Urban governance in Latin America: Bibliometrics applied to the context of smart cities

Governança urbana Latino-Americana: bibliometria aplicada ao contexto das cidades inteligentes

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Abstract

Society lives in a dynamic, complex, and contradictory urban system that seeks the balance between urban development and environmental preservation. For this purpose, there are Information and Communication Technologies which can make the existence of Smart Cities possible. Thus, developing Smart Cities involves applying inter and multidisciplinary knowledge, which permeates even Information Science. This study analyzes Latin American scientific production by applying Bibliometrics to quantify the publications related to smart cities, geotechnologies, governance, and cadastre. We analyzed scientific production indexed in the Scopus database from 2007 to 2017. We also performed the Factorial Correspondence Analysis for visualization of word clusters in order to verify their co-occurrence in the abstracts of articles. The results identified Brazil as the country with the highest number of published documents. The importance of the term "Smart Cities" was evidenced with the increase of production in the last 5 years, a period that accumulates 98% of such publications. The most common term is "Geographic Information System", that appears in 75% of the publications. Finally, in the co-occurrence of words, we identified terms that corroborate with the greater objectives of smart cities.

Keywords: Bibliometrics. Geotechnology. Governance. Smart cities.

Resumo

A sociedade vive em um sistema urbano dinâmico, complexo e contraditório, que busca o equilíbrio entre o desenvolvimento urbano e a preservação ambiental. Para tanto, dispõe-se de Tecnologias da Informação e Comunicação, as quais podem tornar possível a existência de Cidades Inteligentes. Estas devem ser compostas por estratégias e ações de governança inteligente como um novo paradigma a seguir, interconectando a sociedade e o governo com o intuito de resolver questões urbanas. Nota-se que conceituar Cidades Inteligentes envolve aplicar conhecimentos inter e multidisciplinares que permeiam inclusive a Ciência da Informação. Nesse sentido, o presente estudo tem como objetivo analisar a produção científica de países da América Latina aplicando a Bibliometria para

quantificar as publicações relacionadas a Cidades Inteligentes, geotecnologias, governança e cadastro. Foram analisadas produções científicas publicadas no período de 2007 a 2017 e indexadas na base de dados Scopus. Também foi executada uma Análise Fatorial de Correspondência para visualização de agrupamentos de palavras/termos, auxiliada pelo software Iramuteq, de forma a verificar a coocorrência de palavras nos resumos dos artigos. Os resultados obtidos identificaram o Brasil como o país com o maior número de documentos publicados. Evidenciou-se a importância do termo "Smart Cities" pelo aumento da produção nos últimos 5 anos, período que acumula 98% do total das publicações relacionadas. O termo mais publicado é "Geographic Information System", representando 75% das publicações. Por fim, na coocorrência de palavras, foram observados termos que corroboram os objetivos maiores das Cidades Inteligentes.

Palavras-chave: *Bibliometria. Geotecnologia. Governança. Cidades inteligentes.*

Introduction

The diffusion of Information and Communication Technologies (ICT) in recent years is increasingly driving technological innovations, reflecting the dynamics in which societies and cities develop. A new paradigm is being developed whose transformative process expansion lies at its ability to interconnect technological fields through a common digital language. Thus, information is generated, stored, retrieved, processed, and transmitted, creating cumulative feedback cycles between innovation and use (Castells, 2010).

According to Townsend (2014), technology has a significant impact on urban transformations, since 21st century cities are connected not only by highways, but also by data networks. Therefore, it is fundamental to rethink the traditional approach to managing transport systems, water resources, waste, energy, and the environment for cities. This management should guarantee sustainability to the use of these resources (Ojo; Dzhusupova; Curry, 2016).

Such transformations accompany the remarkable increase of inhabitants in urban areas. In 2015, about 54% of the world population was urban. It is estimated that by 2050 this percentage will reach 66%. About 13% of the world population lives in Latin America, where the urban/rural ratio is higher than the world reference, with an 80% urban population (United Nations, 2018). According to the United Nations (2018), in 2015 Latin American had an urban population of over 500 million inhabitants. By 2040, this number should increase to around 650 million inhabitants.

Therefore, the planet is from the cities, voracious energy consumers, waste producers, and broadcasters of most greenhouse gases, seen as the critical and important point where the complex problems of planning, development and sustainability interconnects (Klopp; Petretta, 2017). In the words of Berardi (2013), around the world, most of the resources are consumed in urban environments, being a fact that contributes to the economic and social importance of urban communities, but also for its poor environmental sustainability.

Unprecedented urbanization and the consequent growth of the size and number of cities in different parts of the world present opportunities and challenges, including traditional approaches to city management and urban lifestyle (Ojo; Dzhusupova; Curry, 2016). Thus, when analyzing developing countries, such as Latin American ones, face many challenges, namely: (i) improving urban management; (ii) having limited financial resources; and (iii) carrying out technological adaptations (Calderon; Lopez; Marin, 2018).

In this context, it is difficult for Latin American cities to become smart, but these challenges can be seen as opportunities to improve their populations' quality of life through the implementation of smart initiatives driven by ICT (Calderon; Lopez; Marin, 2018).

Therefore, according to Ojo, Dzhusupova, and Curry (2016), it is essential to understand that among the aspects of a smart city are: (i) participatory governance; (ii) the development of human capital, ICT infrastructures, and active citizenship; and (iii) technological, organizational, and political innovations.

Thus, the Smart City label must be related to people's capacity of generating smart solutions to urban problems (Albino; Berardi; Dangelico, 2015). Therefore, Smart Cities are those that create new relations between technology and society (Meijer; Gil-Garcia; Bolívar, 2016). These relations must be created through technological development and innovation, which should be applied to the management of the urban dynamics (Hernández-Muñoz *et al.*, 2011; Komninos; Schaffers; Pallot, 2011).

Even though there is no conceptual consensus regarding Smart Cities (Nam; Pardo, 2011; Chourabi *et al.*, 2012; Meijer; Gil-Garcia; Bolívar, 2016; Przeybilovicz; Cunha; Tomor, 2017), in summary, technological focus, human resources, and governance are the most recurrent and accepted debates (Nam; Pardo, 2011; Meijer; Bolívar, 2016). In this sense, Gil-Garcia, Pardo, and Nam (2015) identified the following common points: (i) the use of ICT in the city; (ii) the presence of cyber and physical infrastructures; (iii) better provision of services to the population; (iv) the combination, integration, and interconnection of systems and infrastructures to allow social, cultural, economic, and environmental development; and (v) the vision of a better future.

Gil-Garcia, Pardo, and Nam (2016) show that a Smart City needs a smart government and governance, that is, it is not limited to a technological issue but refers to a complex process of institutional change, as Meijer and Bolívar (2016) also mention, even as ICT benefits several cities in improving their governance. Smart governance broadly represents a collection of technologies, people, policies, practices, resources, social norms, and information that interact to support the city's governance activities (Chourabi *et al.*, 2012). Thus, it is directly associated with both innovative strategies (which allow for more agile and resilient government structures) and governance infrastructures (Przeybilovicz; Cunha; Tomor, 2017).

In the context of Smart Cities, smart governance is a fundamental issue (Pereira *et al.*, 2017), involving transparency of government systems, availability of public services, quality of policies and participation in decision-making (Monfaredzadeh; Berardi, 2015).

According to Calderon, Lopez, and Marin (2018), urban governance is an issue that requires attention and thus, e-government should become a priority for local governments. In recent years, the evolution of open governments appear as a part of a new trend that breaks the traditional notion of public management (Gómez; Criado; Gil-Garcia, 2017). In addition, governments' growing use of ICT enables better participation and implementation of public policies, providing services to the public sector (Bolívar, 2016) and society (Pereira *et al.*, 2016).

In fact, technology alone does not make a city smarter and for urban governance, spatial activation is imperative. Roche (2014) understands that the concept of location allows the organization and management of space processes, significantly contributing to Smart Cities. Therefore, the interrelation between governance and the use of Geographic Information Systems (GIS) is necessary. In addition, GIS can be considered a tool to improve governance, as it does not dismiss the need to incorporate popular participation (McCall, 2003).

Based on the aforementioned premises, this research establishes the hypothesis that governance in a Smart City is still formed by the use of geotechnologies that are part of ICT. This hypothesis will be analyzed through a bibliometric analysis, considering a decade (2007 to 2017) of publications. Thus, the relevance of the terms "smart cities", "governance", and "geotechnologies" will be analyzed considering the number of articles published by Latin American researchers in journals indexed in Scopus and the co-occurrence of words in these articles' abstracts.

Methodological Procedures

As previously mentioned, the purpose of this research is to measure scientific production on Smart Cities, Governance, and Geotechnologies in Latin America through a quantitative exploratory-descriptive study. The research examines a period of 10 years and is divided into two stages of analysis that are based on Bibliometrics and Text Mining.

In the first stage, we used the bibliometric analysis that, according to Kamalski and Kirby (2012), allows the examination of the connection among concepts and provide insights into the structure and characteristics of a specific knowledge area. We decided to use the Scopus database as a source of information given its multidisciplinarity and also due to its indexed journals of recognized relevance in terms of publications focused on Smart Cities. This analysis includes the scientific production according to the countries and proportionality regarding the quantity of the production year by year. The searches were performed considering the Titles, Keywords, and Abstracts, according to the terms and delimiters indicated in Table 1.

The first stage quantifies Latin American scientific production according to four key groups, named *G1-Smart City, G2-Geotechnology, G3-Governance*, and *G4-Cadastre*. The first three groups were established due to the previously mentioned interrelationship hypothesis. On the other hand, the inclusion of the group G4-Cadastre is justified by the understanding of the official governmental territorial information and, therefore, are of great importance. The first stage was thus subdivided into two analysis: production by country and annual Latin American production versus worldwide production.

Table 1. Terms and delimiters used in the searches for bibliometrics analysis.

Delimiters	Searched groups	Searched terms	Publications (N)		
			Latin America	Other countries	Entire world
Period: 2007-2017	G1-Smart city		372	10,761	11,133
Documents type:All		Smart city	372	10,761	11,133
Language:All	G2-Geotechnology		3,017	55,509	58,526
		Big data	11	592	603
		City information modelling	1	7	8
		Data-smart	2	99	101
		Data-smart city	-	9	9
		Geographic information system	2,252	51,236	53,488
		geomatics	41	1,123	1,164
		Geoprocessing	595	1,136	1,731
		Geotechnology	81	231	312
		Giscience	12	501	513
		Urban data	22	575	597
	G3-Governance		146	2,805	2,951
		Geogovernance	-	3	3
		Smart governance	6	121	127
		Urban governance	48	1,713	1,761
		Urban management	92	968	1,060
	G4-Cadastre		13	408	421
		Land cadastre	1	50	51
		Land information system	5	280	285
		Multipurpose cadastre	-	16	16
		Territorial cadastre	7	44	51
		Territorial information system	-	18	18
		Total	3,548	69,483	73,031

Source: Prepared by the authors (2019).

The analysis by country resulted in a total of 3,548 documents. For the analysis of the annual production, we considered the isolated results of the 20 terms seached, although they are presented according to their respective group. This analysis resulted in: (i) the year-to-year quantity of Latin American and world production; (ii) the proportion of world scientific production; and (iii) 1st publication of the term.

The second stage is based on text mining of data extracted from the abstracts of the articles, analyzing the co-occurrence of words. According to Usai *et al*. (2018), text mining is related to the discovery of knowledge focused on words and phrases extracted from textual databases. It is centered on technology and involves multidisciplinary studies. Thus, it has been applied by many domains, such as health care, education, and government. Again, the searches were done using the Scopus database. However, according to the terms and delimiters indicated in Table 2, only the Abstracts were considered in these searches. This analysis includes the scientific production according to the countries and the proportionality regarding the quantity of the production year by year.

The second stage analyzed the abstracts of 46 documents related to Latin American production and another 1,066 related to the production of the other countries. These abstracts were submitted as inputs to the Factorial Correspondence Analysis (FCA). For this purpose, we used the software Iramuteq, which performs statistical analysis of data extracted from text mining (Ratinaud, 2009). This software is freely distributed under the GNU GPL v2 license (developed based on the R software and the Python language).

Results and Discussion

Analysis of scientific productions based on bibliometrics

The first analysis of this stage tries to quantify Latin American scientific production according to the four previously established groups (G1, G2, G3, and G4). Figure 1 presents the results obtained in Latin America from maps used to identify the countries with the highest productivity.

In this analysis, Brazil, Mexico, and Ecuador are the only countries to present production in the four groups of searched terms. Moreover, they are the only ones that participate in the scientific production related to G4-Cadastre, presenting 10, 2, and 1 published documents, respectively.

Table 2. Terms and delimiters used in the searches for text mining analysis.

Delimiters	Searched groups	Searched terms	Publications (N)		
			Latin America	Other countries	Entire world
Period: 2007-2017 Documents type: All Language: All	P1	"smart city" OR "smart cities" AND "governance" AND "geographic information system" OR "geoprocessing" OR "GIS".	1	12	13
	P2	"smart city" OR "smart cities" AND "geographic information system" OR "geoprocessing" OR "GIS".	10	214	224
	P3	"smart city" OR "smart cities" AND "governance"	7	417	424
	P4	"governance" AND "geographic information system" OR "geoprocessing" OR "GIS"	28	423	451
		Total	46	1,066	1,112

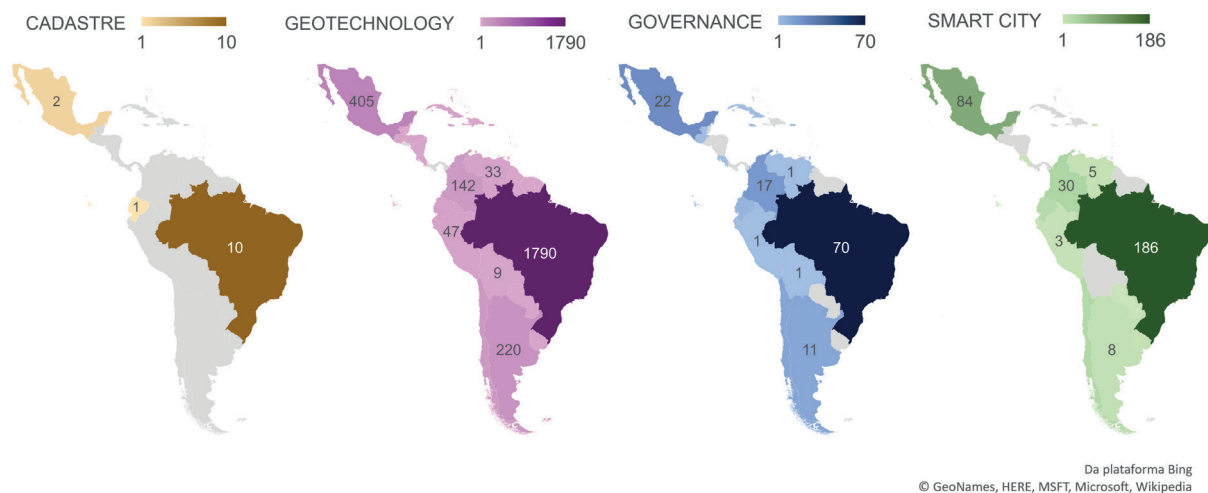Source: Prepared by the authors (2019).

Figure 1. Number of scientific publications produced by country in function to the search terms.

Source: Prepared by the authors (2019).

Considering the sum of the four groups of terms, we observed that the five countries with the highest scientific production are: Brazil, with 2,056 publications; Mexico, with 513; Argentina, with 239; Colombia, with 189; and Chile, with 178.

Subsequently, a second analysis was carried out to establish comparisons regarding the proportionality of Latin American production in relation to world production. Thus, the number of publications according to each search term was considered, and the respective cluster was maintained. We found that the scientific production in the investigated decade (2007-2017) was superior to what was produced in the previous period, except for the G4 ("Cadastre") group. It is worth mentioning the inexpressiveness of this group, representing less than 1% of the total production within the four groups in the analyzed decade. However, restricting the analysis only to its context, we found that Latin American production corresponds to approximately 4% of the group's general production.

In G1 ("Smart City"), 372 of the total 10,761 documents were produced by Latin American countries, accounting for 3.5% of the total produced by this group, i.e., a proportion similar to that found in G4 ("*Cadastre*"). As for G2 ("Geotechnology"), Latin American production corresponds to 3,017 documents, which represents about 5.5% of the total. In G3 ("Governance"), this production represents 146 documents, corresponding to 5.0% of the total of 2,805 publications.

According to the isolated analysis of the terms, there is a significant presence of "Geographic Information System", with 51,236 publications, representing almost 74.0% of the total production and 92.0% of the publications related to G2 ("Geotechnology"). Considering the Latin American context, the 2,252 documents found correspond to approximately 4.5% of the publications related to this term.

It can also be highlighted that from a total of 10,761 publications with the term "Smart City", 372 were produced by Latin American countries. Since 2012, when the accumulated production goes from 226 publications (2007-2011) to 10,535 (2012-2017), it constitutes an expressively rising field of research. The same behavior occurs in the Latin American context, with the rise beginning in 2013, when the annual production goes from 5 to 23 publications, and cumulative production increasing from 7 (2007-2012) to 365 (2013-2017) published texts.

Considering each of the search terms' representativeness, it can be observed that, according to the general production, the terms with the greatest number of publications are: "Urban Governance" (1,761 documents),

"Geoprocessing" (1,731) "Geomatics" (1,164), "Urban Management" (1,060), and "Big Data" (603). All of these terms precede the already qualified "Geographic Information System" and "Smart City".

In Latin America, the 5 most representative terms are: "Geoprocessing" (595 documents), "Smart City" (372), "Urban Management" (92) and "Geotechnology" (81). These terms show that Latin American countries are engaged in research correlated to Smart Cities. However, their technological development is remarkably lower than in developed countries. This fact can also be observed by the absence of Big Data as a relevant term in their research.

Analysis of word cooccurrence based on text mining

This second stage of the research performs an analysis that seeks to evaluate the abstracts' content through Factorial Correspondence Analysis (FCA), which returns the frequency of the words' occurrence in the factorial plane, as shown in Figures 2 and 3.
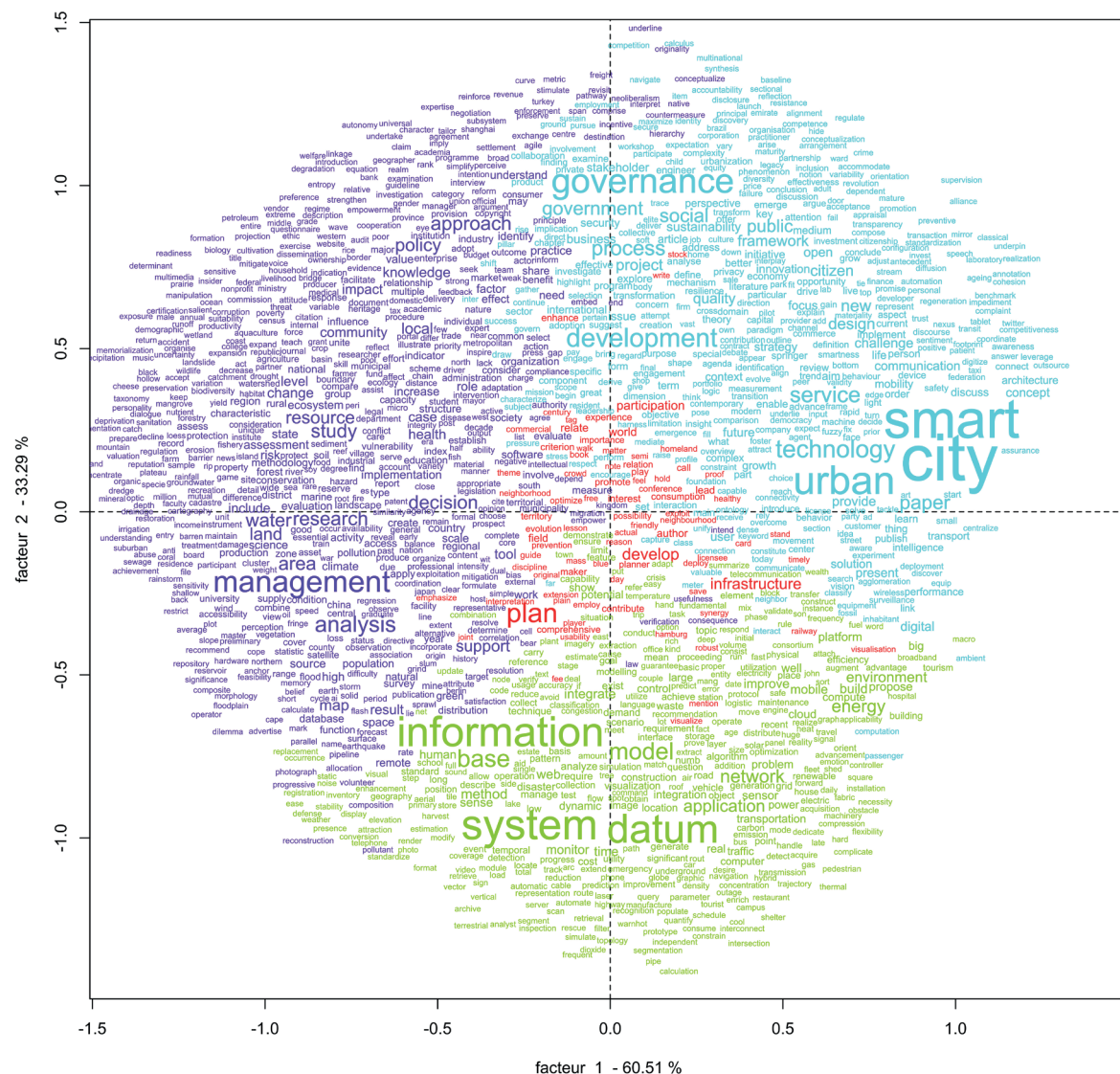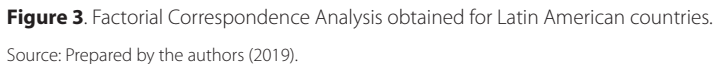

Figure 2. Factorial Correspondence Analysis obtained for non-Latin American countries.

Source: Prepared by the authors (2019).

Figure 3. Factorial Correspondence Analysis obtained for Latin American countries.

Source: Prepared by the authors (2019).

In both Figures 2 and 3, the most frequent terms returned after the analysis of the search clause P1 are shown in red. The most frequent terms of P2, P3, and P4 are marked in green, cyan, and blue, respectively. Comparing the Figures, one notices that the similarity among higher-frequency terms. Thus, one can mostly notice the following terms: "City", "Datum", "Development", "Governance", "Information", "Management", "Plan", "Smart", "System", and "Urban".

The interrelation of word co-occurrence among search clauses can be verified by the location of the word in the Cartesian plane. In this way, the words that are in the central region of the chart (coordinate [0, 0]) are those with co-occurrence ascertained in the four search clauses. Thus, it is observed that the textual corpus of Figure 3 shows a greater dispersion as to the interrelation of co-occurrence, i.e., it only identifies a few words in the central region of the plane. In addition, these words have less co-occurrence, since proportionally to the others, they are less frequent. On the other hand, there is greater homogeneity in the production of the other countries (non-Latin American), as demonstrated by Figure 3.

Therefore, this analysis demonstrates possible research gaps in Latin American countries, as well as the need for a better standardization (homogeneity) of their research platforms in order to reach a level similar to the one of the world research.

Conclusion

In short, the non-collapse of the globalized urban world, as well as the confrontation of Latin American urban issues, are directly related to sustainability. In addition, social, ecological, and economic dynamics must be considered, using ICT for smarter solutions. It is still important to note that such conditions require good governance, making it critical for the cities' management.

Looking at the precepts of smart cities and aligning them with Latin American urban issues requires understanding the urgency of social, economic and environmental demands. It requires understanding that intelligence can also be understood as ensuring the provision and operation of urban systems to all citizens, such as equitable urban and economic planning.

The bibliometric analysis, in terms of quantification of scientific production by countries, found that Brazil, Mexico, Argentina, Colombia, and Chile are the countries with the highest number of publications. As to the second analysis, quantifying the publications by search terms and by year, we identified a higher concentration of publications related to G1 and G2, i.e., through the use of terms "Smart City" and "Geographic Information System". Temporal analysis has shown that the terms "Urban Data" and "Urban Management" have evolved into "Smart Governance", "Big Data", and "City Information Modeling".

It is worth mentioning that, after 2017, the terms "Smart City" and "Geographic Information System" keep up the interest of the research as the number of publications related to the themes are increasing. As shown in the search for "Smart City" in the Scopus database, returning the result of 5,355 publications for the year 2018, which is equivalent to 48% of all scientific production of the decade studied (2007-2017). And the production of 2019 has already reached a total of 3,125 publications, evidencing the continuous interest to this research theme.

From the analysis of the textual corpus regarding word co-occurrences, in the two FCA obtained, the generated clusters emphasized the terms "Plan", "Development", "Governance", "Datum", and "Information", which corroborate with what is sought in a Smart City.

Therefore, this research based on bibliometrics and text mining shows that, over the analyzed period, Latin American scientific production has a small number of publications when compared to the world production, around 5%. Nonetheless, the evolution of scientific production in Latin America, in general, follows the world dynamics.

Contributors

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