Article

Mercator, Fortaleza, v.20,e20026, 2021. ISSN:1984-2201

CHARACTERIZATION OF BUSINESS POLES OF TIMBER HOUSES IN BRAZIL

https://doi.org/10.36517/rm2021.e20026

Victor Almeida de Araujo [a*] - Juliano Souza Vasconcelos [b] - Elen Aparecida Martines Morales [c]
Francisco Antonio Rocco Lahr [d] - André Luis Christoforo [e]

(a) PhD in Forest Resources. University of São Paulo, São Paulo (SP), Brazil.
ORCID: http://orcid.org/0000-0002-2747-4738. **LATTES:** http://lattes.cnpq.br/7419315199923119.
(b) PhD student in Agronomy. São Paulo State University Júlio de Mesquita Filho, Rio Claro (SP), Brazil.
ORCID: http://orcid.org/0000-0002-3305-0384. **LATTES:** http://lattes.cnpq.br/6323583415428794.
(c) PhD in Materials Science and Engineering. Professor at the São Paulo State University Júlio de Mesquita Filho, Botucatu (SP), Brazil.
ORCID: http://orcid.org/0000-0002-9013-1578. **LATTES:** http://lattes.cnpq.br/9011723953760997.
(d) PhD in Structural Engineering. Professor at University of São Paulo, São Carlos (SP), Brazil.
ORCID: http://orcid.org/0000-0002-3510-8498. **LATTES:** http://lattes.cnpq.br/2333091200416653.
(e) PhD in Structural Engineering. Professor at University of São Paulo, São Carlos (SP), Brazil.
ORCID: http://orcid.org/0000-0002-4066-080X. **LATTES:** http://lattes.cnpq.br/7623383075429186.

Article history:
Received 11 January, 2021
Accepted 18 August, 2021
Published 15 October, 2021

(*) CORRESPONDING AUTHOR
Address: Rua Geraldo Alckmin. Vila Nossa Senhora de Fátima, CEP: 18409010,Itapeva (SP), Brasil. Phone: (+55 15) 35249107
E-mail: engim.victor@yahoo.de

Abstract

The importance of civil construction is related to development of territories, permeating generations. But, little is known about civil construction production sectors, especially, in the group directed to timbered houses. Thus, this study identified and characterized those Brazilian poles of timber houses, whose purposes were related to the qualitative-quantitative-geographical self-knowledge by actors and business partners of this sector. Two phases were carried out in the study, being the analysis of companies effectively active to identify their concentrations, and the mapping of business poles from the proposal of a hierarchical scale. Data prospection was supported by the searching of company websites and social networks. Findings evinced a sectoral dynamism in times of retraction, since the volume of active companies has grown in comparison to the rare studies. Most companies are active and present activities more focused on production than market. Business concentrations and poles intensified in the North-South direction of the country, specifically, in developed metropolitan areas and coastal regions.

Keywords: Sectoral Mapping, Business Concentration, Timber Construction.

Resumo / resumen

CARACTERIZAÇÃO DOS PÓLOS COMERCIAIS DE CASAS DE MADEIRA NO BRASIL

A importância da construção civil se relaciona com o desenvolvimento dos territórios, permeando gerações. Mas, pouco se sabe acerca dos setores produtivos da construção civil, sobretudo, do ramo direcionado às casas de madeira. Assim, este estudo identificou e caracterizou os polos empresariais brasileiros das casas de madeira, cujos fins foram relacionados ao autoconhecimento qualitativo-quantitativo-geográfico por parte de atores e potenciais parceiros desse setor. Duas fases foram conduzidas no estudo, sendo a análise das empresas efetivamente ativas para identificar as suas concentrações e o mapeamento dos polos empresariais a partir da proposta de uma escala hierárquica. A prospecção de dados foi suportada por buscas em websites e redes sociais das empresas. Os achados evidenciaram um dinamismo setorial em tempos de retração, já que o volume de empresas ativas tem crescido em comparação aos raros estudos. A maioria das empresas está ativa e apresenta atividades mais focadas à produção do que ao comércio. As concentrações e os polos empresariais se intensificaram na direção Norte-Sul do país, especificamente, nas áreas metropolitanas desenvolvidas e regiões costeiras.

Palavras-chave: Mapeamento Setorial, Concentração Empresarial, Construção em Madeira.

CARACTERIZACIÓN DE LOS POLOS DE NEGOCIOS DE CASAS DE MADEIRA EN BRASIL

La importancia de la construcción civil está relacionada con el desarrollo de territorios, que impregna generaciones. Sin embargo, se sabe poco sobre los sectores productivos de la construcción civil, especialmente la rama destinada a casas de madera. Así, este estudio identificó y caracterizó los polos de negocios brasileños de viviendas de madera, cuyos propósitos fueron relacionados con el autoconocimiento cualitativo-cuantitativo-geográfico por parte de actores y socios potenciales en este sector. Se realizaron dos fases en el estudio, siendo un análisis de las empresas efectivamente activas para identificar sus concentraciones y el mapeo de los polos de negocios a partir de una propuesta de escala jerárquica. La prospección de datos fue respaldada por búsquedas en sitios web y redes sociales de las empresas de este sector. Los resultados mostraron un dinamismo del sector en tiempos de retracción, ya que el volumen de empresas activas ha crecido en comparación con los estudios raros. La mayoría de las empresas está activa y tiene actividades que se centran más en la producción que en el comercio. Las concentraciones y los polos de negocios se han intensificado en la dirección Norte-Sur del país, específicamente, en áreas metropolitanas desarrolladas y regiones costeras.

Palabras-clave: Mapeo Sectorial, Concentración Empresarial, Construcción en Madera.

This is an open access article under the CC BY Creative Commons license
Copyright © 2021, Universidade Federal do Ceará.

INTRODUCTION

Timber houses are a viable option with high sustainability levels, productive pre-fabrication, typological variability, quality standardization, constructive flexibility, and architectural plurality.

Although using wood does not represent an intrinsic guarantee of an ideal architecture, Natterer (2002, 2004) proposed that it makes an essential contribution to environmental conservation, despite the need for more profound construction planning.

Given the cultural transmission from European immigration, Zani (2013) highlighted that the speed and ease of construction and the availability of forest resources were the main reasons for the proliferation of timber houses in Brazil.

According to Folz and Ino (2012), in the Brazilian context, a greater interest in these building systems may be intensified from the demand for more sustainable products, the supply of wood from forest plantations, and the increasing activity of the national construction sector.

Studies on a variety of aspects of the production of timber houses in Brazil have been carried out by authors including Sobral et al. (2002), Punhagui (2014), De Araujo et al. (2018a; 2018b; 2019a; 2019b), and Shigue (2018). Their discussions have been opportune for the perception of this sector; however, a visual representation of this vast industry remains unpublished.

Identifying the companies that compose less expressive sectors, such as timber housing, is essential to personify a self-image. Thus, mapping and identifying concentrations of companies configured as business hubs are means of supporting of development plans.

Porter (1998) interprets these hubs, or clusters, as geographic concentrations of companies and institutions interconnected in a specific domain, including entities linked to each other and other companies essential for competition.

These territorial approaches retain an essential role in innovation and economics, as highlighted by Taddeo et al. (2017). This importance has been confirmed in practice. Schmitz (1997) suggested that groups of small companies worldwide have been able to face consolidated international markets.

Therefore, despite some studies mentioned above regarding the Brazilian production sector of timber houses, the current scenario still demands updated and more detailed data to identify and characterize its business hubs in terms of population volume. Therefore, this proposal sought to identify companies related to the production and trade of timber houses in Brazil, delimit macro-regional, state, and municipal concentrations, and, simultaneously, categorize business hubs according to municipality by developing a hierarchical populational scale. The data obtained is essential for the future, above all, to develop this industry based on easily renewable and industrially processed raw materials, given Winter, Lechner, and Köhler's (2018) prediction that wood has a great chance of leading a future process of construction industrialization.

MATERIALS AND METHODS

STUDY AREA

Based on the observations of De Araujo et al. (2018b) on the formal disarticulation of timber house producers in Brazil, this study sought to explore this information-poor niche to foster their development. Consequently, the study area considers all the members of this business sector located in the Brazilian territory.

DETAILED METHODOLOGY GUIDE

Due to the different characteristics of the information obtained, this study was divided into two phases. In this dyad, data were quantitatively and qualitatively entered and preserved using Microsoft Office 2016 Excel software. While the first phase involved data collection and analysis of active companies to identify their concentrations, the second phase was based on the proposal of a hierarchical scale and the mapping of the Brazilian hubs of companies related to the production and trade of timber

houses.

Initially, the first stage aimed to produce a list of all these companies. This random investigation process involved a broad search for companies online through three platforms: the Google search engine and the Facebook and Instagram social networks. The information displayed for each company found was observed, and, when compatible with this study, its trade name, and data (social networks, website, location, operating condition, and type of activity) were registered in the business listing.

As these searches showed companies that had closed and former producers (with other activities or impeded by judicial indictments), a triangulation process was used to certify the veracity of the data obtained. Thus, the companies were categorized to guide the analysis and obtain valid results by labeling each individual based on their operating status (Table 1).

Property Status	Characteristics related to operation and sector	Result in use
Operating	Existing and related to the sector	Valid
Former producer	Existing but not currently related to the sector	Gross
Inconsistent	Related to the sector, no confirmed existence	Gross
Indicted	Related to the sector, but indicted by the justice system	Gross

Table 1 - Categorization of companies according to their operational status. Source: by the author.

The operational status was verified by checking the dates of updates and public displays of contact with customers. In this case, individual companies whose social profiles had updates and/or client contacts during the previous twelve months (June 2019 to May 2020) were considered actively operative. In contrast, search data on individuals before the period analyzed were considered companies with inconsistent data and, therefore, they were not considered be in operation.

Some active companies were identified as former producers of timber houses, as their operational activities effectively differ from this purpose, such as the production of masonry structures and trade in construction materials. So, it was acknowledged that having been a producer in the past is no guarantee of being a producer at the time of analysis; consequently, ex-producers were not considered.

Surprisingly, it was confirmed that some companies had legal restrictions on their operations attributed to some possible criminal indictment by the Brazilian justice system. Based on the argument applied to the previous group (ex-producers), disregarding indicted companies was justified by the inactivity of their operations.

Each exclusion was ratified based on confirmation in publicly disseminated public and press sources, for example, Borges (2011), Torres (2014), Correio do Povo (2018), Costa (2018), the Public Prosecutor of Rio Grande do Sul State (2018), Müller (2019), and Recalcati (2019), among others.

Once the valid and relevant results for those effectively operating companies were obtained (Table 1), the second phase detected a more assertive scenario. To characterize the valid individuals sampled, the type of operational activity was verified to understand further the sector's productive and commercial representations (Table 2). This secondary stage of the second phase diverged from previous studies that focused essentially on the production scope.

Activity	Characteristic of the company related to the activity	Result in use
Handcrafter	Craft producer of special projects	Valid
Manufacturer	Factory producer of special industrialized projects	Valid
Project and management leader	Office of project design and building execution	Valid
Supplier	Timber industry and sawmill focused on prefabricated kits	Valid
Reseller	Resale company of prefabricated kits	Valid
Assembler	Assembly team of prefabricated kits	Valid

Table 2 - Categorization of companies according to operational activity. Source: by the author.

By grouping these refined data (valid results), a third stage measured and illustrated business concentrations according to the number of active individuals in each Brazilian municipality, state, and macro-region. In representations of federal units and macro-regions, the results were expressed in

percentages, obtained by the proportionality principle.

Based on these quantitative data, the fourth stage involved developing a hierarchical scale to organize and measure the business hubs based on the number of individuals per analyzed territory. The short standard script, which is presented in the following section, was established as a supplementary result to the analysis of this sector, as this tool can be applied to different sectorial studies.

Finally, based on this hierarchical scale, the fifth stage of the hierarchical scale classified and listed the existing hubs, whose results were considered to visually exhibit the contrasts between each identified hub. The creation of these maps respected the locations (municipalities, federative states, and macro-regions) shown in the Google Maps geographic tool.

DEVELOPMENT OF A HIERARCHICAL SCALE TO IDENTIFY BUSINESS HUBS

A hierarchical organization was developed to measure the business hubs by the number of individuals located per municipality. This methodology can be replicated and adapted to any studies of sectoral populations, including individuals from other nations.

This tool sought to advocate a model guide for developing company mappings. Different percentage ranges related to the number of individuals sampled and the categories of characteristic volume were standardized to support the process. In other studies, these amounts of individuals and percentage ranges by measured category can be adjusted case by case, as the industry has many contrasts and populations.

As a result of the absence of classifications on business hubs in the literature, the referential scale was based on the type of development given the number of active companies.

In the case of the results obtained in this study, specifically on the relationship between the active business population and those head offices identified (Appendix 1), an average proportion of between two to three companies per municipality was reached nationally. Categorizing the hubs according to the business volume was carried out successively, from the average ratio obtained for the whole study sector.

This conjecture allowed the first category of hubs to be created and designated as "hub in formation" for that volumetric condition from this national average; that is, municipalities must exceed this average proportion to qualify as a hub. Athreye and Kapur (2006) support this quantitative perception of concentrations, which involve the extent of production between companies.

Business Volume Category	Percent Ranges *	Number of Companies
Hyperdeveloped hub	+13% to 100%	≥ 50 or +
Super-developed hub	+7.8% to 13%	30 to 49
Developed hub	+5.2% to 7.8%	20 to 29
Developing hub	+2.4% to 5.2%	10 to 19
Underdeveloped hub	1.6 to 2.4	7 to 9
Hub in formation	+0.8% to 1.6%	4 to 6
Small group of companies	+0.4% to 0.8%	2 to 3
Isolated company	0 to 4	1
Absence of companies	0%	0

Table 3 - Hierarchy of business hubs according to the number of companies obtained from the percentage ranges of individuals related to the sector studied. Source: by the author.

* suggestions for percentage volume ranges of individuals relative to the sectorial population;

** active individuals regarding the operability of their activities related to timber houses.

In all, nine categories were devised to formalize the registration of individuals and municipalities. The designations "absence of companies" and "isolated company" are the starting point for those locations with no company or only one individual in the sector under study, respectively. The proportion

of two to three individuals was called "small group of companies" since this ratio determined the specific inflection point for a city to be classified as a hub. Next, the classification of the hubs included six intensities: in formation, underdeveloped, developing, developed, super-developed, and hyperdeveloped. Each degree was formed by an index composed of a minimum and a maximum percentage referring to the minimum and maximum number of individuals admitted in each category (Table 3).

DATA VALIDATION BY STATISTICAL ANALYSIS

An additional step was employed in the study to validate the results. The margin of error ensured the probability of reliable answers, considering the quantities obtained (sample and total population). In this analysis, three scenarios were predicted to suggest possible population sizes for the sector.

Notwithstanding its wide diffusion in the Human Sciences, this statistical tool has been used efficiently in Engineering studies such as Kozak and Cohen (1999), Sejdiu et al. (2015), Pazkad, Osmond and Corkery (2017), and De Araujo et al. (2018a; 2018b; 2019a; 2018b), among others. The sampling error margin was verified by carefully following the recommendations of the Raosoft statistical software. To this end, Raosoft (2004) recommends a 95% confidence level and a 50% response distribution.

RESULTS AND DISCUSSION

FIRST PHASE: DATA MINING AND THE ANALYSIS AND IDENTIFICATION OF HUBS

After 40 days of searching for companies in the timber house sector in Brazil, the results giving new answers petered out, suggesting the end of this preliminary stage. Then, the second stage categorized each company according to its current operating condition, and the final listing was completed (Table 4).

Most of these companies (75.6% of the sector) were actively operating. However, this amount could be even higher if any individual(s) classified as inconsistent (18.4%) was (were) working in the analyzed period. Compared to De Araujo et al. (2018a; 2018b; 2019a; 2019b), only a tiny portion of the companies (1%) were identified as former producers. Finally, 5% of the companies identified have restrictions due to judicial indictments (Table 4).

Due to the constant search for companies to form the sectorial list (Table 4), the random online investigation did not count those companies that choose not to disclose their brands and products in digital media.

Despite the huge popularity of social networks and corporate websites, it is still possible that both old and new companies are not online or do not want coverage on such media.

Status Type	Number of individuals (companies)
Operational	378
Former producers	5
Inconsistent	92
Indicted	25
Gross total across the industry	500

Table 4 - Population quantification according to operating status. Source: by the author. Collection Date: June 1, 2020.

Due to the lack of a formal definition of the timber house production sector in Brazil to represent companies and gather their information, the total population of this sector is uncertain and dynamic, like any sector deficient in studies and representation. Sparse studies have delimited the possible size of this sector at different times.

Sobral et al. (2002) highlighted that the state of São Paulo had about 15 producers in 2001. However, the first analysis at the national level was conducted by Punhagui (2014), whose list included around 50 producers of prefabricated timber houses. Subsequently, considering different production models (craft to modular) and construction techniques (15 systems and variants), De Araujo et al. (2018a; 2018b; 2019a; 2019b) listed a broad sectorial representation of at least 210 Brazilian producers, 107 of which were physically identified between 2015 and 2016.

Thus, given the lack of an exact population volume for this research period (2020), whether in the scientific literature or governmental and institutional technical documents, this data is still formally non-existent, justifying this study's initiative to determine its size, as shown in Table 4.

As not all of the five hundred companies that theoretically make up the general scenario of the timber house sector in Brazil (Table 4) were considered, the sample only summarized the 378 individuals in effective operation, that is, without measuring inconsistent or indicted companies or former producers.

However, three different broader general scenarios to the one used (+10%, +25%, and +50% of individuals) were suggested to scale the sectorial size to a lower sampling error rate (Table 5).

Sector population	Number of individuals (companies)	Margin of error (%)
Refined scenario obtained	378 **	–
Gross scenario obtained	500 **	± 2.49
Gross scenario 1	550 ***	± 2.82
Gross scenario 2	625 ***	± 3.17
Gross scenario 3	700 ***	± 3.42

Table 5 - Sampling according to the populations obtained and projected in the studied sector. Source: by the author. Collection Date: June 1, 2020.

Compared to the gross scenario, the refined hypothesis evidenced a margin of error according to the 5% (± 2.5%) ideal advocated by Pinheiro et al. (2011). Compared with the three gross scenarios suggested for the sector (Table 5), the refined sample still had an acceptable level (10% or ± 5%), in line with the same authors.

Both the scenarios obtained (refined and gross sample) and those suggested (gross 1 to 3) were statistically validated and, above all, ensured the inclusion of operating companies throughout the determination of the business hubs (second phase).

Finally, regarding the most recent scenario described by De Araujo et al. (2018a; 2018b; 2019a; 2019b), active companies (Table 5) have grown by about 30% in the last four years, despite the retraction of the national construction industry by an equal 30% as suggested by Bonatelli (2019).

SECOND PHASE: VALID RESULTS, THE USE OF THE HIERARCHICAL SCALE AND HUB MAPS

Although the general analysis of the gross results portrays a wide-ranging panorama of Brazil's timber house business sector for the period analyzed, this initial phase accounts for some possible uncertainties regarding the companies with doubtful characteristics identified in Table 1 and measured in Table 4. That said, the exclusion of these individuals was also supported by Athreye and Kapur's (2006) study, where delimiting the number of an industry's active companies provides a simple measure of its concentration.

All the individuals sampled were categorized according to their operational activity related to the production and/or trade of timber houses (Table 2). According to Figure 1, about 57% of the sector are full producers (handcrafted in construction sites and factories in industrial plants) with productive and commercial operations. Of the remainder, 19% are partial companies working in production and services (suppliers of prefabricated kits and project and construction management offices), and 24% are construction services companies (retailers and assemblers of prefabricated kits).

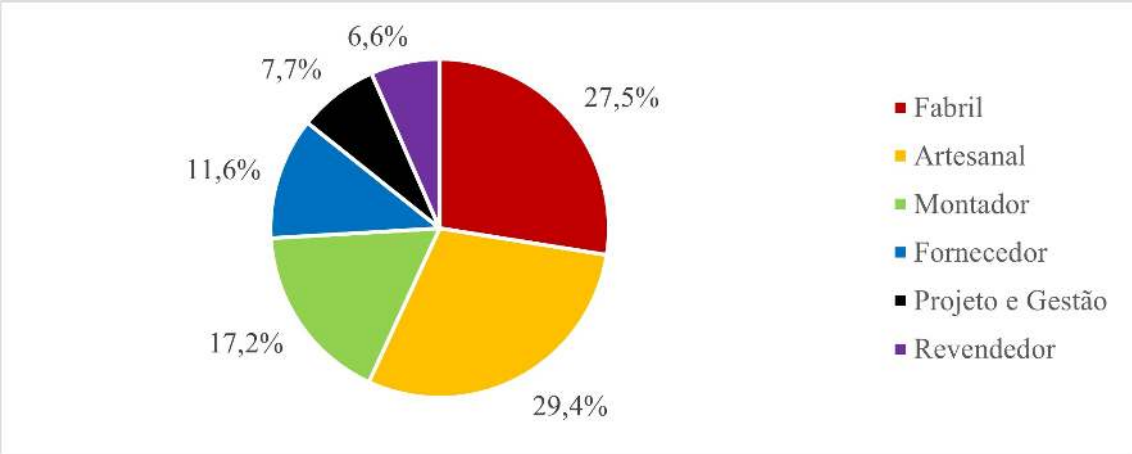

Figure 1 - Operational companies categorized according to operational activity. Source: by the author. Collection Date: June 1, 2020.

The relationship between production and trade in timber houses showed a greater propensity for production activities. This predisposition to produce houses offers a solid argument for consideration in future public housing policies to mitigate Brazil's persistent high housing deficit according to Gavras (2019), since this sector has different productive and commercial modalities (Figure 1).

Once the headquarters of the 378 companies that formed the valid results had been compiled into a detailed list, the mapping began to identify business concentrations located in Brazil. The complete ranking of business volume (by municipality, state, and macro-region) can be found in Appendix 1. Therefore, in summary, the sectoral composition consists of 378 individuals spread over 151 municipalities located in 15 federative states of the five national macro-regions. The uneven distribution of this sector was noted, both by macro-region (Figure 2a) and by state (Figure 2b). From the point of view of its macro-regional distribution, the sector was concentrated in the South and Southeast.

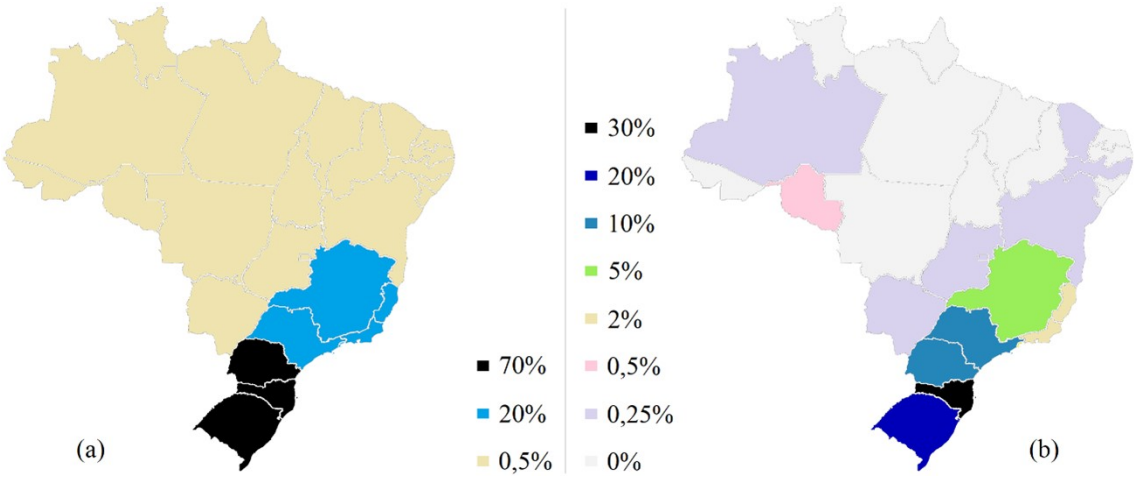

Figure 2 - Volume of active companies in the Brazilian timber house sector according to: (a) macro-regions and (b) federative units. Source: by the author using data plotted on maps adapted from Vemaps (2019). Collection Date: June 1, 2020.

Despite the high forestry potential of the North and Center-West regions, whose territories still concentrate considerable parts of the Amazon, according to Ducke and Black (1954) and Amigo (2020), few timber house companies were found in these areas. Even with the extensive logging in Amazonian forests diagnosed by the Brazilian Institute of Geography and Statistics (2018a; 2018b), Pereira et al. (2010) found that the most significant consumption of native wood is by international and domestic markets in the Southeast and South. The Northeast had low representation in this sector (Figure 2a). By state, these business concentrations were identified in the South and Southeast regions, specifically, in

the federative units of Santa Catarina, Rio Grande do Sul, Paraná, São Paulo, Minas Gerais, Rio de Janeiro, and Espírito Santo (Figure 2b). The finding is consistent with the Brazilian states with the highest level of industrialization suggested by Bragueto and Marques (2017) and the National Confederation of Industry (2017).

Despite this scenario (Figure 2a), wood processing has only been present for a few centuries. Dean (1996) cited more than 50 sawmills in the state of São Paulo in the first half of the nineteenth century. In the southern states, Cabral and Cesco (2008) dated the exploitation of native forests to the late nineteenth century.

There have been worthy studies on the proliferation and origins of these timber dwellings in the southern macro-region, by authors such as Claro (1991), Silva and Basso (2000), Oliveira (2003), Weimer (2005), Szücs and Batista (2007), Giovanni (2008), Larocca Junior, Larocca and Lima (2008), Batista (2011), Berriel (2011), Imaguire Junior and Imaguire (2011), Zani (2013), and Bogo (2017), among many others.

Bogo (2017) identified that timber houses were incorporated into both urban and rural architecture in the southern states. Concerning origin, Zani (2013) viewed Paraná's architectural repertoire as a regional housing culture disseminated from 1930 to 1970 by migrant and immigrant carpenters. This foreign influence was also mentioned by Bogo (2017) in Santa Catarina, where construction began between the mid-nineteenth and early twentieth century, mainly when it was colonized by German, Italian, Slav, and Azorean immigrants. According to Weimer et al. (1992), timber houses appeared in Rio Grande do Sul in the early 1910s.

In São Paulo state, the proximity to the southern macro-region, the proliferation of various examples of construction supported by the largest consumer market in the country, and the presence of immigrants also support a similar situation to the three southern states. However, only a few studies have dealt with the origins of timber houses in São Paulo, including Campos (2008), Hijioka et al. (2013), and Hijioka (2016).

Alongside the beginning of the railway infrastructure, the renovation of building techniques in the capital of São Paulo took place in 1860, through the construction of chalets made of bricks and imported pine wood, processed in local sawmills (CAMPOS, 1997; 2008).

Commercial advertisements in leaflets about timber chalet kits imported from the United States in 1878 have been confirmed by Campos (2008). In Vale do Ribeira region, Hijioka, Joaquim, and Ino (2013) identified traditional Japanese architecture from 1917, which had timber structures sealed with earth and bamboo. In this southern region of São Paulo, Hijioka (2016) also found plank and weatherboard houses dating from the 1950s, with raised structures to protect against flooding and soil moisture.

Given this history and the current scenario of the timber house sector presented in Figure 2 (a, b), the most plausible explanation for the existence and permanence of these business concentrations in the Southeast and South macro-regions is based on the immigrants' cultural heritage, which persists in formerly colonized territories. This influence is affirmed by the production and consumption of traditional constructions and the continuation of over a century of logging activities in the country's southernmost areas. Furthermore, these substantial businesses have also been fueled by the current growth of consumer markets eager for more sustainable housing.

The organization of results in the hierarchical scale (Table 3) categorized twenty municipalities from six federal states as business hubs based on the factors recommended by the tool in question.

Therefore, the volume of four active individuals per location became a minimum requirement to integrate the list of business hubs focused on timber houses (Table 6).

No business hub was found in the North, Northeast, and Center-west macro-regions; neither were any locations categorized as a "hyperdeveloped hub." However, Gravataí municipality in Rio Grande do Sul may be the first to reach this mark (Table 6), when it has 50 active companies in this sector study (Table 3).

The municipal distribution was unevenly fragmented between 80% in the South and 20% in the Southeast. Notably, Gravataí, Curitiba, and Florianópolis had the most extensive business volumes in the sector (Table 6). The percentage of municipalities by state were divided between Rio Grande do Sul

and Santa Catarina (35% each), Paraná and São Paulo (10% each) and Minas Gerais and Espírito Santo (5% each).

Hub Category	Municipality (State*,**)
Hyperdeveloped	–
Super-developed	Gravataí (RS)
Developed	Curitiba (PR) and Florianópolis (SC)
Developing	Joinville (SC), Palhoça (SC) and São Paulo (SP)
Underdeveloped	Belo Horizonte (MG) and Caxias do Sul (RS)
Hub in formation	Novo Hamburgo (RS), Navegantes (SC), Pelotas (RS), Viamão (RS), Alvorada (RS), Blumenau (SC), Campinas (SP), Chapecó (SC), Rio Grande (RS), São José (SC), União da Vitória (PR) and Vila Velha (ES)

Table 6 - Final list of hubs and categorization by business volume. Source: by the author. Collection Date: June 1, 2020.

* Acronym for the federative states of the Southeastern region: ES: Espírito Santo; MG: Minas Gerais; SP: São Paulo. ** Acronym for the federative states of the Southern region: PR: Paraná; RS: Rio Grande do Sul; SC: Santa Catarina.

As the timber house business hubs were primarily identified in the southern macro-regions (Table 6), the geographic representation prioritized a detailed presentation of each state in the South (Figure 3b) and Southeast (Figure 3c).

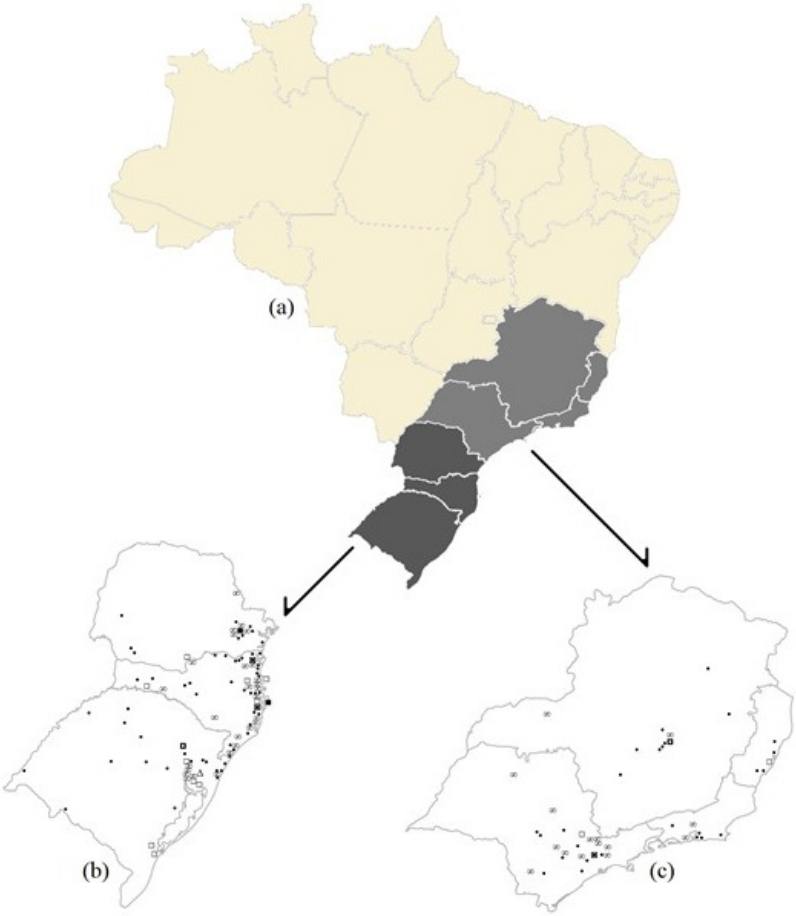

Figure 3 - Maps: (a) of Brazil highlighting the macro-regions with the highest business concentration and the corresponding display of business hubs identified in the states of: (b) South and (c) Southeast. Source: by the author using data plotted on maps and map contours adapted from Vemaps (2019). Collection Date: June 1, 2020.

Despite its presence in Brazil's five macro-regions (Appendix 1), the sector was more intense in the Southeastern and Southern states (Figures 2a, 2b, 3a) and was clearly distributed through multiple agglutinations in cities close to each other (Figure 3b, 3c). As a rule, a hub's presence was linked to the existence of other cities with companies in its surroundings.

Two group patterns were clearly observed by mapping the state agglutinations (Figure 3b,c). The first group involved the more developed regions (state capitals and metropolitan regions), and the second was formed by cities located along the coastal regions. In the case of companies in developed regions, whether in state capitals (for example, Belo Horizonte, Curitiba, Florianópolis, Fortaleza, and São Paulo) and peripheral municipalities (including Araucaria, Betim, Gravataí, Niterói, Palhoça, Suzano, and Vila Velha) or in decentralized metropolitan regions (Campinas, Caxias do Sul, Cascavel, Joinville, Uberlândia), the scenario coincided with the composition of metropolitan regions recognized by the Brazilian Institute of Geography and Statistics (2020) and the economically representative hubs suggested by Lemos, Diniz, and Guerra (2003) and Góis Sobrinho, and Azzoni (2014). The visible presence of less industrialized companies in coastal areas was justified by market issues, given that Cesar (2002) confirms the intense use of timber houses as holiday homes.

Therefore, this sector's more production vocation, as shown in Figure 2, could justify the creation of modern industrial and commercial development policies.

Recognizing the considerable business mass in regions close to the Brazilian coast (Figure 3a,b) would facilitate the production outflow abroad via seaports. Thus, the Brazilian government could be inspired by countries where these sectors are more market and technology intensive. Many examples have been supported by trade associations and government policies for industrial development, usually by forming business clusters and strategic committees. There are notable formal initiatives in Austria (NORD, 2008), Sweden (NORD, 2008; KUZMAN; SANDBERG, 2017), Lithuania (MEDINIŲ NAMŲ GAMINTOJŲ ASOCIACIJA, 2008), Estonia (EESTI PUITMAJALIIT, 2009), and Japan (LUO et al. 2018). At the same time, some embryos formed by academic studies, business projects, and government attempts exist in the Netherlands (GOVERSE et al., 2001), Denmark (WRABER, 2009), and Brazil (DE ARAUJO et al., 2018b; SHIGUE, 2018), among others.

However, in Brazil, the lack of continuity of these initiatives could be a fundamental factor interfering with the progress of the timber house sector since its development has been modest compared to other more developed countries. The sector's informality is perpetuated in several relationship axes, including those between companies, between companies and their suppliers and the market, as well as between companies and the government. Despite this poor panorama, Shigue (2018) has identified many actions over the last decades to promote the use of wood in construction, such as articulation groups, technical-scientific events, and specialized media channels.

However, few of these examples have been regular and uninterrupted. Therefore, the continuity of the actions related to the timber house business sector is fundamental for its promotion and development.

CONCLUSION

The findings are evidence of the visible dynamism of the timber house business sector, which, despite the retraction of Brazilian civil construction, shows an increase in the volume of active companies compared to the data from the few previous studies.

The first phase identified five hundred companies related to the production and trade of timber houses, of which three-quarters exhibited an active status. The second part showed that only a quarter of the sector works specifically with commercial activities; most of the sector's businesses are full or partial producers. This intermediate phase also demonstrated that the 378 active companies are located in 151 municipalities in the five Brazilian macro-regions. The concentrations of these active companies intensified towards the South of the country, especially in developed metropolitan areas and coastal regions due to market and economic issues. The scenario has been encouraged by the strong traditions of foreign settlers who established and promoted timber housing in these southern territories. The third phase mapped the business hubs and established the hierarchical scale, which can be applied to other sectors.

The business hubs were located with greater intensity in the southern states, and the municipalities of Gravataí, Curitiba, and Florianópolis have reached developed status. The hierarchical scale is an efficient tool in the scripted creation of maps.

REFERENCES

AMIGO, I. When will the Amazon hit a tipping point? Nature, Londres, v. 578, p. 505-507, 2020.

ATHREYE, S.; KAPUR, S. Industrial concentration in a liberalising economy: A study of Indian manufacturing, The Journal of Development Studies, Londres, v. 42, n. 6, p. 981-999, 2006.

BATISTA, F. D. A casa de madeira: um saber popular. v. 2. Curitiba: Instituto Arquibrasil, 2011. 101 p.

BERRIEL, A. Tectônica e poética das casas de tábuas. v. 3. Curitiba: Instituto Arquibrasil, 2011. 103 p.

BOGO, A. J. Arquitetura em madeira em Santa Catarina: patrimônio histórico e tipologia habitacional atual. Arquitextos, São Paulo, n. 18.208.02, 2017.

BONATELLI, C. PIB da construção deve crescer 2% em 2019 e 3% em 2020. In: O Estado de São Paulo, 2019. Disponível em: . Acesso em 20 mai 2020.

BORGES, F. P. Casal é suspeito de aplicar golpe da casa pré-fabricada em BH. In: Estado de Minas, 2011. Disponível em: . Acesso em 20 mai 2020.

BRAGUETO, C. R.; MARQUES, A. C. S. Novo mapa do emprego industrial no Brasil: mesorregiões geográficas relevantes. Geografia, Londrina, v. 26, n. 1, p. 92-103, 2017.

CABRAL, D. C.; CESCO, S. Notas para uma história da exploração madeireira na Mata Atlântica do Sul-Sudeste. Ambiente & Sociedade, Campinas, v. 11, n. 1, p. 33-48, 2008.

CAMPOS, E. Arquitetura paulistana sob o Império: aspectos da formação da cultura burguesa em São Paulo. 1997. 814 f. Tese (Doutorado em Arquitetura) – Universidade de São Paulo, São Paulo, 1997. 4 v.

CAMPOS, E. Chalés paulistanos. Anais do Museu Paulista, São Paulo, v. 16, n. 1, p. 47-108, 2008.

CESAR, S. F. Chapas de madeira para vedação vertical de edificações produzidas industrialmente. Florianópolis, 2002, 302 f. Tese (Doutorado em Engenharia de Produção) – Universidade Federal de Santa Catarina, Florianópolis, 2002.

CLARO, A. A produção de casas de madeira em Santa Catarina. 1991. 379 f. Dissertação (Mestrado em Tecnologia da Arquitetura) – Universidade de São Paulo, São Paulo, 1991.

CONFEDERAÇÃO NACIONAL DA INDÚSTRIA. Perfil da indústria brasileira. 2017. Disponível em: . Acesso em 20 mai 2020.

CORREIO DO POVO. Dois homens são presos em ação contra golpe na entrega de casas pré-fabricadas. In: Correio do Povo, 2018. Disponível em: . Acesso em 20 mai 2020.

COSTA, J. L. Surge a quarta empresa ligada à venda de casas de papel. In: GauchaZH, 2018. Disponível em: . Acesso em 20 mai 2020.

DE ARAUJO, V. A.; GUTIÉRREZ-AGUILAR, C. M.; CORTEZ-BARBOSA, J.; GAVA, M.; GARCIA, J. N. Disponibilidad de las técnicas constructivas de habitación en madera, en Brasil. Revista de Arquitectura, Bogotá, v. 21, n. 1, p. 68-75, 2019a.

DE ARAUJO, V. A.; MORALES, E. A. M.; CORTEZ-BARBOSA, J.; GAVA, M.; GARCIA, J. N. Public support for timber housing production in Brazil. Cerne, Lavras, v. 25, n. 4, p. 365-374, 2019b.

DE ARAUJO, V.; NOGUEIRA, C.; SAVI, A.; SORRENTINO, M.; MORALES, E.; CORTEZ-BARBOSA, J.; GAVA, M.; GARCIA, J. Economic and labor sizes from the Brazilian timber

housing production sector. Acta Silvatica et Lignaria Hungarica, Sopron, v. 14, n. 2, p. 95-106, 2018a.

DE ARAUJO, V. A.; VASCONCELOS, J. S.; MORALES, E. A. M.; SAVI, A. F.; HINDMAN, D. P.; O'BRIEN, M. J.; NEGRÃO, J. H. J. O.; CHRISTOFORO, A. L.; LAHR, F. A. R.; CORTEZ-BARBOSA, J.; GAVA, M.; GARCIA, J. N. Difficulties of wooden housing production sector in Brazil. Wood Material Science & Engineering, Londres, p. 1-10, 2018b.

DEAN, W. A ferro e fogo: a história e a devastação da Mata Atlântica brasileira. São Paulo: Cia. Das Letras, 1996. 484 p.

DUCKE, A.; BLACK, G. A. Notas sôbre a fitogeografia da Amazônia brasileira. Boletim Técnico do Instituto Agronômico do Norte, Belém, n. 29, p. 1-62, 1954.

EESTI PUITMAJALIIT. Estonian woodhouse association. 2009. Disponível em: . Acesso em 20 mai 2020.

FOLZ, R. R.; INO, A. Estrutura de eucalipto roliço e o subsistema de vedação de residência unifamiliar. Floresta e Ambiente, Seropédica, v. 19, n. 2, p. 210-218, 2012.

GAVRAS, D. Déficit habitacional é recorde no país. In: O Estado de São Paulo, 2019. Disponível em: . Acesso em 20 mai 2020.

GIOVANNI, E. N. Pau pra toda obra: o uso da madeira na arquitetura catarinense. 2008. 143 f. Dissertação (Mestrado em Urbanismo, História e Arquitetura da Cidade) – Universidade Federal de Santa Catarina, Florianópolis, 2008.

GÓIS SOBRINHO, E. M.; AZZONI, C. R. Aglomerações industriais relevantes do Brasil. São Paulo: Nereus/USP, 2014. 32 p. Disponível em: . Acesso em 20 mai 2020.

GOVERSE, T.; HEKKERT, M. P.; GROENEWEGEN, P.; WORRELL, E.; SMITS, R. E. H. M. Wood innovation in the residential construction sector; opportunities and constraints. Resources, Conservation & Recycling, Amsterdam, v. 34, n. 1, p. 53-74, 2001.

HIJIOKA, A. Minka - casa dos imigrantes japoneses no Vale do Ribeira. 2016. 229 f. Tese (Doutorado em Arquitetura e Urbanismo) – Universidade de São Paulo, São Carlos, 2016.

HIJIOKA, A.; JOAQUIM, B. S.; INO, A. Minka - the houses of Japanese imigrants in Ribeira valley, São Paulo, Brazil. In: CORREIA, M.; CARLOS, G.; ROCHA, S. (Orgs). Vernacular heritage and Earthen architecture - contribuitions for sustainable development. 1. ed. Londres: Taylor & Francis, 2013, p. 99-104.

IMAGUIRE JUNIOR, K.; IMAGUIRE, M. R. G. A casa de araucária. v. 1. Curitiba: Instituto Arquibrasil, 2011. 101 p.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. Produção da extração vegetal e da silvicultura: tabela 289 - quantidade produzida e valor da produção na extração vegetal, por tipo de produto extrativo. 2018a. Disponível em: . Acesso em 20 mai 2020.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. Produção da extração vegetal e da silvicultura: tabela 291 - quantidade produzida e valor da produção na silvicultura, por tipo de produto da silvicultura. 2018b. Disponível em: . Acesso em 20 mai 2020.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. Unidades territoriais do nível região metropolitana. 2020. Disponível em: . Acesso em 20 mai 2020.

KOZAK, R. A.; COHEN, D. H. Architects and structural engineers: an examination of wood design and use in nonresidential construction. Forest Products Journal, La Grange, v. 49, n. 4, p. 37-46, 1999.

KUZMAN, M. K.; SANDBERG, D. Comparison of timber-house technologies and initiatives supporting use of timber in Slovenia and in Sweden – the state of the art. iForest, Viterbo, v. 10, p. 930-938, 2017.

LAROCCA JUNIOR, J.; LAROCCA, P. L.; LIMA, C.A. Casa eslavo paranaense: arquitetura de madeira dos colonos poloneses e ucranianos do sul do Paraná. Ponta Grossa: Editora Larocca Associados, 2008. 236 p.

LEMOS, M. B.; DINIZ, C. C.; GUERRA, L. P. A nova configuração regional brasileira e sua geografia econômica. Estudos Econômicos, São Paulo, v. 33, n. 4, p. 665-700, 2003.

LUO. W.; MINEO, K.; MATSUSHITA, K.; KANZAKI, M. Consumer willingness to pay for modern wooden structures: a comparison between China and Japan. Forest Policy and Economics, Amsterdam, v. 91, p. 84-93, 2018.

MEDINIŲ NAMŲ GAMINTOJŲ ASOCIACIJA. Lithuanian wood houses industry. 2008. Disponível em: . Acesso em 20 mai 2020.

MINISTÉRIO PÚBLICO DO ESTADO DO RIO GRANDE DO SUL. Viamão: organização criminosa é denunciada por golpe da casa própria. 2018. Disponível em: . Acesso em 20 mai 2020.

MÜLLER, A. Empresa da capital é investigada por lesar 14 vítimas que compraram casas, mas não receberam. In: GauchaZH, 2019. Disponível em: . Acesso em 20 mai 2020.

NATTERER, J. K. A way to sustainable architecture by new technologies for engineered timber structures. In: WORLD CONGRESS OF TIMBER ENGINEERING, 8., 2004, Lahti. Anais... Lahti: 2004, p. 1-18.

NATTERER, J. K. New technologies for engineered timber structures. Progress in Structural Engineering and Materials, Hoboken, v. 4, n. 3, p. 245-263, 2002.

NORD, T. Prefabrication strategies in the timber housing industry: case studies from Swedish and Austrian markets. Technical report 16:2008. Luleå: Luleå University of Technology, 2008. 109 p.

OLIVEIRA, C. F. Autoconstrução em madeira. Estudo de caso: Florianópolis/SC. 2003. 212 f. Dissertação (Mestrado em Arquitetura e Urbanismo) – Universidade de São Paulo, São Carlos, 2003.

PAZKAD, P.; OSMOND, P.; CORKERY, L. Developing key sustainability indicators for assessing green infrastructure performance. Procedia Engineering, Londres, v. 180, p. 146-156, 2017.

PEREIRA, D.; SANTOS, D.; VEDOVETO, M.; GUIMARÃES, J.; VERÍSSIMO, A. Fatos florestais da Amazônia 2010. Belém: Imazon, 2010. 122 p.

PINHEIRO, R. M.; CASTRO, G. C.; SILVA, H. H.; NUNES, J. M. G. Pesquisa de mercado. Rio de Janeiro: Editora FGV, 2011. 154 p.

PORTER, M. E. Clusters and the new economics of competition. Harvard Business Review, Brighton, v. 76, n. 6, p. 77-90, 1998.

PUNHAGUI, K. R. G. Potencial de reduccion de las emisiones de CO2 y de la energia incorporada em la construccion de viviendas en Brasil mediante el incremento del uso de la madera. 2014. 422 f. Tese (Doutorado em Energia e Meio Ambiente na Arquitetura) – Universitat Politecnica de Catalunya, Barcelona, 2014.

RAOSOFT. Raosoft sample size calculator. 2004. Disponível em: . Acesso em 20 mai 2020.

RECALCATI, J. PROCON alerta sobre golpe de casas pré-fabricadas em SC. In: Oeste em Foco, 2019. Disponível em: . Acesso em 20 mai 2020.

SCHMITZ, H. Collective Efficiency and Increaseing Returns. Working Paper 50. Brighton: Institute of Development Studies, University of Sussex, 1997.

SEJDIU, R.; BEJTJA, A.; IDRIZI, L.; BAJRAKTARI, A. A survey of volume, species and origin of dry timber consumed by the wood processing industry in the region of Ferizaj. In: INTERNATIONAL CONFERENCE OF APPLIED SCIENCES, 1., 2015, Tetovo, Proceedings... Tetovo: 2015, p. 1-7.

SHIGUE, E. K. Difusão da construção em madeira no Brasil: agentes, ações e produtos. 2018. 237 f.

Dissertacao (Doutorado em Arquitetura e Urbanismo) – Universidade de São Paulo, São Carlos, 2018.

SILVA, R. D.; BASSO, A. Sistemas construtivos em madeira destinados à habitação no Paraná. Semina: Ciências Exatas e Tecnológicas, Londrina, v. 21, n. 4, p. 83-88, 2000.

SOBRAL, L.; VERÍSSIMO A.; LIMA, E.; AZEVEDO, T.; SMERALDI, R. Acertando o alvo 2: consumo de madeira amazônica e certificação florestal do Estado de São Paulo. Belém: Imazon, 2002. 72 p.

SZÜCS, C. A.; BATISTA, F. D. Arquitetura de madeira na região de Curitiba: estudo comparativo entre a casa tradicional e contemporânea. In: ENCONTRO LATINO-AMERICANO SOBRE EDIFICAÇÕES E COMUNIDADES SUSTENTÁVEIS, 2., 2007, Campo Grande. Anais... Porto Alegre: ANTAC, 2007. p. 798-807.

TADDEO, R.; SIMBOLI, A.; IOPPOLO, G.; MORGANTE, A. Industrial symbiosis, networking and innovation: the potential role of innovation poles. Sustainability, Basel, v. 9, n. 169, p. 1-17, 2017.

TORRES, E. Fique atento ao golpe da casa própria. In: Diário Gaúcho, 2014. Disponível em: . Acesso em 20 mai 2020.

VEMAPS. Maps of Brazil. 2019. Disponível em: . Acesso em 20 mai 2020.

WEIMER, G. Arquitetura popular da imigração alemã. 2 ed. Porto Alegre: Editora da UFRGS, 2005. 296 p.

WEIMER, G.; SALVIA, F.; CRUZ, G. P.; RIBEIRO, D.; BAKOS, M. M.; BARBOSA, V. L. M. (Orgs.). Urbanismo no Rio Grande do Sul. Porto Alegre: Editora da UFRGS, 1992. 144 p.

ZANI, A. C. Arquitetura em madeira. Londrina: Eduel; São Paulo: Imprensa Oficial do Estado de São Paulo, 2013. 396 p.

APPENDIX

Macro-region	Federative State	City	Amount of Companies
Center-west	Federal District	Brasília	1
	Goiás	Senador Canedo	1
	Mato Grosso do Sul	Ponta Porã	1
Northeast	Bahia	Itamaraju	1
	Ceará	Fortaleza	1
	Pernambuco	Recife	1
North	Amazonas	Manaus	1
	Rondônia	Porto Velho	2
Southeast	Espírito Santo	Vila Velha	4
		Alfredo Chaves, Guarapari, João Neiva and Vitória	1
	Minas Gerais	Belo Horizonte	8
		Santa Luzia and Uberlândia	2
		Betim, Campo Belo, Contagem, Divinópolis, Governador Valadares, Igarapé, Matozinhos and Tourmalina	1
	Rio de Janeiro	Rio de Janeiro	3
		Petrópolis.	2
		Barra do Piraí, Maricá, Niterói, São Gonçalo and São Pedro da Aldeia	1
	São Paulo	São Paulo	10
		Campinas	4
		Itatiba and Santa Isabel	3
		Atibaia, Boituva, Bragança Paulista, Itapeva, Mogi das Cruzes, São Carlos, São José do Rio Preto, Sorocaba and Vargem Grande Paulista	2
		Botucatu, Cabreúva, Capão Bonito, Embu, Juquitiba, Piracicaba, Salto de Pirapora, São Manuel and Suzano	1
South	Rio Grande do Sul	Gravatai	45
		Caxias do Sul	8
		Novo Hamburgo	6
		Pellets and Viamão	5
		Alvorada and Rio Grande	4
		Canoas, Porto Alegre and São Leopoldo	3
		Cachoeirinha, Imbé and Sapucaia do Sul	2
		Arroio do Sal, Camaquã, Campo Bom, Constantina, Igrejinha, Osório, Picada Café, Rolante, Santa Bárbara do Sul, Santa Cruz do Sul, Santa Maria, Santana do Livramento, Santo Cristo, Soledade, Taquari, Tramandaí, Uruguaiana and Xangri-la	1
	Paraná	Curitiba	26
		União da Vitória	4
		Araucaria, Campo Largo, Colombo, Pinhais and Sengés	2
		Campina Grande do Sul, Cascavel, Enéas Marques, Fazenda Rio Grande, Francisco Beltrão, Itaperuçu, Matinhos, Piraquara and São José dos Pinhais	1
	Santa Catarina	Florianópolis	21
		Joinville and Palhoça	10
		Navegantes	5
		Blumenau, Chapecó and São José	4
		Biguaçu, Brusque, Concordia, Criciúma, Garopaba, Imbituba and Jaraguá do Sul	3
		Araquari, Araranguá, Camboriú, Itajaí, Itaperna, Lages, Porto União, São João do Sul and Tubarão	2
		Balneário Barra Velha, Balneário Gaivota, Balneário Piçarras, Barra Velha, Bom Jesus, Botuverá, Brunópolis, Campo Alegre, Canelinha, Capivari de Baixo, Dona Emma, Garuva, Ibircaré, Itapoá, Jaguaruna, Mafra, Passo de Torres, Penha, Pinhalzinho, Porto Belo, Rio Negrinho, Santo Amaro da Imperatriz, São Bento do Sul, São João Batista, Três Barras, Turvo and Videira	1

TOTALS BY CATEGORY			
Macro-region	Federative State	City	Amount of Companies
5	15	151	378

Appendix 1- List of locations (regions, states, and municipalities) and quantities of operational companies sampled (by municipality) for the period 2020