INNOVATION AND SUSTAINABILITY RESEARCH NETWORKS FOR THE BUILT ENVIRONMENT: SMART CITIES

Redes de pesquisa em inovação e sustentabilidade para o ambiente construído: cidades inteligentes

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RESUMO

Este trabalho visa mapear as redes de cooperação em pesquisa científica no Brasil, identificando as áreas de atuação relevantes do Parque de Inovação e Sustentabilidade do Ambiente Construído, como *Smart Cities*. Utilizando a base Lattes, foi possível identificar os principais players na produção científica e observar que as regiões sudeste e sul colaboram mais com o tema de cidades inteligentes, enquanto o Distrito Federal interage mais com o Pará e São Paulo. Para aumentar a rede de cooperação, é necessário expandir a colaboração com outros estados, como Rio Grande do Norte, Rio de Janeiro, Bahia e Santa Catarina.
Palavras-chaves: *Smart Cities*; Redes de Cooperação; Lattes.

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ABSTRACT

This work aims to map cooperation networks in scientific research in Brazil, identifying relevant fields of activity, such as smart cities, carried out by the Innovation and Sustainability Park of the Built Environment. Using the Lattes database, it was possible to identify the main players in scientific production and observe that the Southeast and South regions collaborate more with the theme of smart cities, while the Federal District interacts more with Pará and São Paulo. To expand the cooperation network, it is necessary to intensify collaboration with other states, such as Rio Grande do Norte, Rio de Janeiro, Bahia and Santa Catarina.
Keywords: Smart Cities; Cooperation Network; Lattes.

INTRODUCTION

In order to work, the Brazilian innovation ecosystem depends largely on state incentives, since culturally speaking, the private sector in Brazil carries out minimal investment in research and innovation. This is reflected in the distribution of researchers and developers of research and innovation, the majority of whom work in the public sector, in universities and research and development centers.

Government incentives in Science, Technology and Innovation (ST&I) are as a result of public policies implemented in the last fifty years, and can be either direct or indirect, depending on governmental policies and political strategies. According to Rossetti (1987), for this type of state intervention, i.e. via public policies, it is necessary to understand the on-going policies in the country so that new strategic guidelines more specifically related to smart cities can be devised. This means understanding the availability of resources, the support infrastructure, the structure of the production system, the financial system, economic relations with other countries, how the national product is made up and the repatriation of income as well as the economy as a whole (ROSSETI, 1987).

Thus, research and innovation policies must be based on the current Brazilian scenario to avoid wasting financial and human resources in actions of low or zero impact on the ecosystem. Research and development of innovation in sustainability is fundamental in today's world, primarily in terms of the built environment industry, one of the most important industries for the economy in a developing country. The current model of capitalist production does not consider the limits of nature's resilience, i.e., its capacity to regenerate. It is therefore fundamental to create an industry with an optimum, sustainable scale, that reduces the environmental impacts across the entire production chain and the pressure on natural resources. This is not only to guarantee sustainable development for Brazil, but also to avoid making the same mistake as developed countries in not taking care of the environment.

One of the current bases used for the development of technological research in a city is the potential for the existence of a smart city. The term smart city arose in the 1990s and refers to the use of technological innovations in information and communication to overcome the main challenges facing cities, such as security and sustainability. This means that local governments must innovate when planning and prioritizing investments in cities (RIZZON et al., 2017). Of PISAC's 15 research areas, the area smart city is one that is currently in rapid development (ZHAO; TANG; ZOU, 2019).

Cooperation networks that are established on the technology platform are vital to innovation dynamics; studies are also carried out that try to systemize these relationships and how they culminate in innovation. The principal innovation model, the triple helix, shows which universities present the greatest degree of university-industry-government interaction (ETZKOWITZ; LEYDESDORFF, 1995). Despite and due to society's evolution and how it has changed in recent years, the traditional triple helix has been improved with the addition of new players: society (quadruple helix) and the environment (quintuple helix) (MINEIRO et al., 2018).

Micheal Porter (2001) describes how the role of innovation clusters is essential to competitive advantage, since the strategy presented would result in many spillovers due to the positive external factors resulting from agglomeration, such as greater sharing of knowledge and bigger technology transfer agreements due to regional and physical proximity. PISAC is a type of innovation cluster that encourages greater interaction between players in the innovation ecosystem, built environment industries, the government, and the existing research network within and outside of universities (LI et al., 2019).

This type of policy that uses innovation and entrepreneurship clusters acts as a tool to create positive externalities in order to make the most of small and scarce infrastructure. Universities, such as the University of Brasilia, can act as important anchors to establish regional clusters, and are important spatial determinants of the entrepreneurship and innovation cluster.

To better understand this situation, the present study will map the main research collaboration networks of innovation and sustainability in PISAC's (Innovation and Sustainability Park for the Built Environment) most relevant area, since PISAC is a technology platform based on policies from partnerships between the government, universities and industry. The study will allow us to identify the main area and main players in Brazilian research and development in industry today, and in turn demonstrate the potential of Brazilian science when a policy is employed to establish technological platforms. It is hoped to answer the following questions: Which area of

Brazilian research in sustainable technologies of the built environment is currently showing the greatest evolution? Which main research and development networks participate in this area of PISAC research? And, how can current Brazilian scientific production be described?

1 LITERATURE REVIEW

2.1 Innovation

Schumpeter, the forerunner of the concept of innovation, explains the process of economic development via entrepreneurship and credit, in which economic growth is due to technological innovation and development, which are considered variables in the economic cycle that increase the economy's productive capacity. This linear concept of innovation considers the growth cycle as dependent on the supply of science and technology, thus an increase in credit directed to entrepreneurial enterprises would lead to economic development (BARATA, 1992).

According to Schumpeter's theory, technological innovations drive economic growth, since the entrepreneurial capacity of agents that have support from technological innovations result in new opportunities. Therefore, to get the most from these opportunities, the presence of capitalists, or as he calls them venture capitalists, who are willing to provide credit to the entrepreneurs, is necessary (SANTOS; FAZION; MEROE, 2011).

In an attempt to standardize the concept of innovation, the OCDE (Organization for Economic and Co-operation Development) created the Oslo Manual. The generic definition of innovation in the Oslo Manual (2018) is a product or process that is new or has been improved, and is significantly different from its predecessors, and that has been made available for use, either as a product for a client or a process for a unit (OECD; EUROSTAT, 2018).

The types of innovation include product innovation, which is the invention or refinement of a product or service that is available on the market. Process innovation refers to a new process or the significant improvement of a process of one or more entities that previously did not use but now use the innovative process. Organizational innovation refers to the innovative practices surrounding the organization of a firm, administration and management. Marketing innovation refers to innovation in relation to product design, product placement, promotions, and prices, i.e., marketing, sales and after-sales service (OECD; EUROSTAT, 2018).

1.2 Quintuple Helix Model

Throughout the history of economic thought many experts have tried to define how economic development can be achieved, as well as coming up with a "magic" formula for sustained growth and explaining why some countries have stood out more than others in certain areas. Innovation is essential to the development of a nation. According to Schumpeter (1934), technological innovation is an endogenous factor in the equation of economic development in a capitalist economy; his research heavily influenced studies on the dynamic of the evolutionary theory, leading to branches of the Schumpeterian and Neo-Schumpeterian schools of thought (FERREIRA, 2018). The triple helix model was born from the necessity to identify how relationships between economic agents, such as universities, industry and government, developed a successful innovation strategy (ETZKOWITZ; ZHOU, 2017). At the core of innovation is knowledge, since it is via innovation that knowledge is transformed into economic activity, which in turn generates economic development. Many studies analyze the relationship between the synergy of economic agents and their innovative capacity. Based on this it can be assumed that a stronger university-company-government partnership leads to greater innovative capacity in companies, making them more competitive in a global, capitalist scenario (FERREIRA, 2018).

The dissemination of knowledge as a result of cooperation and interdependence between the players of the three spheres is crucial to enabling an exchange of ideas, which allows companies to grow via open innovation. This method goes beyond understanding the strong and weak points of the relationship and is based on forming national or even regional alliances that aim to increase the innovative capacity of organizations and their level of competitiveness (ETZKOWITZ; LEYDESDORFF, 1995).

In Brazil, the triple helix model has become an important guide for national and regional policies, since the

IFES are institutions that are central to the knowledge sector. This is also the case with technological platforms that promote relationships between the government and productive sector, the primary example being a start-up incubator, in other words, adding value to businesses of young companies and building competitive advantages for these start-ups (LEYDESDORFF, 2012).

Constant changes are occurring worldwide regarding the way in which the players connect, and so there is naturally an evolutive process going on in the triple helix model. The quadruple helix model is about strengthening the generation of knowledge. In this model there is a collaboration network with participation from civil society and the wider community. The importance of the role of society therefore stands out in terms of establishing goals and objectives for the innovative environment (MINEIRO et al., 2018).

Civil society is the principal user and beneficiary of the collaboration network, making it central to the model, since members are presented as co-developers and co-creators of innovation, and therefore stimulate the process. Civil society also includes collective organizations and associations. The current complexity surrounding the application of knowledge and innovation has led to the construction of broader models to better understand these structures (MINEIRO et al, 2018).

In the search for a long-term sustainable society, the quintuple helix model represents a framework in which the environment is a driver of innovation and flow of knowledge. Innovations known as green technologies pose a challenge to current collaboration networks, and therefore this fifth helix is not only presented as a player, as in the earlier models, but also as a response to current environmental concerns. This brings a new transdisciplinary perspective to innovation as well as the capacity to change and amplify socioecological and natural environment transformations (MINEIRO et al., 2018).

The fifth helix includes an ecological side to innovations, where global warming is, as opposed to being a challenge, presented as an effective innovative opportunity in relation to natural capital. Thus, the prime focus of the quintuple helix is to include the natural environments as subsystems for the current models of innovation and knowledge. As a result, this is important for the preservation and survival of mankind, enabling the creation of new green technologies (CARAYANNIS; BARTH; CAMPBELL, 2012).

Thus, the quintuple helix presents the collaborative synergy of five subsystems in the exchange of knowledge, in other words, five helixes: the education system, the economic system, the environment, civil society and the political system. This analysis shows how the assets in each subsystem must be prepared so that mankind's progress goes hand in hand with sustainable development (CARAYANNIS; BARTH; CAMPBELL, 2012).

1.3 Technological Platform

Technological platform is a term coined by a consultant at the World Bank, C. Weiss, who describes the platform as a place of communication and exchange of information between stakeholders (TEIXEIRA, 2012). In IT, an area in which it is widely utilized, the term refers to a system made up of key activities to develop a structure capable of carrying out new functionalities. When understood in the world of innovation, the technological platform serves as a system that induces interaction between players in the ecosystem with innovation being the result (OLIVEIRA; PITERI; MENEGUETTE, 2014).

In Brazil, the term technological platform was idealized by the Scientific and Technological Development Support Program (PADCT), whose mission is to promote technological development in Brazilian firms by increasing investment in R&D, as well as stimulating partnerships between the productive sector and academia based on shared priorities (CHIARELLO, 2000).

Therefore, technological platforms can be considered an instrument with a dual function: to plan and prospect. Planning refers to organizing and planning activities related to science and technology of a specific region or sector. Prospection refers to identifying opportunities from existing technological constraints, thus subsidizing a means of communication and negotiation (CHIARELLO; ROCHA, 2001).

The objective of the platform is to eradicate limitations and reduce uncertainties, establishing connections between innovative players to create partnerships and cooperation projects. It is therefore part of the platform's process to continually reflect on society in terms of the technological paradigms and, without impeding the success of the program, it must have four specific moments, according to Figure 1 (CHIARELLO; ROCHA, 2001).

Figure 1 - Process for the technological platform to succeed
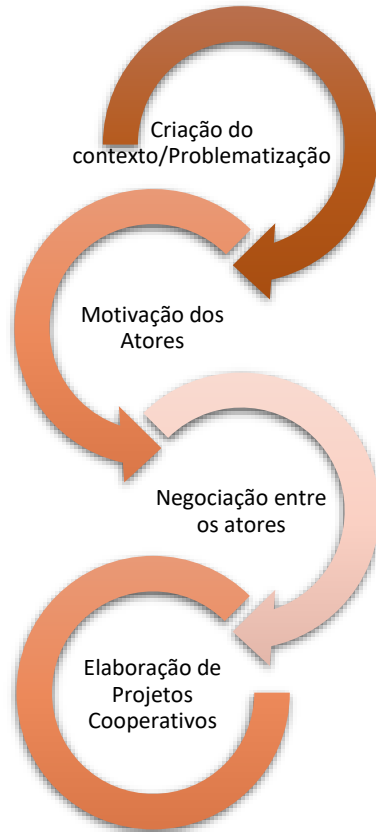
Source: Rocha (2001).

1.4 PISAC - Innovation and Sustainability Park for the Built Environment

The objective of the Innovation and Sustainability Park for the Built Environment, situated on the Darcy Ribeiro Campus at the University of Brasilia, is to be a technological platform that changes paradigms through development, tests and the spread of innovation and sustainable technologies to processes and products conceptualized, constructed and operated in the built environment (BLUMENSCHEIN; FERRARI; BARROS, 2019).

PISAC aims to facilitate communication and promote partnerships between different figures in society, by implementing cooperation projects. It also aims to identify opportunities of R&D and training, with a focus on innovation, sustainability and resilience, considering the planning, construction and operation of the built environment, as well as acting as a technological platform to reflect on S&T, regulation mechanisms and the organization of public policies in the sector.

A range of activities are carried out in order to meet the institutions objective, and considering the scope of the platform's business, three types of process are found: society-led actions, support and management. PISAC has three main activities: i) research, ii) prototyping and product development and iii) service provision and training (BLUMENSCHEIN; FERRARI; BARROS, 2019). These activities fall into fifteen areas of knowledge:

Table 1 - Areas of knowledge of PISAC

Intelligent Cities	Environmental Resource Management	Artificial Intelligence
Urban Resilience	Spatial Environment	Energy Efficiency
CPIC Innovation (Productive Chain of the Construction Industry)	Optic Sensors - FBG (Fiber Bragg Grating)	Water Efficiency
CEPE - Productive Chain of Prison Construction	Shape memory materials	Econometric Studies
Special Buildings - Schools and Hospitals	Biomimetics	BIM – Building Information Modeling

Source: Developed by the author.

2 METHODOLOGY

2.1 Method to define Relevant Area of Knowledge - Scopus

To define the relevant area from PISAC's 15 areas of knowledge, the following three areas were chosen: Smart Buildings, Smart Cities and Urban Resilience. These areas were chosen given their scope and since they are most closely related to Economic Sciences. Based on these three areas, research was carried out using Scopus in order to define which area of knowledge would be the most relevant based on each one's volume of scientific production.

The research was only carried out on articles and book chapters from February 19, 2021, and no time span was defined for the research. As seen in Table 1, the volume of scientific production on smart cities is the highest of the three areas of knowledge, meaning that this area is more greatly explored than smart building and urban resilience.

Table 1 - Scientific Production

Areas of Knowledge	Papers	Book Chapters
Smart cities	7309	1211
Smart buildings	1196	113
Urban resilience	632	110

Source: Research results

Graph 1 - Scientific production in the Scopus database over time - smart buildings, smart cities and urban resilience.
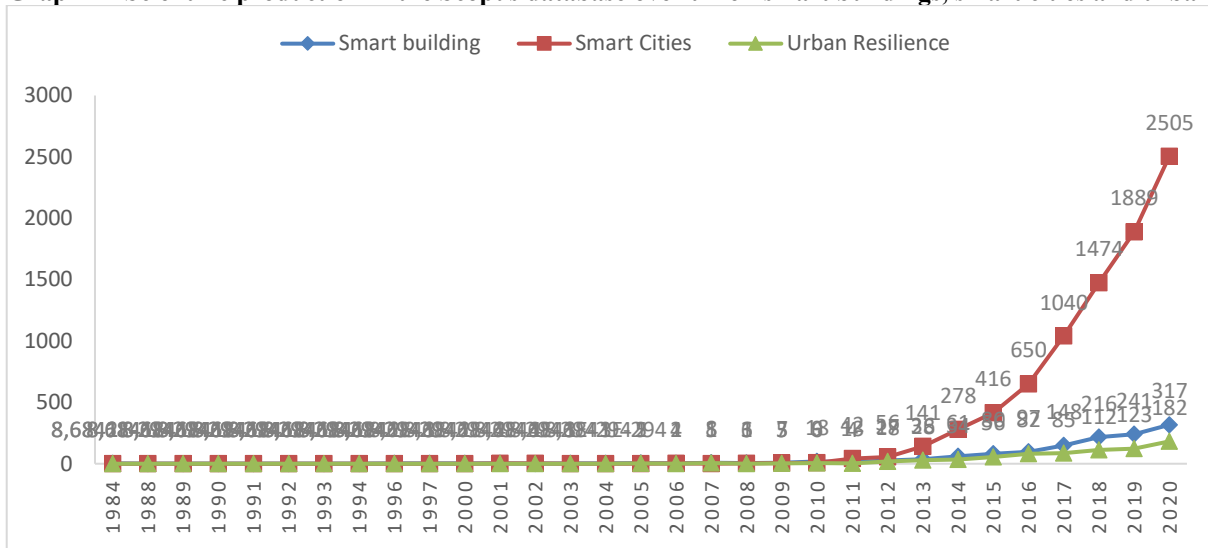
Source: Scopus.

Despite the term smart buildings existing since the mid-80's, it is the term smart cities that has grown in relevance since 2013. Despite being a newer term, it has been more greatly explored in recent years on the international scene, which justifies the choice of smart cities as the area of knowledge to map cooperation networks.

2.2 Data Sources

Scientific production in this case was largely evaluated based on international standards and on the principal international repositories. This however has negative consequences for the peripheral production, since it does not consider other circuits of scientific knowledge dissemination; it is important to highlight the connection between the production performance and financing of research and development (BEIGEL, 2014).

The types of circuits of scientific publication include international, transnational, regional and national. When other circuits are disregarded in favor of international circuits the structural heterogenous characteristics of the scientific knowledge decrease, which is detrimental when used as a base to create public policy strategies in ST&I (BEIGEL; GALLARDO; BEKERMAN, 2018).

Studies that do not consider regional, transnational and national circuits are limited since the tendencies of internationalizations of certain themes could eradicate or diminish the relevance of a significant part of scientific production which is on the periphery of international repositories (MUGNAINI et al., 2019).

Thus, the data source chosen was the Brazilian Federal Government's Lattes Curriculum Platform for Scientific and Technological Development, given its wide reach of capacities of national research networks, primarily in terms of a historical record of the scientific and technical production (DIAS; MOITA; DIAS, 2016).

Since the Technological Platform (PISAC) is Brazilian, it is important that an open and national repository is used, which belongs to the Federal Government and is directly connected to the Ministry of Science, Technology, Innovation and Communication. It is therefore hoped that the true capacities of Brazilian scientific research can be presented since the Lattes Platform provides an accurate overview of the academic structure of scientific production in the country (NASCIMENTO et al., 2021). Therefore, the terms "intelligent cities" and "smart cities" were researched on the Lattes Platform, and 2475 resumés came back.

2.3 Network Analysis Method

The key to network analysis is to better understand the context of the research surrounding smart cities in Brazil, including social profile, geographic distribution, alliances between research groups and projects in the sector. Thus, the method must include how to understand and map the scientific knowledge in terms of diversity,

time-slicing and dynamics (ZHAO; TANG; ZOU, 2019).

Regarding alliances between groups, an analysis of the scientific publications carried out collaboratively and research projects was undertaken to uncover the researchers that collaborate with each other. The wider areas of scientific knowledge that these individuals work in in terms of smart cities was also studied. It is therefore possible to map the dimension of the research and development of the subject smart cities: strategies and objectives of Brazilian research. The initial analysis looks at the number of publications in order to understand if the area is growing, as could be verified from the international scientific production. An analysis of the production of articles and projects which explore smart cities was then carried out.

**Figure 2 - Analysis Method of Cooperation Networks in Smart Cities**

Source: Developed by the author.

3 RESULTS AND DISCUSSION

A wide set of information can be obtained from the Lattes Platform, including Scientific Articles, Books, Book chapters, Projects, education of Brazilian researchers and masters and PhD theses. With smart cities defined as the specific research in the area of knowledge, it was possible to verify, according to Graph 2, that publications began in 2005, with projects first appearing in 2010 onwards.

However, articles on smart cities are also increasing, which reflects the interest of Brazilian researchers, as well as the overall expansion of the area at this time. Despite not being analyzed analytically, a significant increase in book chapters, masters and PhD diplomas and masters and PhD theses which include the area of smart cities was noted. It can therefore be deduced that there is growing interest on the part of Brazilian researchers on the subject.

Graph 2 - Timeframe of scientific production on smart cities
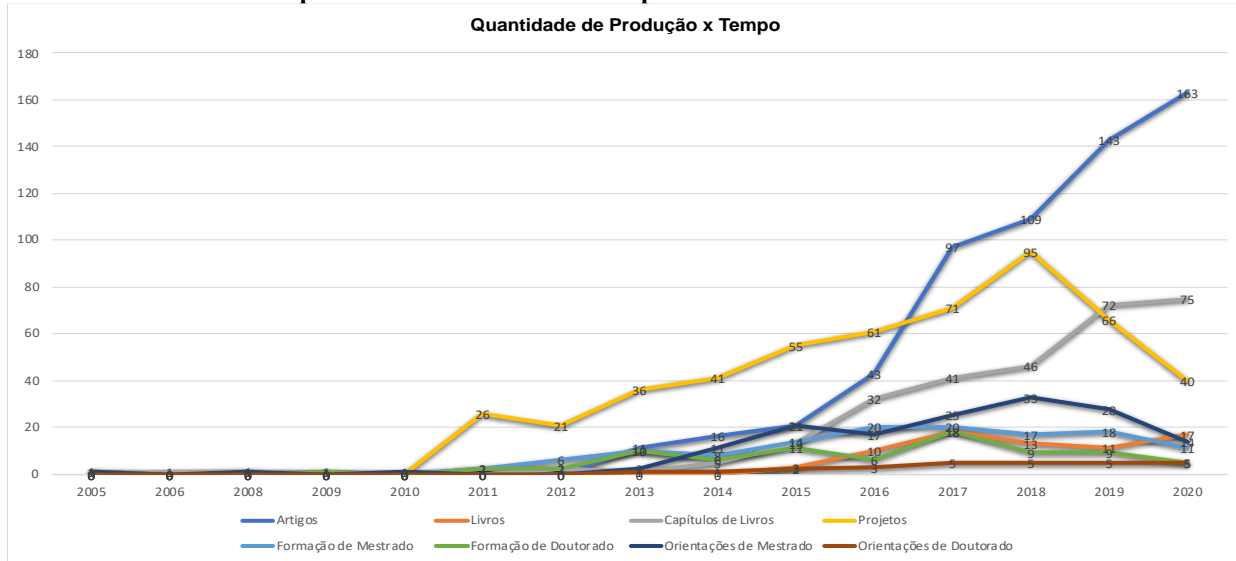
Source: Research result.

Articles on smart cities are also increasing, thus reflecting the interests of Brazilian researchers, as well as

the overall expansion of the area at this time. Despite not being analyzed analytically in this work, there is a relevant increase in the number of book chapters, masters and PhD diplomas and masters and PhD theses on smart cities, thus indicating growing interest from Brazilian researchers on the subject.
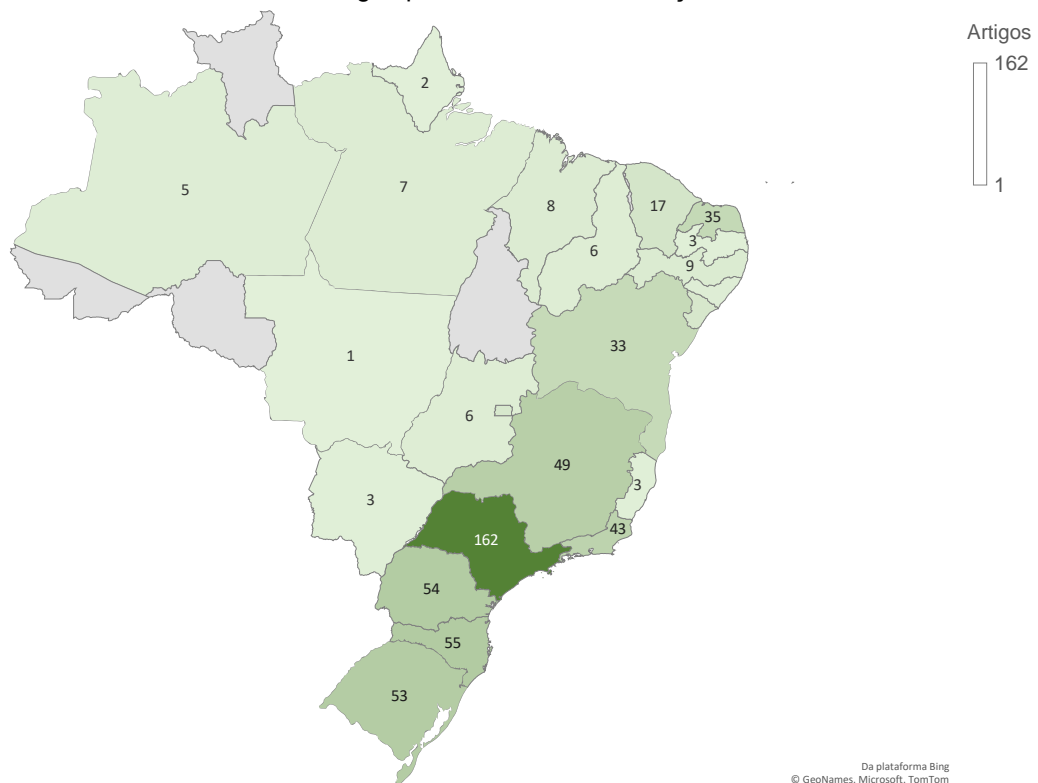
3.1 Analysis of the Articles

Brazilian-produced articles on smart cities span the whole country, as can be seen in Figure 2. The majority however of authors that study this area are found in the South and Southeast.
This highlights the regional differences in financial and human resources, since these particular regions represent the highest population and highest contribution to the country's GDP (according to the 2018 IBGE, São Paulo is responsible for 31.561% of Brazil's GDP). It is therefore inevitable that these regions will present a higher contribution on the subject. The Northeast follows in terms of the number of articles, with the states of Rio Grande do Norte, Bahia and Ceará standing out. Graph 3 presents the wider area of knowledge that the articles on smart cities are found, namely social and applied sciences, exact and earth sciences, and engineering.
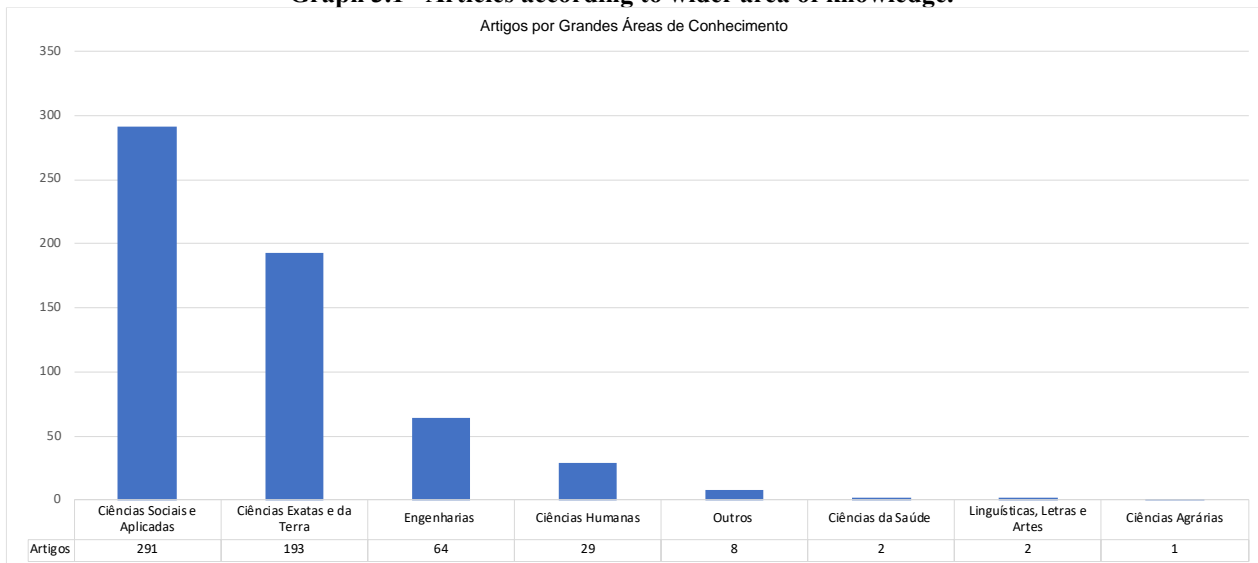
Figure 3 - Map of the distribution of articles according to location of researchers

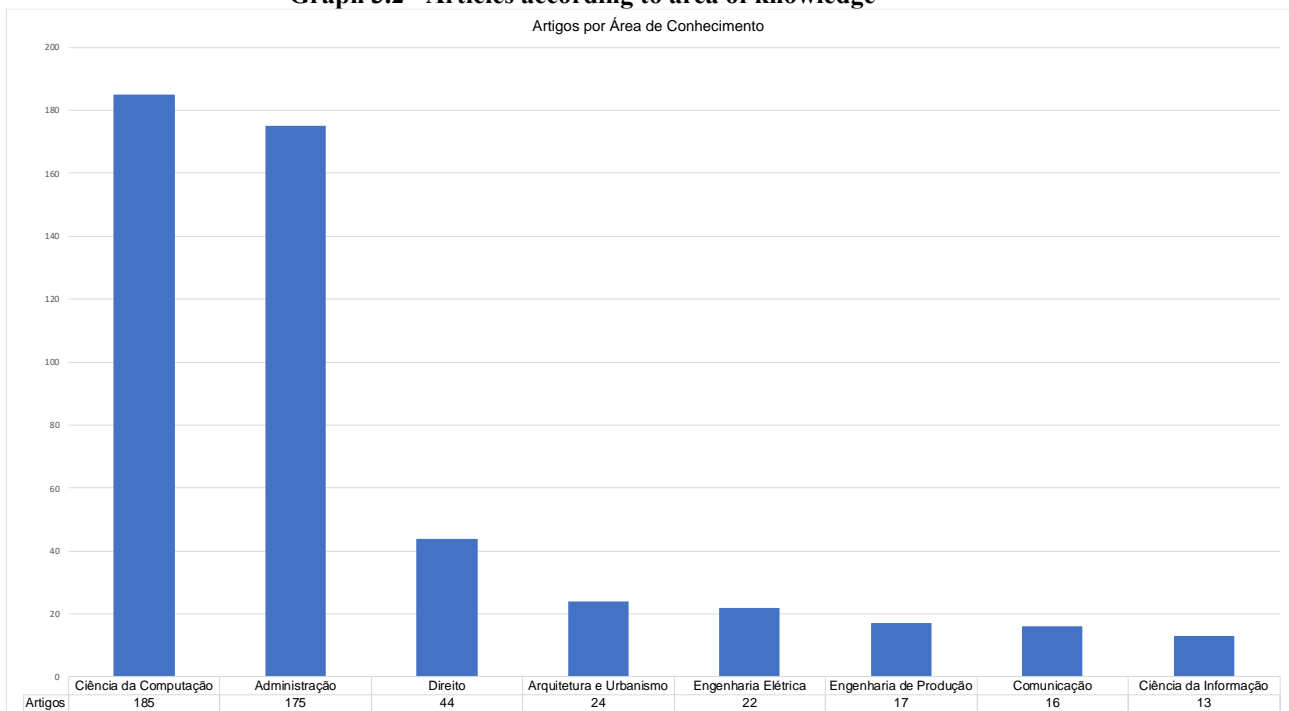Número de Artigos por Estados da Federação

Source: Research Results.

Graph 3.1 - Articles according to wider area of knowledge.

Artigos por Grandes Áreas de Conhecimento

Artigos	Ciências Sociais e Aplicadas	Ciências Exatas e da Terra	Engenharias	Ciências Humanas	Outros	Ciências da Saúde	Linguísticas, Letras e Artes	Ciências Agrárias
	291	193	64	29	8	2	2	1

Source: Research results.

Graph 3.2 - Articles according to area of knowledge

Artigos por Área de Conhecimento

Artigos	Ciência da Computação	Administração	Direito	Arquitetura e Urbanismo	Engenharia Elétrica	Engenharia de Produção	Comunicação	Ciência da Informação
	185	175	44	24	22	17	16	13

Source: Research results.

The predominant area of knowledge in the articles is computer science followed by administration, law, and architecture and urbanism (see Graph 4). Graphs 3 and 4 show the transdisciplinary nature of the subject, as well as collaboration with other areas, primarily computer science and administration.

Figure 2 - Collaboration network between states: articles on smart cities.
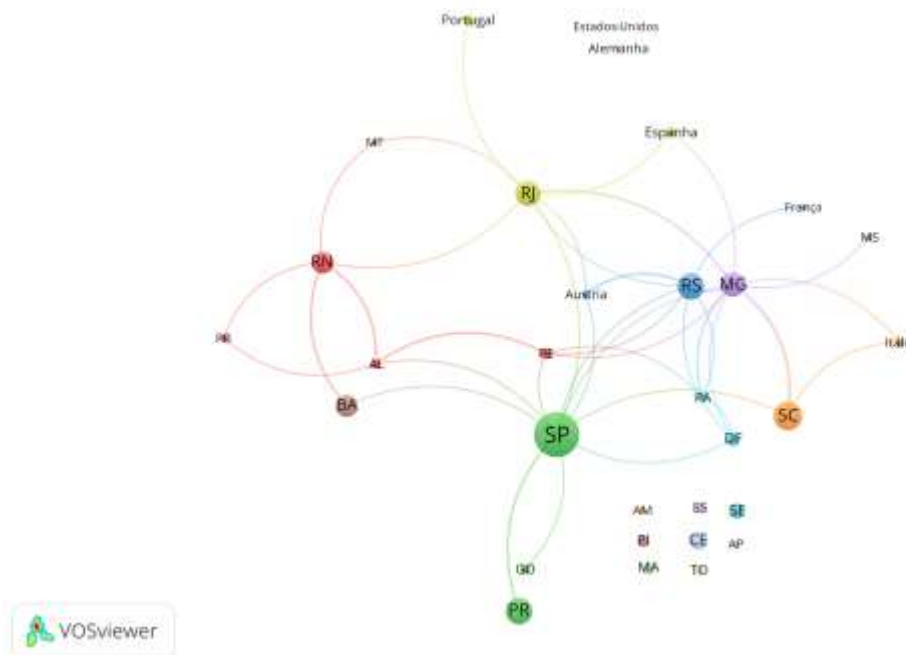

The collaboration network presents the main states and the states with which they collaborate. Some states solely produce research in their own state. One of the main features of this network is that the Federal District state does not collaborate with other states that play an important role in the scientific production on smart cities.

The states of Rio de Janeiro, Bahia, Rio Grande do Norte, Paraná and Santa Catarina present no collaboration with the Federal District; it is therefore important to create means of collaboration with those involved with this subject area in these states. PISAC must devise strategies that focus on collaboration that will strengthen ST&I in the area of smart cities.

3.2 Analysis of the Projects

The distribution of projects that broach the subject of smart cities is shown in Figure 3. It is clear that the same tendency as seen in the previous topic, on the production of articles, applies. The most interesting fact however is that Rio Grande do Norte is among the top three federated states with the highest number of projects, overtaking the three states in the Southern region, which have a higher contribution in terms of articles.
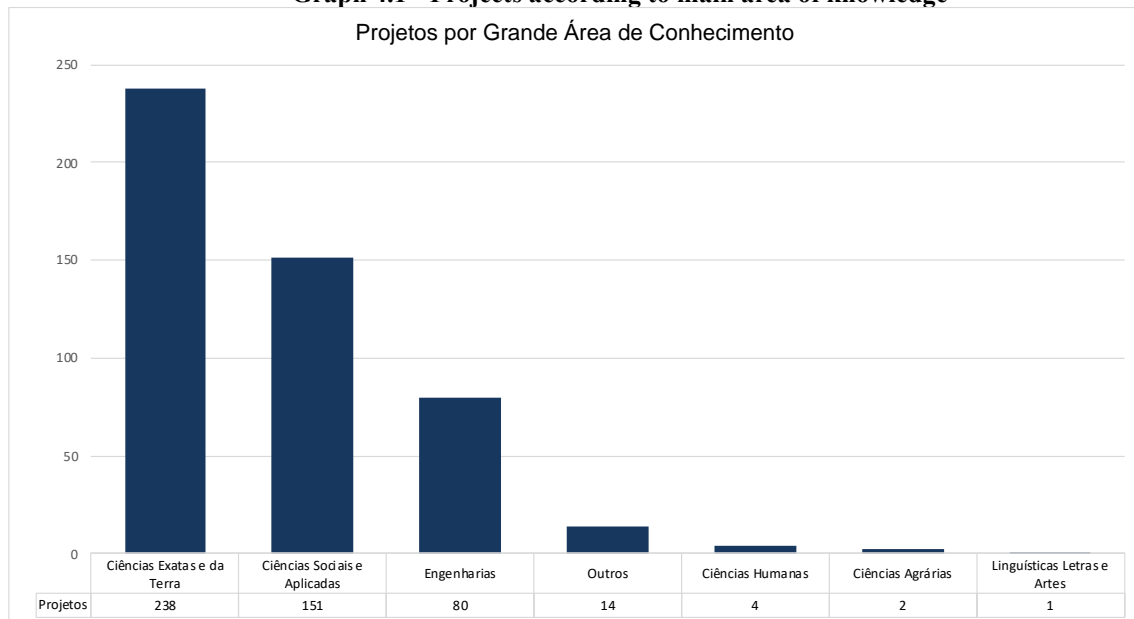
Figure 4 - Map of the distribution of projects according to researcher location.

Número de projetos por Estados da Federação
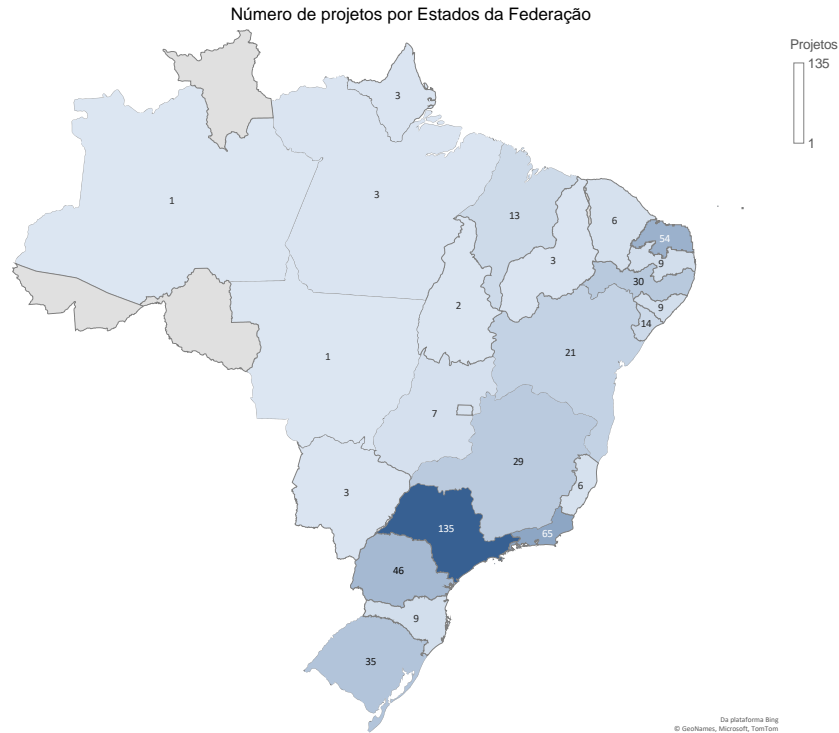
Source: Research results.

The most important question posed in the study was: which variables make Rio Grande do Norte one of the main national players regarding the development of projects on smart cities. When evaluating the information made available by researchers on the Lattes database, it was deduced that these authors undertake research that involves entrepreneurialism and innovation, and this is independent of the researcher's primary professional focus. When analyzing the main areas of knowledge in the projects, three areas stand out: exact and earth sciences, social and applied sciences and engineering.

Graph 4.1 - Projects according to main area of knowledge

Projetos por Grande Área de Conhecimento

|	Ciências Exatas e da Terra	Ciências Sociais e Aplicadas	Engenharias	Outros	Ciências Humanas	Ciências Agrárias	Linguísticas Letras e Artes
Projetos	238	151	80	14	4	2	1

Source: Research results.

According to Graph 4.2, which presents the areas of knowledge of the projects that encompass the theme smart cities, computer science is more prominent than the other areas, as well as being the primary driver of

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information and communications technology (ICT) that enables the ideation of smart cities. Administration, electric engineering, and law were found to be less relevant in the projects on smart cities.

Graph 4.2 - Projects according to area of knowledge
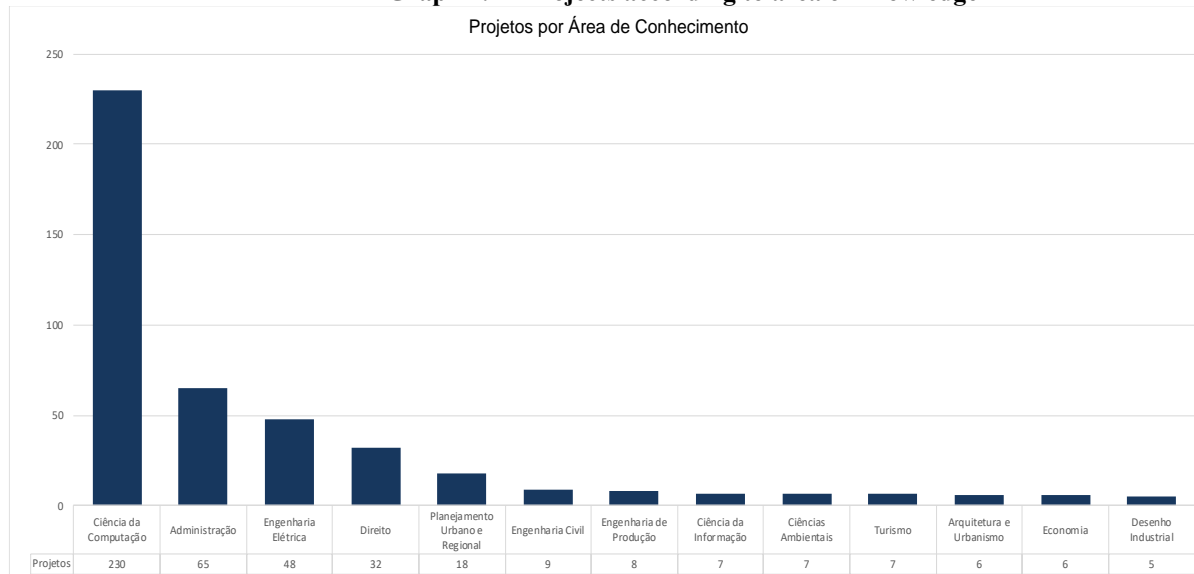
Source: Research results.

4 PRINCIPAL PLAYERS

This chapter presents the main researchers regarding the analysis of the articles (Table 2) and the main researchers of the projects related to smart cities (Table 3). From these two tables it is possible to confirm that the field of computer science is the principal area of knowledge.

Table 2 - Principal authors according to volume of articles published.

Estados	Nome do Pesquisador	Número de Artigos	Área de Conhecimento
Bahia	Daniel Gouveia Costa	9	Ciência da Computação
São Paulo	Marcos Cesar Weiss	9	Administração
Paraná	Tharsila Maynardes Dallabona Fariniuk	7	Educação
Minas Gerais	Renata Maria Abrantes Baracho Porto	6	Arquitetura e Urbanismo
Bahia	André Luiz Martins Lemos	5	Comunicação
Piauí	Joel José Puga Coelho Rodrigues	5	Ciência da Computação
Santa Catarina	Eduardo Moreira da Costa	5	Administração
São Paulo	Flávia Consoni	5	Ciências Ambientais
Paraná	Sergio Akio Tanaka	4	Ciência da Computação
Rio Grande do Norte	Lucas do Monte Silva	4	Direito
Rio Grande do Norte	Nelio Alessandro Azevedo Cacho	4	Ciência da Computação
Rio Grande do Norte	Patricia Borba Vilar Guimarães	4	Direito
São Paulo	Erico Przeybilovicz	4	Administração
São Paulo	Wilson Levy Braga da Silva Neto	4	Direito
Alagoas	Luiz Antonio Felix Junior	3	Administração
Bahia	João Paulo Just Peixoto	3	Ciência da Computação
Paraná	Fábio Duarte de Araújo Silva	3	Ciência da Informação
Rio Grande do Norte	Ricardo Tadeu Soares Santos	3	Administração
Rio Grande do Sul	Jorge Luis Victória Barbosa	3	Ciência da Computação
Santa Catarina	Clarissa Stefani Teixeira	3	Engenharia de Produção

Source: Research results.

Table 3 reflects the data in the previous chapter, with a large number of researchers producing many projects on smart cities, found in the Northeast region.

Table 3 - Principal authors according to volume of projects

Estados	Nome do Pesquisador	Número de Projetos	Área de Conhecimento
Rio de Janeiro	André Luis Azevedo Guedes	8	Administração
Rio Grande do Norte	Almir Mariano de Sousa Junior	5	Planejamento Urbano e Regional
Sergipe	Rogério Patrício Chagas do Nascimento	5	Ciência da Computação
São Paulo	Rita de Cassia Giraldi	5	Turismo
Bahia	Joberto Sérgio Barbosa Martins	4	Ciência da Computação
Maranhão	Francisco José da Silva e Silva	4	Ciência da Computação
Pernambuco	Kiev Santos da Gama	4	Ciência da Computação
Pernambuco	Vinicius Cardoso Garcia	4	Ciência da Computação
Rio de Janeiro	Marie Anne Macadar Moron	4	Administração
Rio Grande do Norte	Everton Ranielly de Sousa Cavalcante	4	Ciência da Computação
Rio Grande do Norte	Ivanovitch Medeiros Dantas da Silva	4	Engenharia Elétrica
Alagoas	Andre Luiz Lins de Aquino	3	Ciência da Computação
Minas Gerais	Davi Viana dos Santos	3	Ciência da Computação
Minas Gerais	Daniel Ludovico Guidoni	3	Ciência da Computação
Pernambuco	Stênio Flávio de Lacerda Fernandes	3	Ciência da Computação
Paraná	Ricardo Mendes Junior	3	Ciência da Informação
Rio de Janeiro	Miguel Elias Mitre Campista	3	Ciência da Computação
Rio Grande do Sul	Ana Lucia Cetertich Bazzan	3	Ciência da Computação
Rio Grande do Sul	Carlos Oberdan Rolim	3	Ciência da Computação
São Paulo	David Bianchini	3	Engenharia Elétrica

Source: Research results:

CONCLUSIONS

The development of a circuit of innovation of ST&I in smart cities is essential to enabling Brazil to be independent of foreign technologies. Brazil boasts extensive scientific expertise which must be mapped, and from this point of view it was possible to verify a number of particular characteristics. These include a large participation of researchers from a wide range of fields of study, from law to electrical engineering and architecture and urbanism, thus highlighting the trans disciplinarity of the subject.

Though it appears to be a strictly technological area, the development of smart cities should be aligned with areas of business administration to develop management techniques for decision-making using data collected from diverse urban systems. Law is one field with particular relevance given the legal limits surrounding the collection and use of data on the citizens that live in the cities.

The data concluded that the Federal District is not an important player nationally-speaking, and that connections between this state and other players, including Rio Grande do Norte, Rio de Janeiro, Bahia and Santa Catarina, is of great importance. Some interaction is evident between Pará and the Federal District, however if the latter is to establish itself as a key player in ST&I, it must forge relationships with other regions in Brazil. PISAC is therefore key to stimulating cooperation projects between researchers in the Federal District and the principal Brazilian players in the area of smart cities.

The main difficulty in the present study is the rate at which the data is updated. Given that Lattes is an open database, some researchers may not update their resumés for years, and so the current activities of these professionals are unknown. For future studies that involve the mapping of Brazilian scientific expertise, exploratory research should be carried out on the particular factors that lead each state to develop different skills within the field of smart cities. For example, smart cities that opt to develop the city's tourism system, the transport system, the housing system or even a group of systems to help develop environmental and social sustainability in the city.

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