the vertices of this polygon, such as Belo Horizonte, or are contained within it, such as Florianópolis. Moreover, Salvador was selected, a third-tier metropolis in the Northeast region, not directly connected with the urban-industrial fabric of the Central-South region of Brazil (ROCHA; SILVEIRA NETO; GOMES, 2011; SCHERER; AMARAL; FOLCH, 2019). It should be noted that the "March towards the West" intensified after the 1960s, with the new planned capital, Brasília, playing a key role.

Brazilian urbanization has been increasingly explained through the hypothesis of *extensive urbanization*, according to which the dialectical relationship between countryside and city was overcome by the emergence of the urban (as a noun, indicating urban society) that extends virtually throughout the national territory (CASTRIOTA; TONUCCI, 2018; MONTE-MÓR, 2006), and, increasingly, across the planet (MONTE-MÓR, 2006; KEIL, 2018).

In order to enable a stylized visualization of the urban network in Brazil and the areas of influence of the Cities, Figure 2 illustrates the result of a mapping process that resulted from an analysis of the area of influence or polarization, based on productive chains and geomorphological, political and cultural characteristics. In this figure, the map of Brazil has been remodeled according to its main metropolises and centers, and each polygon represents the area of influence of one or more of the main Cities, represented by the black dots. This is an easier, more simplified manner of visualizing the urban network of Brazil, presented throughout the article, than the one provided by Regic. The illustration, instead of the typical Regic map, brings greater prominence to the metropolises studied in this article – Belo Horizonte (MG), Brasília (DF), Salvador (BA), Florianópolis (SC) and Vitória (ES). As with all simplifications, there is some loss of precision or detail. It is strongly recommended to consult "Map 1 – Urban Network – Brazil – 2018" of Regic 2018 (IBGE, 2020).

Figure 2. The Brazilian Urban Network (2000s)
Fonte: Produced by the authors, adapted from Brasil (2008).

The evolution of the Brazilian urban network has been characterized by a certain degree of repositioning due to a reinforcement on the same set of main centralities (MOURA; NOGAMINE; FERREIRA, 2021). However, more significant changes have been observed in the urban roles and functions of cities and in the interactions between the centers. Transformations may also be perceived in view of "changes in the content and forms in the use of space, combining territorial continuity and discontinuity, concentrated densities, and fragments dispersed throughout the territory" (id., 2021, p. 10)[4]. In this aspect, the City and the Urban Network influence and are influenced by the structural transformations that take place at different scales and periods. Moreover, such transformations involve changes in the physical, spatial and functional characteristics of Cities (IPEA, 2016).

Based on characteristics such as these, in this article, we seek to link the relationships between the urban network and the real estate market. The latter reflects and reveals significant aspects related to the spatial and functional organization of the urban network. The general characteristics of the real estate market, as well as its dynamics, enable analyzes to be undertaken regarding the spatial division of land use and the urban structure between the different levels

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4. This and all other non-English citations hereafter have been translated by the authors.

of centrality/urban hierarchy and within the population arrangements. To this end, the following topic introduces the methodological choices of the study, which, through multivariate statistical techniques – principal component analysis and cluster analysis – seek to create typologies in the real estate market in the selected population arrangements.

2. Methods and data

In recent years, a number of academic studies have described the Brazilian real estate market (AGUIAR; SIMÕES; GOLGHER, 2014; ALMEIDA, MONTE-MÓR, AMARAL, 2017; CAMPOS, 2017; FURTADO, 2007; 2011; NADALIN, 2010; PAIXÃO; ABRAMO, 2008; PAIXÃO; LUPORINI, 2019). However, their focus has always been on a specific city or agglomeration. Due to the location of the authors and/or the availability of public registration data, most of them centered on either Belo Horizonte or São Paulo. There are also works related to the real estate dynamics of the so-called "mid-sized cities", mainly in the interior of the state of São Paulo (see, for example, BARCELLA; MELAZZO, 2020; MELAZZO, 2010). However, to the best of our knowledge, these studies have been based on data from classified ads in newspapers (ABREU; AMORIM, 2014), which substantially differentiates them from the approach adopted in this article, detailed in this section. More recently, an attempt was made regarding Brasília (ALBUQUERQUE et al., 2018). Unlike the United States (SHILLER, 2014) or China (WU; DENG; LIU, 2014)[5], there is no official index of the Brazilian real estate market. Although the Central Bank has made attempts in this direction, the data reveals no evidence of a national index, nor does it enable an analysis of either specific or intra-metropolitan regions.

Given the lack of consolidated and comparable data or an official index for the real estate market in Brazil, throughout time the literature has been based mainly on data from: i) newspaper advertisements; ii) fiscal data on real estate transactions from municipal governments (Capital Gains Tax, known in Brazil as ITBI); and iii) primary data collected in loco. For a critical appreciation of the various problems of these sources, see, among others, Almeida, Monte-Mór and Amaral (2017) and Melazzo (2010). Due to the scope of this work, it should be noted that these traditional sources are very limited spatially: in some cases, they cover only one neighborhood, and in others, only the formal part of transactions that take place in a single municipality. As highlighted in the introduction, understanding

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5. Robert Shiller is one of the creators of the best-known indices for the US housing market, the Case--Shiller indices, which began in the 1980s. Wu Jing, in turn, is one of the creators of an official index for the Chinese housing market.

urbanization, in conjunction with contemporary real estate dynamics, requires a much larger scale. Recently, on the one hand, with the advancement of advertisement platforms for real estate brokerage, and, on the other, with the dissemination of computer programming knowledge in academia, a series of publications built on the basis of web crawlers ("robots" or "scrapers") has emerged, which extract data from these sites. Two examples are those of Almeida, Monte-Mór and Amaral (2017), who used the Netimóveis platform for the Metropolitan Region of Belo Horizonte, and Winke (2017), who worked with the Immobilien Scout GmbH and IDN ImmoDaten GmbH for Frankfurt (Germany) platforms. These platforms are different from advertising sites (such as the Brazilian OLX) since they have been built by real estate companies and gather together ads from hundreds of individual real estate companies. In the abovementioned examples, Netimóveis has a network of more than 150 real estate companies and more than 100 thousand ads (with no repetition), and the two German platforms collect systematic information from 113 real estate companies. It is not the advertising families or individuals who create and manage the ads, as with OLX or other platforms.

In this article, the Netimóveis platform, which has existed in several Brazilian states for a number of years, has also been used. Through the use of a web crawler, it was possible to build a base with more than 30 thousand observations of various typologies for the selected agglomerations. This led to the sample presented in Table 1. The definitions of urban network levels follow official data from the IBGE (2020).

Although data on real estate brokerage is becoming popular in academia, it is essential to indicate the limitations that exist. The supply tends to under-represent informal markets, despite the fact that land tenure is not strictly a necessary condition for a property to be advertised. In addition, there is a tendency to overprice asking prices, given that the negotiation process may generate discounts for the buyer. As the aim of this article is to compare different agglomerations with data collected in the same manner, it is assumed that this is not a problem in itself – if such overpricing is similarly distributed throughout the municipalities.

The agglomerations selected herein reflect the area of the Brazilian market from the platform chosen at the time of data collection (2016): Brasília, Belo Horizonte, Florianópolis, Salvador and Vitória, as presented in Table 1. Although there were other agglomerations on this platform, there were insufficient observations in order to provide certainty as to the means and medians used (more than thirty observations per municipality as a cut-off criterion). Indubitably, it would be of great value if the sample had contained other national metropolises, but this was not possible. Within each of the selected urban agglomerations, it was necessary to

choose some of the main municipalities. In the case of Florianópolis, the criterion of at least thirty observations signified that other metropolitan municipalities were not included in the analysis.

State	Population arrangement	Tier	Municipality	Population (2010)	Annual income *per capita* (BRL/2010)	Area (km²)	HDI[a] (2013)
Federal District[b]	Brasília	2nd	Brasília	2,570,160	62,859.43	5,780	0.824
			Águas Claras	135,000	54,054.12	32	–
Minas Gerais	Belo Horizonte	3rd	Belo Horizonte	2,375,151	32,844.41	331	0.810
			Contagem	603,442	37,995.25	195	0.756
			Nova Lima	80,998	109,298.94	429	0.813
Bahia	Salvador	3rd	Salvador	2,675,656	18,264.13	693	0.759
			Lauro de Freitas	163,449	28,859.89	58	0.754
Santa Catarina	Florianópolis	3rd	Florianópolis	421,240	32,385.04	675	0.847
Espírito Santo	Vitória	3rd	Vitória	327,801	64,001.91	97	0.845
			Vila Velha	414,586	21,914.19	210	0.800
			Serra	409,267	33,039.02	548	0.739

Table 1. The selected urban-regional agglomerations and municipalities

Source: Produced by the authors based on IBGE Cidades and Regic (2008).

Note: a) HDI: Human Development Index; b) The Federal District has a differentiated administrative structure. Águas Claras and Brasília are administrative regions, not municipalities.

As may be observed in Table 1, the sample includes not only the main centrality, but also one or more municipalities of each population arrangement, except in the case of Florianópolis (due to the data; see above). This inclusion is essential to understand the structure of the metropolises, with urbanization expanding more and more and with daily commuting (from home to work) reaching tens of kilometers (ALMEIDA; MONTE-MÓR; AMARAL, 2017; SOJA, 2000; SUDJIC, 1992). Parr (2005) defined the category "city-region" (MAGALHÃES, 2009) based precisely on the commuting capacity of its residents. The sample includes a metropolis from each macro-region of Brazil, except for the Northern region, for which data was lacking for this study, in addition to having a different spatial scale and land use pattern (MONTE-MÓR, 2004; SPAROVEK et al., 2019).

To synthesize and summarize the information contained in the database, principal components analysis (PCA) and cluster analysis were used, which are statistical tools for multivariate analysis widely used in the literature on regional

and urban economics in Brazil (SIMÕES et al., 2005). Through these methods, we sought to create typologies on the structure of real estate markets from the population arrangements in question, which reveal significant rarely studied aspects regarding the functional and spatial division of land use and urban structure at different levels of centrality within the urban network.

The aim of PCA is to reduce and classify a database, preserving an important part of the information contained within the original variables. The structure of the existing correlations is expressed through a smaller number of dimensions, the principal components, which condense a significant part of the total variability. This is an exploratory method that neither involves methods to be tested a priori nor does it postulate causality (HAIR et al., 2009; MINGOTI, 2005). The principal components are generated based on the highest eigenvalues associated with the sample correlation matrix, which reveal the percentage of the total variance explained by the components. Thus, the k new dimensions are generated by linear combinations of the original p variables ($k < p$), in which the weight of each original variable i in the principal component j will be determined by the corresponding eigenvector. In other words, the methods synthesize information and are useful when there is a large number of characteristics, as is the case of the study object of this article.

The typologies considered were: i) **apartment** – apartments with one to four bedrooms, a typology that also includes lofts and studios (very small two-room apartments); ii) **houses** – houses in general, houses in gated communities and semi-detached houses; and iii) **commercial category** – stores, commercial offices, rooms, commercial areas and warehouses. The set of variables contains information on the typologies advertised for sale related to the area, price, number of bedrooms and ensuites, number of bathrooms, number of parking spaces, in addition to the percentage of supply in that municipality that accept financing. These property typologies, combined with the available information, gave rise to seventeen variables. While it is recognized that there are important differences between residential real estate and commercial real estate markets, not including one of these categories in the analysis could distort the understanding of the main characteristics of metropolises as a whole. Essentially, the presence of offices, rooms and commercial areas characterizes the main centralities of each metropolis, much as their absence characterizes certain residential suburbs, and industrial warehouses correspondingly characterize industrial axes of the metropolises. If residential and commercial markets are analyzed separately, the results may demonstrate a material difference from the results presented below.

Information	Unit	Variables per typology
Price	R$ (BRL)	Apartment (*price_ap*), House (*price_house*) and Store (*price_store*)
Area	m²	Apartment (*area_ap*), House (*area_house*) and Store (*area_store*)
Financing	% of the supply that accepts financing	Apartment (*financ_ap*), House (*financ _house*) and Stores (*financ _store*)
Bedrooms	Number	Apartments (*bed_ap*) and Houses (*bed_house*)
Ensuites	Number	Apartments (*suite_ap*) and Houses (*suite_house*)
Bathrooms	Number	Apartments (*bath_ap*) and Houses (*bath_house*)
Garage	Number of spaces	Apartments (*garagem_ap*) and Houses (*garagem_house*)

Table 2. The variables used in the study

Source: Produced by the authors.

Given the seventeen variables created in the base, the PCA was a useful tool to synthesize such an amount of information. The median values of these variables were used – the mean was not used due to the extreme values.

One additional step consisted of classifying the similarities between the chosen municipalities through cluster analysis, a technique whose objective is to group the elements of the sample as a result of a set of attributes according to measures of similarity or dissimilarity, so that the clusters formed are internally homogeneous or heterogeneous among themselves (HAIR et al., 2009; MINGOTI, 2005). With regard to this article, our starting point was a measure of dissimilarity, the Euclidean[6] distance between the observations, as a reflection of the selected characteristics. An agglomerative hierarchical cluster was used, since there was no previous suggestion as to how many clusters (sets) there were. This approach allowed us to visualize similarities and dissimilarities between these municipalities and agglomerations, as well as creating typologies of real estate markets by municipalities in the agglomerations studied. For example, the results demonstrate that there is a characteristic pattern of real estate supply for the "industrial cities" of each metropolis, as detailed in the following section. Ward's clustering method and the same seventeen variables were used, which include the median values by municipality and by typology of the available variables (prices, rent, area, monthly building maintenance fee, number of rooms, suites, parking spaces, proportion of supply that accepts financing).

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6. The Euclidean distance between two cities, i and j, may be calculated as $d(i, j) = [\sum p(x_{ip}-x_{jp})^{½}]$, taking into account the p dimensions considered.

3. Results: variabilities and similarities of the real estate markets in the Brazilian urban network

The results of the PCA demonstrated that three components explain around 75% of the total variance. More details may be obtained from the attachments at the end of the article. Figure 3 presents the graph of variables and municipalities for two dimensions. According to Scherer, Amaral and Folch (2019, p. 13), this "is a useful tool since the angle formed by any two variables, represented as vectors, reflects their actual pairwise correlation. Also, on the graph, objects are distributed based on their similarity and attraction to each other". The direction and size of the arrows represent the loads for each of the features of the property, while the position of the points represents the combination of the scores of the first two components of each municipality.
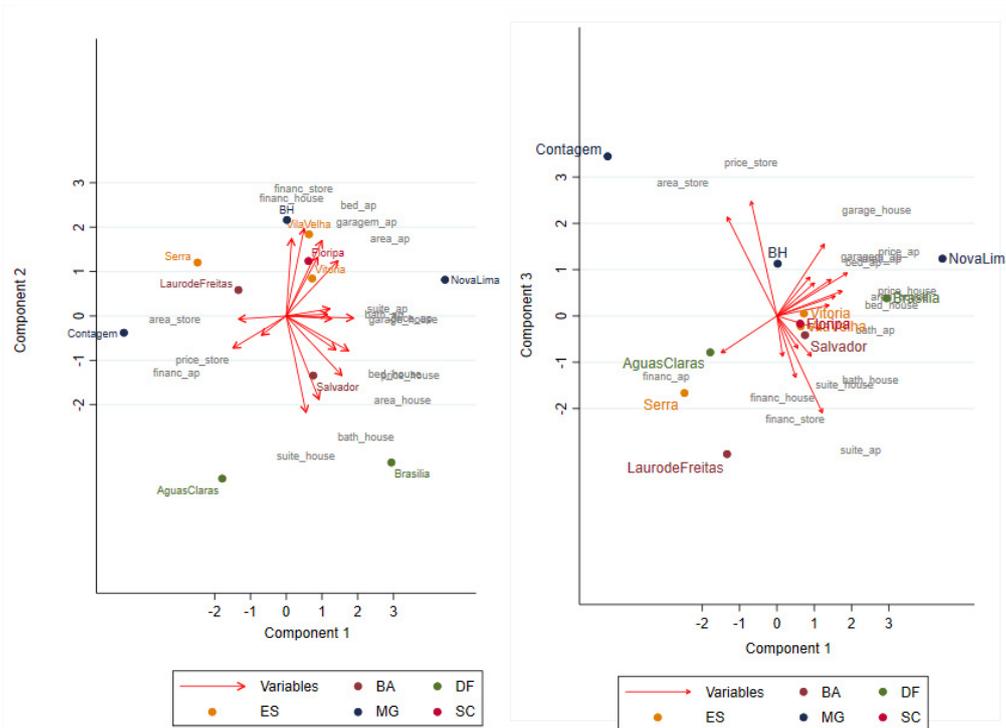

Figure 3. PCA: variables, municipalities and two dimensions
Source: Produced by the authors.
NB: The dots (.) represent observations and the arrows (→) represent variables.

It should first be clarified that the name "Florianópolis" was abbreviated to "Floripa" and "Belo Horizonte" to "BH" so as to fit into the figure. The PCA results illustrate the distinctive features of the housing market in the municipalities of the selected agglomerations. In Figure 3, the graph on the left presents the

relationship between Components 1 and 2 of the PCA, while the graph on the right presents the relationship between Components 1 and 3. Component 1 mainly carries information on apartment and house prices, together with house size (m²). Thus, it may be described as an information synthesis of the residential market, especially in terms of price/m². Component 2 differentiates between houses and apartments, highlighting on the decreasing axis the importance of the constructive characteristics of houses, such as size, number of bedrooms and bathrooms, and, on the increasing axis, these same characteristics for apartments. Component 3, in turn, focuses on aspects of the commercial real estate market, with greater emphasis for areas and prices.

Variable	Comp. 1	Comp. 2	Comp. 3	Not explained
area_ap	0,2888	0,2482	0,1572	0,1758
area_house	**0,3105**	−0,2679	0,0851	0,1035
area_store	−0,2658	−0,014	**0,4259**	0,06507
bath_ap	0,2300	0,0077	−0,0573	0,6632
bath_house	0,1833	**−0,3755**	−0,173	0,1602
bed_ap	0,1993	**0,3385**	0,1416	0,2523
bed_house	0,2778	−0,1525	0,0464	0,4254
financ_ap	−0,2966	−0,1446	−0,1587	0,3049
financ_house	0,0304	**0,3476**	−0,1734	0,4406
financ_store	0,0999	**0,3920**	−0,2646	0,147
garage_house	0,2529	−0,0128	**0,3091**	0,3417
garagem_ap	0,1762	0,2644	0,1673	0,4585
price_ap	**0,3756**	−0,0092	0,1849	0,03254
price_house	**0,3479**	−0,1567	0,1073	0,1234
price_store	−0,1377	−0,087	**0,4934**	0,1863
suite_ap	0,2430	0,0322	**−0,4174**	0,1532
suite_house	0,1104	**−0,4346**	−0,1382	0,1355

Table 3. Components
Source: Produced by the authors.

In general, the municipalities with the highest prices and areas, for residential use, present the highest values in Component 1 (horizontal axis). This is the case of Brasília and Nova Lima. The first is the federal capital of Brazil, where residences are commonly described as high-value homes in the so-called "Plano Piloto", mainly near Lake Paranoá. From the 1980s, Nova Lima became a privileged space for the

elites of Belo Horizonte who acquired houses in gated communities (ALMEIDA; MONTE-MÓR; AMARAL, 2017; COSTA et al., 2006; TONUCCI FILHO; FREITAS, 2020). At the other end of this axis, Contagem and Serra are industrial cities, where housing for both the middle- and working-class residents is produced. The vertical axes (Components 2 and 3 in Figure 3) carry information regarding the constructive characteristics of houses and apartments (2) and commercial properties (3). In the Component 2 axis, Belo Horizonte, Vila Velha, Vitória and Florianópolis are the most outstanding. The first is known for its density (more than 7,000 inhabitants/km^2), which is high by Brazilian standards. The other three are coastal agglomerations, with Vila Velha and Vitória being part of the same metropolis. Both Vitória and Florianópolis are islands. These geographic characteristics, associated with human geography and local real estate dynamics, have produced verticalized coastal strips, with many apartments, as indicated by Villaça (2001).

Part of Belo Horizonte's vertical/high density has extended through to the limits of Nova Lima, where a new centrality (Seis Pistas/Vila da Serra) features expensive apartments in high-rise buildings. This is one of the reasons why in Nova Lima there are both expensive houses (further from Belo Horizonte, in gated communities) and expensive apartments (on the border with Belo Horizonte) (ALMEIDA; MONTE-MÓR; AMARAL, 2017; CAVALCANTE; ALMEIDA; BAKER, 2016; UFMG, 2011). On the other hand, the real estate markets mostly offer houses in Brasília. This configuration is one of the reasons why Águas Claras has been predominantly occupied by apartment buildings. Industrial and/or suburban cities, such as Contagem, Serra and Lauro de Freitas, are less vertical.

The third main component of Figure 3, which highlights aspects of the commercial real estate market, presents the municipality of Contagem in the plot – possibly due to the use of land for constructing large industrial/logistic warehouses and for shopping malls.

This discussion guides the classification of similarities between the municipalities of the agglomerations through cluster analysis. The agglomeration coefficient was 0.88, suggesting a strong clustering structure, i.e., relatively highly segregated groups.

Figure 4 illustrates the dendrogram, or tree map, for the hierarchical clustering of municipalities in the selected agglomerations. The results indicate that real estate markets are somewhat segregated in these metropolises. Real estate markets supply very different products in the same population arrangement. For example, Belo Horizonte, Nova Lima and Contagem belong to the same metropolis, however their real estate markets are quite different. The same occurs with

Brasília-Água Claras, Vitória-Serra and Salvador-Lauro de Freitas. These pairs of municipalities are physically separated by just a few kilometers, but they present very different residential and commercial properties in terms of price, constructive characteristics and proportions of advertisements that accept financing. On the other hand, real estate markets supply relatively similar products in municipalities in different metropolises, indicating relative homogeneity in real estate production across Brazil.
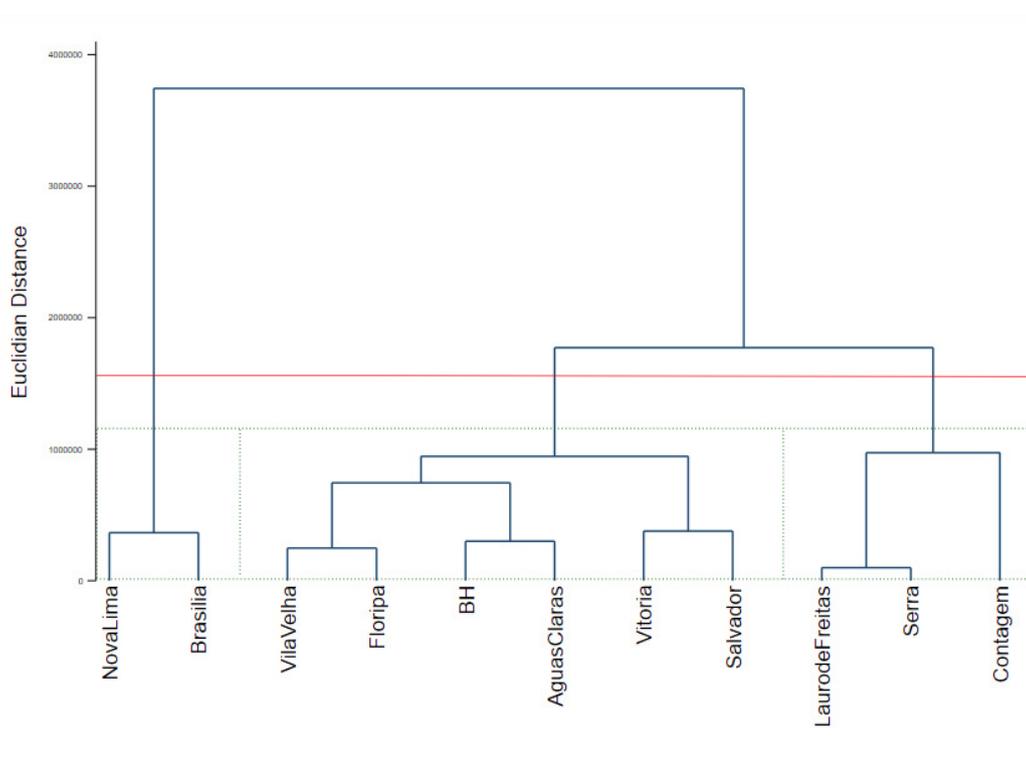

Figure 4. Hierarchical clustering
Source: Produced by the authors.

On one side of Figure 4, Contagem, Serra and Lauro de Freitas are on the same branch of the generated tree. We may, illustratively, refer to this branch as the old industrial cities. They have similar real estate markets, with high proportions of affordable financed apartments, simple houses with a reduced number of bedrooms and bathrooms, large industrial/logistics warehouses and shopping malls. Spatially, these municipalities have political limits with the capital of the respective state and are crossed by major highways. At the other extreme of Figure 4, Nova Lima and Brasília illustrate real estate markets related to the local elites, who live in mansions close to water bodies and, to a lesser extent, in expensive apartments. In other words, the variables related to prices and the

constructive characteristics of the housing market (mainly house typology) were those that stood out the most in these two municipalities. The third large group, formed based on the selected seventeen variables and composed of Vila Velha, Florianópolis, Belo Horizonte, Águas Claras, Vitória and Salvador, is characterized by having more diversified markets. Here, relatively expensive apartments and a significant supply of services are highlighted, seized by commercial real estate with high values and relatively small areas. Florianópolis, Belo Horizonte, Vitória and Salvador are the main centers of the respective metropolises. The results for Vila Velha and Águas Claras, both belonging to this third large group, and that are not capital cities, may be interpreted because of the urbanization process that has raised the price of land sufficiently to stimulate the verticalization of their territories (supply of apartments), in addition to having generated significant commercial hubs for upper-middle income groups (supply of rooms and stores).

Although there is a notable difference, in terms of population and GDP, between Vitória and Florianópolis and the other metropolises considered in the study, the most recent classification by Regic grouped both as metropolises on the same level as Belo Horizonte and Salvador. In the 2008 publication, the two appeared at a lower level, as Regional Capital A, the fourth level in the hierarchy. The results of this work, expressed in Figure 4, based on the real estate markets, corroborate this latest publication by Regic/IBGE, since the municipalities that make up the population agglomerations of Vitória and Florianópolis are classified in the same branches of the tree resulting from the hierarchical clustering as the municipalities in the Belo Horizonte and Salvador agglomerations.

The results also shed some light on issues related to whether the residents of municipalities can afford to pay in relation to the characteristics of the local real estate market. Considering the per capita income level (Table 1), Salvador and Vila Velha particularly raise concerns regarding their housing affordability, since they are grouped by the cluster with Belo Horizonte, whose per capita income is much higher. For example, the median prices per square meter of apartments in Vila Velha (around R$4,400/m) were only slightly lower than those in Belo Horizonte (around R$5,100/m) and Águas Claras (around R$ 5,300/m). Salvador (R$ 5,200/m) raises even greater concerns regarding affordability and access to housing, considering the per capita income of residents in the municipality. It should be remembered, once again, that the methodologies used considered seventeen variables, which extend beyond the price and area of supply, and include several real estate typologies.

This empirical approach also enables us to introduce some evidence on the spatial trends of Brazilian metropolises, in terms of concentration/dispersion or

decay of central areas as opposed to the emergence of polycentrism. The results indicate that capitals continue to play relevant roles as commercial points and offer a diversity of real estate properties. These central cities of the metropolises remain as central places for both commercial and residential use. This may be interpreted as evidence of how Brazilian, and possibly Latin American, urbanization differs from that of the United States, for example, where central cities became degraded areas in many metropolises and the elites "fly" to suburban homes (ABRAMO, 2012; BETANCUR, 2014; EHRENHALT, 2012; HARVEY, 2014).

The result presented echoes the observations of part of the literature in studies on gentrification, in which it is stated that there is no generalized, radical process whereby the elites have returned to city centers in peripheral or semi-peripheral countries of global capitalism, since they have not made a massive move away from the main centralities in the past (BETANCUR, 2014; MALOUTAS, 2018; ALMEIDA et al., 2022). This result is also in line with those found by Nadalin, Furtado and Rabetti (2018), according to which relevant metropolises in the national context continue to have strong centers. The aforementioned researchers also mentioned that Belo Horizonte and Salvador decreased the vacancy rate of the real estate stock in the central areas between 2000 and 2010, although they were still very expressive (9% in the first and 10% in the second). On the other hand, the results detailed herein provide evidence of a formation process of new centralities on the peripheries Cities and the suburbanization of wealth through gated communities – both processes widely described in the national literature (ALMEIDA; MONTE-MÓR; AMARAL, 2017; CALDEIRA, 2001; COSTA et al., 2006). Of the municipalities available for analysis, Nova Lima was the emblematic case.

Such results capture a snapshot of the real estate markets of these urban-regional agglomerations at a given point in time. However, they do not capture the one referring to real estate dynamics (these are static), nor do they intend to provide definitive interpretations of these agglomerations. As discussed in the first section of this article, the nature of urban networks is constantly changing, as are real estate markets. This may be observed through the results of Regic over different decades. Furthermore, new extractions of real estate data and other sources may lead to different results.

Final considerations

This article has explored Brazilian real estate markets from the perspective of their urban network and urbanization. The methodology used may serve as a basis for studies in other countries and may also be applied to other types of databases. The PCA and the hierarchical clustering techniques have demonstrated how the

selected metropolises present a very segregated spatial structure, considering their real estate markets. Specific municipalities within the population arrangements are predominantly destined to be the habitat of the middle- and working classes, such as Contagem (MG), Serra (ES) and Lauro de Freitas (BA), while, in others, the real estate market produces luxury homes for the elites, such as Nova Lima (MG) and Brasília (DF). These forms of segmentation/segregation in the market are present in all the arrangements studied.

Capital cities continue to be very relevant as commercial and residential areas. On the other hand, there is evidence that centralities form in other metropolitan municipalities beyond the capitals.

In other words, real estate markets offer very different products in the same population agglomeration. Pairs of municipalities that are geographically close have very different residential and commercial properties in terms of price and constructive characteristics. On the other hand, there is evidence of relative homogeneity in real estate production, with real estate markets offering relatively similar products in municipalities in different metropolises. These two results suggest a pattern of segregated and, at the same time, generic urban-regional agglomerations in the Brazilian regions studied.

It is possible to classify the real estate markets of the studied metropolises into ideal types that, illustratively, we may refer to as industrial suburbs (Contagem, Serra and, to an extent, Lauro de Freitas), main centralities within their agglomeration (Salvador, Vitória-Vila Velha, Belo Horizonte and Florianópolis) and wealthy suburbs (Nova Lima). The urban structure of the Federal District needs to be further studied, with a peculiar segmentation pattern between Brasília (grouped by the clustering method with Nova Lima) and Águas Claras (grouped with the main centralities).

The next steps of this research could include more municipalities and population agglomerations in the sample. According to recent research, comparisons between different levels of the urban network may lead to important implications for both macroeconomic and housing policies. For example, the effects of interest rates on house prices may vary at different levels of cities in a country's urban network (ZHANG et al., 2016). The cycles of booms, crises and housing bubbles may also present a different pattern (DEFUSCO et al., 2018). Subsidies for real estate financing must also consider the diversities and similarities in real estate (re) productions across countries. One of the most desirable advances in this type of research would be the creation and consolidation of a national property index in Brazil – a typical challenge for undeveloped countries with large territories and populations.

Attachments

Component	Eigenvalue	Explained variance	
		Percentage	Cumulative
Component 1	6,1911	0.3642	0.3642
Component 2	3,9010	0.2295	0.5937
Component 3	2,7387	0.1611	0.7548
Component 4	1,5710	0.0924	0.8472
Component 5	1,1474	0.0675	0.9147

Table A1. Eigenvalues and percentage of the explained variance of the first five components
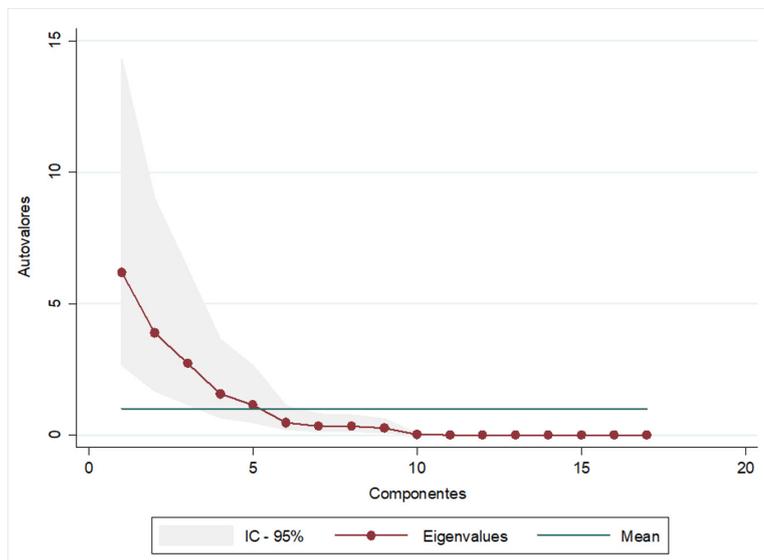Source: Produced by the authors.

Figure A1. Scree plot of the eigenvalues
Source: Produced by the authors.

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