

## THE CONTRIBUTION OF KNOWLEDGE MANAGEMENT TO SMART CITIES FOR INNOVATION: PROPOSAL FOR A PRESCRIPTIVE FRAMEWORK AND A RESEARCH AGENDA

*A CONTRIBUIÇÃO DA GESTÃO DO CONHECIMENTO ÀS CIDADES INTELIGENTES VISANDO A INOVAÇÃO: PROPOSTA DE UM FRAMEWORK PRESCRITIVO E UMA AGENDA DE PESQUISA*

*LA CONTRIBUCIÓN DE LA GESTIÓN DEL CONOCIMIENTO A LAS CIUDADES INTELIGENTES OCUPA INNOVACIÓN: PROPUESTA DE MARCO PRESCRIPTIVO Y AGENDA DE INVESTIGACIÓN*

 Darci de Borba<sup>1</sup>  
 Rosiane Alves Palacios<sup>2</sup>  
 Edimara Mezzomo Luciano<sup>3</sup>  
 Marcirio Silveira Chaves<sup>4</sup>

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### Abstract

**Objective:** To verify how Knowledge Management (KM) is being associated with Smart Cities (SC) initiatives, through the analysis of the scientific production of both themes in indexing journals in the last 10 years. This article has three research questions: 1. What are the methodological approaches adopted to investigate research problems on KM in SC. 2. What are the research topics investigated on KM in SC? and 3. How is research on KM characterized in SC?

**Relevance/originality:** This research analyzes how KM is associated with SC initiatives and proposes a research agenda on KM in SC.

**Methodology/approach:** The method used was a semi-systematic literature review.

**Main results:** The research found gaps concerning the adaptation of KM models in the context of SC, the selection of relevant variables for the analysis of KM in SC, the effect of KM on the results of SC initiatives, and how actions emerging issues of transparency and governance can influence or be influenced by KM.

**Theoretical/methodological contributions:** The article builds an overview of the collaboration of two fields in evidence today. In addition to the analysis of all articles in the sample, which includes quantitative data, the authors bring a proposed research agenda with the aim of promoting the maturation of the theme. The main theoretical contributions are in the proposal of the prescriptive framework and the research agenda.

**Social/management contributions:** In a context of excess knowledge, decision-making becomes complex. Thus, understanding how KM can act in the complex context of SC helps managers to visualize alternatives to problems, selection, and organization of knowledge that affect decision-making.

**Keywords:** Smart cities. Knowledge management. Semi-systematic literature review.

<sup>1</sup>Especialista em educação corporativa. Universidade do Vale do Rio dos Sinos - UNISINOS, Porto Alegre, RS, Brasil. [darci17@gmail.com](mailto:darci17@gmail.com)

<sup>2</sup>Especialista em gestão pública. Universidade Federal do Pampa - UNIPAMPA, RS, Brasil. [rosianepalacios.rp@gmail.com](mailto:rosianepalacios.rp@gmail.com)

<sup>3</sup>Doutora em administração. Universidade Federal do Rio Grande do Sul - UFRGS, Porto Alegre, RS, Brasil. [eluciano@puccs.br](mailto:eluciano@puccs.br)

<sup>4</sup>Doutor em Informática. Universidade de Lisboa, Lisboa, Portugal. [mschaves@gmail.com](mailto:mschaves@gmail.com)

## Resumo

**Objetivo:** Verificar como a Gestão do Conhecimento (GC) está sendo associada às iniciativas de Cidades Inteligentes (CI), por meio da análise da produção científica de ambos os temas em indexadores de periódicos nos últimos 10 anos. Este artigo tem três questões de pesquisa: 1. Quais são as abordagens metodológicas adotadas para investigar os problemas de pesquisa sobre GC nas CI?; 2. Quais são os temas de pesquisa investigados sobre GC nas CI? e 3. Como se caracterizam as pesquisas sobre GC nas CI?

**Relevância/originalidade:** Esta pesquisa analisa como a GC está sendo associada às iniciativas de CI e propõe uma agenda de pesquisa sobre a GC em CI.

**Metodologia/abordagem:** O método utilizado foi a revisão semi-sistemática de literatura.

**Principais resultados:** A pesquisa encontrou lacunas no que se refere à adaptação dos modelos de GC no contexto das CI, a seleção de variáveis relevantes para análise de GC em CI, o efeito da GC nos resultados das iniciativas de CI e como as ações emergentes de transparência e governança podem influenciar ou serem influenciadas pela GC.

**Contribuições teóricas/metodológicas:** O artigo constrói uma visão abrangente sobre a colaboração de dois campos em evidência na atualidade. Além da análise de todos os artigos da amostra, que inclui dados quantitativos, os autores trazem uma proposta de agenda de pesquisa com o objetivo de promover o amadurecimento da temática. As principais contribuições teóricas estão na proposta do framework prescritivo e da agenda de pesquisa.

**Contribuições sociais/para a gestão:** Em um contexto de excesso de conhecimento, a tomada de decisão se torna complexa. Assim, entender como a GC pode atuar no contexto complexo das CI ajuda os gestores a visualizar alternativas para os problemas, seleção e organização de conhecimento que interferem na tomada de decisão.

**Palavras-chave:** Cidades inteligentes. Gestão do conhecimento. Revisão semi-sistemática de literatura.

## Resumen

**Objetivo:** Verificar cómo la gestión del conocimiento (GC) se está asociando con las iniciativas de ciudades inteligentes (CI), a través del análisis de la producción científica de ambos temas en revistas indexadas en los últimos 10 años. Este artículo tiene tres preguntas de investigación: 1) ¿Cuáles son los enfoques metodológicos adoptados para investigar problemas de investigación sobre GC en CI?; 2) ¿Cuáles son los temas de investigación investigados sobre GC en CI? y 3) ¿Cómo se caracteriza la investigación sobre GC en CI?

**Relevancia / originalidad:** Esta investigación analiza cómo la GC se asocia con las iniciativas de CI y propone una agenda de investigación sobre la GC en CI.

**Metodología / enfoque:** El método utilizado fue una revisión bibliográfica semi-sistemática.

**Resultados principales:** La investigación encontró brechas con respecto a la adaptación de los modelos de GC en el contexto de la CI, la selección de variables relevantes para el análisis de la GC en la CI, el efecto de la GC en los resultados de las iniciativas de CI y cómo las acciones las cuestiones emergentes de transparencia y gobernanza pueden influir o ser influidas en la GC.

**Contribuciones teóricas / metodológicas:** El artículo construye un panorama de la colaboración de dos campos que se evidencian hoy. Además del análisis de todos los artículos de la muestra, que incluye datos cuantitativos, los autores traen una propuesta de agenda de investigación con el objetivo de promover la maduración de la temática. Los principales aportes teóricos se encuentran en la propuesta del marco prescriptivo y la agenda de investigación.

**Contribuciones sociales / de gestión:** En un contexto de exceso de conocimiento, la toma de decisiones se vuelve compleja. Por lo tanto, comprender cómo puede actuar la GC en el contexto complejo de la CI ayuda a los gerentes a visualizar alternativas a los problemas, la selección y organización del conocimiento que interfiere en la toma de decisiones.

**Palabras clave:** Smart cities. Gestión del conocimiento. Revisión de literatura semi-sistemática.

## Introduction

Smart Cities (SC) appear in a context in which the population increases and the scarcity of resources demand planned solutions, opening space for the adoption of projects and initiatives that use Information Technology (IT) in their favor. The term SC is the result of Bollier's publications on intelligent growth. However, after 2005 the term started to be adopted and disseminated by IT companies, such as IBM, Cisco, and Siemens when associating the products they sold with specifically designed solutions for cities (Colin & Ian, 2011).

The driving force behind technological innovation that permeates the SC field results largely from the convergence of IT. In addition to the automation of basic and structural functions involving people, buildings, and traffic systems, other monitoring analysis and planning functions have also taken part in the universe that aims to qualify efficiency, equity, and quality of life. Because of this perception, knowledge is seen as an asset and the intimate relationship between Knowledge Management (KM) and IT, which requires a fine-tuned alignment so that the communication process, which is the driving force of KM, can flow smoothly (Al-Ammary, 2014). At this point, it is important to investigate the relationship of people, and their willingness to share knowledge, when there are no reward systems involved (Al-Ammary, 2014). People's willingness to interact and actively share is a fundamental aspect for KM to generate real values for those involved (Mushtaq & Bokhari, 2011).

A city becomes intelligent when it invests resources in human and social capital and in fields such as IT, transport, infrastructure, and communication – which are elements that generate sustainability and economic development (Caragliu, Del Bo & Nijkamp, 2011). Sharing in the context of SC occurs through networks of people, companies, and technologies (Manville et al., 2014). Approaches that use knowledge bases, such as Knowledge-Based Urban Development, are being increasingly used in SC projects (Ardito, Ferraris, Petruzzelli, Bresciani & Del Giudice, 2019). The understanding of KM strategies and the factors that affect their development such as IT become relevant issues for the success of SC projects (Nawab, Nazir, Zahid & Fawad, 2015).

It is worth mentioning that the current multidimensional presentation of management requires extra efforts on the part of managers who, in addition to monitoring and accessing various sources of knowledge, must learn to incorporate this knowledge into value innovations and social impact (Teixeira, Oliveira & Curado, 2018). When considering that KM comprises a set of diverse activities, the literature points out the main vectors responsible for the progress of knowledge: The processes of creation, retention, and sharing (Nawab et al., 2015; Tanaji,

2012). It is also needed to consider the change in the perspective of creation and KM that emerged when knowledge was divided into two types and the dynamics of its modification that occurs through four interrelated processes: socialization, externalization, internalization, and combination, whose conversion from tacit to explicit, and vice versa, increases its value (Takeuchi & Nonaka, 2009).

A relevant point for the adoption of the KM perspective for SC management is the result of the diffusion of digital technologies that generate Big Data (Osman, 2019). The analysis of this data set can prove to be a valuable source of insights; however, it requires technological support (Tang et al., 2015). Another aspect that reinforces the urgency of a management posture focused on KM is the growing demand for open and public data that promote transparency and public control of government activities (Klein, Klein & Luciano, 2018).

In the perspective of the scenario described, it is necessary to understand the current challenges of KM in SC, since these studies emerge with speed and interdisciplinary in the organizational field, which makes it difficult to identify the state of the art (Snyder, 2019). As researchers, we can understand that the expansion of the scope of a given field of study comes in large part from the investigative stance of academics in solving theoretical and practical challenges. Such investigations, sometimes supported by theories and models already developed and/or tested, use the most varied methodological approaches, to extract findings and identify gaps that, through an aligned research agenda, may evolve to the analysis of constructs and variables. Therefore, it becomes relevant to understand the existence of theoretical lenses and models that support KM in the scope of SC. As well as, understanding the methodological approaches that best adapt to the complexity and diversity of the field. Bringing together the different publications related to the themes, it is possible to compare the findings and highlight the variables and constructs that still deserve investigation. Such propositions are related to the end of the article as a research agenda. Given the gaps presented, this article aims to answer the following research questions:

- **RQ1:** What are the methodological approaches adopted in investigating the KM and SC research problems?
- **RQ2:** What are the research topics about KM in the SC?
- **RQ3:** How the research on KM in SC is characterized?

To answer these questions, the objective of this article is to verify how KM is being associated with SC initiatives, through the analysis of the scientific production of both themes in journal indexes in the last 10 years. This introduction presents the theme, the objective of the study, and its justification. Section 2 describes the systematic review of the literature. Section 3 presents the analysis of the results. Section 4 discusses the results and Section 5 closes the paper with the final remarks and the research agenda.

## Method

To investigate how KM may be related and used to improve SC initiatives, the scientific production of both themes was analyzed in relevant journals indexed by the main scientific repositories. A semi-systematic literature review (Snyder, 2019) was chosen due to the multidisciplinary nature and a large number of scholars of the analyzed themes, so a regular systematic review would not be possible. This study has quantitative and qualitative procedures. To visualize trends and patterns in scientific production related to KM and SC themes, a quantitative approach was used to organize, relate, and measure the findings in the research bases – the citations, annual productions, and production by journals were measured. To explore and discuss the findings, it was decided to use the content analysis technique. The study was structured in three stages: 1. A systematic search; 2. A systematic analysis of the literature and 3. A content analysis.

Using a positivist, qualitative and exploratory approach (Malhotra, 2001), we sought to highlight the main approaches and variables analyzed in published articles where the relationship between KM and SC was explored – thus assisting the production of insights on the research question. The stages of the semi-systematic search were concluded, and the findings were coded and categorized according to their nature (Bardin, 2006).

For this research, the Web of Science [WOS] database (<https://apps.webofknowledge.com>, retrieved on May 30, 2019) and Scopus database [SCO] (<https://www.scopus.com>, retrieved on May 30, 2019) were used. The selection of these indexers was due to the scope and complementarity of the search tools, as well as the accuracy verified in comparison to the other options available. The terms used in the search were Smart Cities and Knowledge Management, keeping in quotes to restrict the results. The results were limited to the English language, firstly, due to the perception that the SC theme presented a better evolution at the global level and, secondly, because of its universal usage among the

scientific community. The terms chosen for articles searching showed an advantage of covering the fields of study, given that the intersection of the themes KM and SC has fewer publications.

The search was initially limited to publications dated between January 2010 and May 2019, however, to update the database of this study, in November 2020 a new search was performed with the same parameters and two articles were added from this new search. Only papers in journal articles were considered in all searches. The year 2010 was the period in which publications on SC associated with KM started, so the limit was suggested for methodological reasons, without influencing the luck of material. In the Scopus database, the search for documents was used covering the fields of the article title, abstract, and keywords. In the Web of Science, we search for the title, abstract, and keywords fields. Figure 1 illustrates the process of searching for articles in detail.

**Figure 1** – Search design and semi-systematic analysis of the sample

Stage	Scopus	Web of Science	Sum
1) The total number of articles with the expressions: "Knowledge Management" and "Smart Cities".	<b>36</b>	<b>28</b>	= <b>64</b>
2) Articles kept after filter application: Articles published in journals since 2010 and the elimination of duplicates.	<b>31</b>	<b>10</b>	= <b>41</b>
3) Articles kept after abstract and title reading.	<b>17</b>	<b>6</b>	= <b>23</b>
4) Articles kept after the full content reading.	<b>14</b>	<b>6</b>	= <b>20</b>
5) Articles kept after sample update.	<b>1</b>	<b>1</b>	= <b>22</b>

**Source:** Made by the authors (Nov. 2020).

Adding the results of the two bases, 41 articles were initially found. However, four of the articles were eliminated due to duplicity in both databases; subsequently, four more articles were excluded after reading the title and 13 papers were disregarded after reading all abstracts, leaving 20 articles for analysis. For the cluster and word cloud analysis NVIVO® software was used, which facilitated the categorization and understanding of the connections between works.

After the first stage, when the articles obtained in the repositories were listed, the article selection stage began. Those articles published in scientific journals from 2010 were preferred, therefore, materials from congresses, symposia as well as repeated materials, were removed from the sample (step 2). When reading the title and abstract, articles whose theme was either

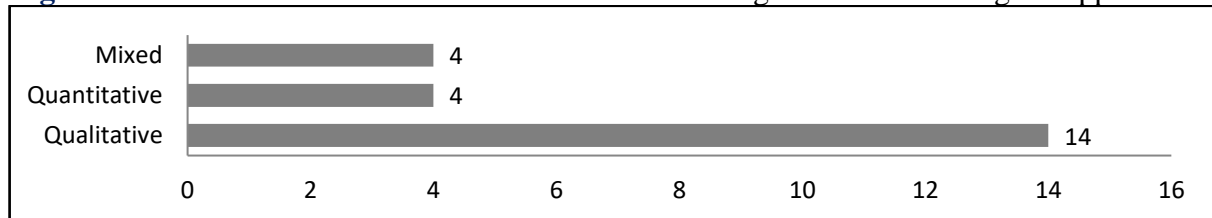
far from the research focus or too broad were discarded, such as educational development in the context of SC, digital systems for shopping malls, use of social media for education, business designs for SC, health care, use of IT for skills development, the effect of competitiveness to increase the ecological footprint, in addition to four articles that were not available and one that was removed for presenting only two citations since 2014 (step 3). In the complete reading of the article, three publications that did not align with the intended focus were also removed, namely: co-creation of knowledge to predict natural disasters, innovation in companies and public organizations, and use of indicators in SC (step 4).

## Results analysis

### *Article’s semi-systematic analysis*

Regarding the approach used in the studies, the qualitative ones predominated according to Figure 2. This excerpt seeks to answer the research question “RQ.2: *What are the methodological approaches adopted to investigate the research problems on KM in SC?*”.

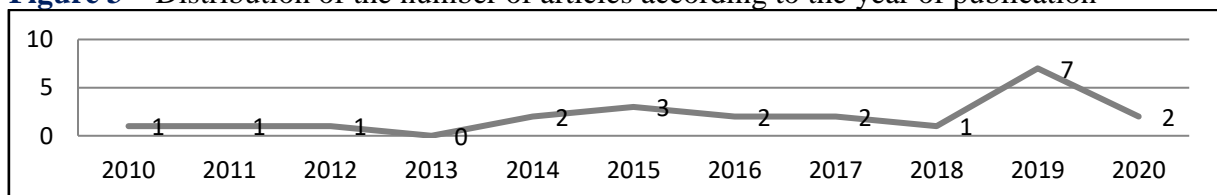
**Figure 2** – Distribution of the number of articles according to the methodological approach



Source: Made by the authors (Nov. 2020).

When associated with the data in Figure 3, which shows an increase in the publications of the themes from 2015, they suggest that the theme is emerging and it is in an exploratory phase. Given the variability of relationships investigated in the articles, there is evidence that it is still necessary to better develop the variables that influence the development of SC projects from the perspective of KM. This will be further developed.

**Figure 3** – Distribution of the number of articles according to the year of publication



Source: Made by the authors (Nov. 2020).

Figure 3 shows the distribution of publications since 2010, ordered over the years, most articles date from 2019, which indicates that the themes in question are in evidence and possibly rising in the academia due to a larger number of publications in recent years. This interest increase may be related to the rise of data and the need to extract knowledge from these databases.

The analyzed articles are distributed among 14 journals. The journal with the highest number of published articles is the *Technological Forecasting and Social Change* with 4 papers among those analyzed and which has an international classification Q1 and H Index 93, according to the Scimago portal (<http://www.scimagojr.com>, retrieved in July 1<sup>st</sup>, 2019), that illustrates the journal's scientific relevance. The journals *Cities*, *Future Generation Computer Systems*, and *Journal of Intellectual Capital* present two articles each. The other journals were grouped by presenting only one article published within the parameters surveyed, with a minimum H Index of 16, as shown in Figure 4.

**Figure 4** – Distribution of work studied according to journals and H index

Journal name	Total of articles	H Index
Technological Forecasting and Social Change	4	93
Cities	2	71
Future Generation Computer Systems	2	93
Journal of Intellectual Capital	2	73
Others <sup>a</sup>	12	From 16 to 132

**Note:** <sup>a</sup> Journals with less than one article in the RSL sample were grouped in this line with information from the H Index range.

**Source:** Made by the authors (Nov. 2020).

Concerning the number of citations, we found an average of 113.45 and a median of 21.5 in the analyzed sample. Only one article presented more than 1,000 citations and 11 articles with less than 16 citations. Next, Figure 5 presents the number of citations for each study as well as the year of publication.



**Figure 5 – Articles and authors according to number of citations**

Article Title	Author (s)	Citations n.
Smart cities of the future	Batty <i>et al.</i> (2012)	1.364
Smart cities: A conjuncture of four forces	Angelidou (2015)	396
From intelligent to smart cities	Deakin e Al Waer (2011)	328
The management of organizational ambidexterity through alliances in a new context of analysis: Internet of Things (IoT) smart city projects	Bresciani, Ferraris e Del Giudice (2018)	82
Smart city intellectual capital: an emerging view of territorial systems innovation management	Dameri e Ricciardi (2015)	62
Diverse titles <sup>a</sup>	van Waart, Mulder e de Bont (2016), Osman (2019), Ferraris, Erhardt e Bresciani (2019), Carvalho, Santos e Van Winden (2014), Sepasgozar, Hawken, Sargolzaei e Foroozanfa (2019) e Ardito <i>et al.</i> (2019).	<=46
Diverse titles <sup>b</sup>	Matos, Vairinhos, Dameri e Durst (2017), Gao, Ali, Curry e Mileo (2017), Ortiz-Fournier, Márquez, Flores, Rivera-Vázquez, e Colon (2010), Mordacchini <i>et al.</i> (2015), Nielsen, Baer e Lindkvist (2019), Kazantsev e Zakhlebin (2014), Sotres <i>et al.</i> (2019), Wataya e Shaw (2019), Orłowski <i>et al.</i> (2016), Lima (2020) e Laurini (2020)	<=16

**Notes:** <sup>a</sup> To facilitate the reading of the figure, the titles of the articles that presented 46 citations or less, were grouped in this line, however, the authors' reference and the year in the second column was maintained as a way to enable the location in the references.

<sup>b</sup> To facilitate the reading of the figure, the titles of the articles that presented 16 citations or less, were grouped in this line, however, the authors' reference and the year in the second column was maintained as a way to enable the location in the references.

**Source:** *Google Scholar* (<https://scholar.google.com>, retrieved on January 15<sup>th</sup>, 2020).

The most cited article is *Smart cities of the future*, dating from 2012, being one of the oldest within the filtered period. This article outlines an important vision for the future for SC, defining goals that concern the development of a new understanding of urban problems, coordination, and creation of technologies, use of data, and urban problem-solving. In addition to a complete overview of the research challenges and relevant scenarios. The author of the article, Michael Batty, from University College London has 1,111 research items with more than 37 thousand citations, according to the query made on the Google Scholar website (<https://scholar.google.com>, accessed on January 15<sup>th</sup>, 2020). His research interests involve urban development, SC technologies, and data analysis.

The second most cited article was *Smart cities: The conjuncture of four forces* that discusses the identification of the forces that shape the concept of SC. Dividing the history of SC in the Urban Future and the Economy of Knowledge and Innovation, the author addresses the dichotomy between technology – which advances at a fast pace, creating an expanding market for SC products and solutions – and the demand on the side of cities that aims to solve

the problems of efficiency and sustainability, making the breeding ground for an economy of SC products. Margarita Angelidou, from the Aristotle University of Thessaloniki, published the work in 2015. It has 34 research items accumulating 1,310 citations, according to the query made on the Google Scholar website (<https://scholar.google.com>, accessed on January 15<sup>th</sup>, 2020). His research interests are social entrepreneurship, urban planning, urbanism, social innovation, and others.

The third most cited article is *From intelligent to smart cities*, which presents a more local perspective, proposing that knowledge transfer is essential for participation in the planning, development, design, and layout of communities and neighborhoods and the democratic renewal necessary for the process of modernization and management of self-sustainable communities. The authors make an important criticism about what they consider to be the misuse of the city development proposal to meet corporate marketing needs instead of the social intelligence necessary for cities to become truly intelligent. Mark Deakin of Edinburgh Napier University and Husam Alwaer of the University of Dundee published the work. Mark has 124 research items and more than 1,700 citations, according to a query made on the Researchgate website (<https://www.researchgate.net>, accessed on January 15<sup>th</sup>, 2020). The author's profile on Google Scholar was not found. His research interests are on technological approaches applied to the development of SC. Husam Alwaer has 51 research items with 1,306 accumulated citations, according to the query made on the Google Scholar website (<https://scholar.google.com>, accessed on January 15<sup>th</sup>, 2020). His research interests are sustainability, SC, intelligent constructions, among others.

Among the most recent articles, from the year 2019, *Ambidextrous work in smart city project alliances: unpacking the role of human resource management systems* already has 28 citations and deals with the challenges of ambidexterity in SC partnerships from the perspective of human resources.

### **Themes covered by the studies**

This section seeks to answer the research question “RQ2: What are the research topics investigated about KM in SC?”. Knowledge sharing is widely addressed in works that highlight the involvement of citizens, government, and IT companies in the search for smarter cities. The participation of stakeholders and companies interested in the process of modeling new SC projects appears as an alternative so that one can have a new perspective on the problems faced by cities. Culture and citizen participation are also factors to be considered in SC projects.

There is a presence of companies marketing issues that develop technologies for SC and the so-called sociotechnical imagery of cities – where there is a difference between what companies in the IT market and society conceive as real needs of cities. Also, pressure persists for cities to become smart. The development of SC may have more to do with cities that meet the needs of corporate brands, such as in marketing campaigns, than with knowledge transfer.

Regarding technology, among the studies, the development of models such as the Urban Services Technology Acceptance Model carried out in Iran stands out. There is also the contribution in the form of a new model for project management. The recommendation to use open data for the benefit of SCs stands out. The role of technology as a facilitator of KM is evident, delivering greater agility in data mining and information collection with the help of citizens. There are interrelationships between intellectual capital and SCs, especially about the need to engage citizens in decision-making as active participants in the production and collection of data.

One of the works proposes that an SC itself is an intellectual body, not only because it is strongly based on processes that use data and information to produce knowledge about the city, but also because it is rooted in a reasoning system, where the main actors produce a living system with a different logic from those of other cities. These actors are capable of demonstrating rational behavior, choosing courses of action, and pursuing defined objectives in areas such as transport, communications, quality of life, and economics.

The cognitive nature of a smart city is also a dynamic process of producing intellectual capital and using it for more assertive decisions, and with more information about developing cities. The integration of SC strategies and the provision of intellectual capital are considered critical success factors to improve the capacity of cities to face the demanding challenges of urbanization and scarcity of natural resources. Figure 6 presents the results related to the topics covered in each survey to understand the link between KM and SC initiatives.

**Figure 6 – Topics covered by author and year**

Topics covered	References
Aims to explain the relationship between the momentum of technology and the demand for SC solutions that converge to the creation of SC products.	Angelidou (2015)
The authors propose that universities hold responsibility for the competitiveness and superiority of knowledge-based ecosystems.	Ardito <i>et al.</i> (2019)
It proposes to explain the science of SC through six scenarios and proposing seven project areas.	Batty <i>et al.</i> (2012)
It discusses ambidexterity and the role of the Internet of Things (IoT) in the scope of information and communication technologies (ICTs) and in supporting value-added services for citizens.	Bresciani <i>et al.</i> (2018)
Analysis, through a case study, the connection of different types of locations of a company “born global” and how the exploration of what they called “territorial innovation” occurs.	Carvalho <i>et al.</i> (2014)
It explores the approach and concepts of intellectual capital and its use in SC, from a managerial perspective.	Dameri e Ricciardi (2015)
It examines the role of communities in SCs from a more local perspective, in which innovation networks and creative partnerships play a relevant role in learning, knowledge transfer, and capacity building exercises.	Deakin e Al Waer (2011)
It assesses how ambidextrous work within the scope of SC is supported by human resource management systems and proposes a complex combination of corporate HR systems.	Ferraris <i>et al.</i> (2019)
They address the challenges of integrating data flows from real-time sensors into applications within SCs.	Gao <i>et al.</i> (2017)
It studies the correlation between the number of international students at Russian universities and the positive changes that occur in the human capital of a Russian student and its neighboring areas, especially in public spaces.	Kazantsev e Zakhlebin (2014)
Discusses solutions to integrate the concepts of SC and KM. Highlight the links between intellectual capital and SC and their synergistic ability to improve competitiveness and sustainability.	Matos <i>et al.</i> (2017)
Proposes a model of opportunistic networks for potential crowdsourcing within the scope of SCs. It uses elements of cognitive psychology on dynamic memory structures and cognitive mental-heuristic models.	Mordacchini <i>et al.</i> (2015)
It examines the need to manage ambidextrous organizations and support exploratory innovation, in addition to proposing a knowledge transfer model.	Nielsen <i>et al.</i> (2019)
It presents the results of research carried out to develop a design method for SC systems.	Orłowski <i>et al.</i> (2016)
It analyzes the processes to develop the characteristics of an SC focused on sustainable development. Data collected through a case study.	Ortiz-Fournier <i>et al.</i> (2010)
It analyzes how ICTs can empower SC initiatives through the production of large volumes of known data (big data). Proposes a new big data analysis framework for SC called “Smart Cities Data Analysis Panel - SCDAP”.	Osman (2019)
It proposes three steps to improve the cultural ecosystem of cities, selecting culturally appropriate technologies, adapting that technology, and managing acceptance.	Sepasgozar <i>et al.</i> (2019)
From the perspective of the fragmentation of IoT through suppliers and platforms, the authors suggest a compromise in the acceptance of the technology. Therefore, they present a case study for Global Internet of Things Services (GIoTS) which, due to its interoperability, can become an intelligent urban mobility service.	Sotres <i>et al.</i> (2019)
The authors explore the shared vision of SC among government, industry, universities, and citizens, promoting a participatory approach. It proposes studies of transition management and the model of knowledge production in the quadruple helix.	van Waart <i>et al.</i> (2016)
It describes a framework for measuring assets in the implementation of SC about urban development policies.	Wataya e Shaw (2019)
Conducted a study with 18 companies that adopted elements characteristic of smart cities to design their organizations.	Lima (2020)
It studies how human knowledge and artificial intelligence can be combined in geographic knowledge systems, essentially based on machine processable-knowledge and the concept of rules.	Laurini (2020)

**Source:** Made by the authors (Nov. 2020).

## The connection between KM and SC

The articles were gathered by similarity, highlighting the main ideas related to the research topics. This excerpt seeks to answer the main research question “**RQ3**: How the research on KW in SC is characterized.”

The article entitled *Smart cities of the future* addresses the creation of shared knowledge for the democratic governance of cities, with participation and self-organization as pillars for building a global knowledge resource that, by definition, will represent a public good, accessible to each citizen, institution or company, exploring intelligent data management (Batty et al., 2012). Adopting a more local perspective, the article *From intelligent to smart cities* proposes that knowledge transfer is essential for participation in the planning, development, design, and layout of communities and neighborhoods and the democratic renewal necessary for the modernization and management process of self-sustainable communities (Deakin & Al Waer, 2011).

The paper *A Participatory approach for envisioning a smart city* reports that participatory prototyping takes place, involving participants from all four parts of the quadruple helix – that shows potential for the production of knowledge about the development of future SCs that respond to the concerns and values of their stakeholders (van Waart et al., 2016). In the same way, suggests stakeholders’ consideration, however, bringing a sustainable perspective, the article *Increasing smart city competitiveness and sustainability through managing structural capital* highlights the interrelationships between intellectual capital, especially its component structure, and SC and synergistic quality to improve competitiveness and sustainability. The integration of SC strategies and the provision of intellectual capital is considered a critical success factor to improve the capacity of cities to face the challenges of urbanization and the scarcity of natural resources (Matos et al., 2017).

Exploring the advantages and challenges of using technologies, the article *Implementing citizen-centric technology in developing smart cities: A model for predicting the acceptance of urban technologies* highlights that local knowledge has been largely ignored as a source of innovative potential for SC. It addresses knowledge sharing, proposing a model that integrates knowledge from several domains to address the complex range of factors that may influence the acceptance of new technologies by users in future SCs (Sepasgozar et al., 2019). In the same vein, however introducing the concept of IoT, the article *Breaking vendors and city locks through a semantic-enabled global interoperable Internet-of-things system: The smart parking case*, reports that interoperability solutions are being presented to ensure that the IoT

infrastructure is deployed in SCs, regardless of their manufacturer or platform and that it can share information, data and knowledge in a meaningful way, that is, share knowledge between cities (Sotres et al., 2019).

With a structural view, the article *Smart cities system design method based on case-based reasoning* builds knowledge bases and allows it to be possible to identify design processes and functions to design specific architecture for SC systems (Orłowski et al., 2016). Bringing structural issues, however, exploring an economic bias, the article *Smart cities: A conjuncture of four forces*, develops a set of forces that are related to SC initiatives, placing knowledge as the basis of the economy. In this sense, technology, which facilitates knowledge, pushes technological solutions to SC (Angelidou, 2015). *The management of organizational ambidexterity through alliances in a new context of analysis: Internet of Things (IoT) smart city projects*, proposes to test the relationships between knowledge management actions and information technology resources with the improvement of ambidexterity related to alliances in projects of SCs (Bresciani et al., 2018). Laurini (2020) suggests in his study that artificial intelligence and knowledge management can not only help urban governance, but can go further, based on experiments that must be planned in various contexts, and mentions three elements that must be established: 1) the commonly used data and information can be transformed into blocks of knowledge; 2) the rules must not only be identified but encoded in a single processable language and; 3) a dedicated inference mechanism must be designed and implemented.

Reinforcing the alignment between intellectual capital and SCs, the article *Smart city intellectual capital: an emerging view of territorial systems innovation management* identifies positive relationships between the vision of intellectual capital and the vision of SCs. From a managerial perspective, the intellectual capital approach can be systematically adopted for the development of SC initiatives (Dameri & Ricciardi, 2015). With a close approach, however exploring cognitive aspects, the article *Crowdsourcing through cognitive opportunistic networks*, studies what contributions the opportunistic models applied in crowdsourcing can bring to help in the SC environment. The goal is to collect information perceived by people about places, using cognitive overlapping schemes for semantic memory, revealing a new mechanism for sharing and relating information about specific places (Mordacchini et al., 2015).

With the usage of empirical applications of knowledge management solutions in CI, the article *Knowledge spaces and places: From the perspective of a "born-global" start-up in the*

*field of urban technology*, analyzes the case of a company that tests and sells software for the use of SCs. The development of the theme proposes that applications of this type should be made in real life and not in laboratories, precisely to test the creation and sharing of knowledge in its full development (Carvalho et al., 2014). Expanding the scope for mass data, the article *The novel big data analytics framework for smart cities* proposes a new framework for mass data analysis (Big Data) that serves as a source of knowledge to improve SC initiatives. Considering the importance of mass data for value creation, the authors suggest that the analysis be done in layers and in real-time (Osman, 2019).

The article *Ambidextrous work in smart city project alliances: unpacking the role of human resource management systems*, investigates the relationship between initiatives in the area of human resources to improve the capacity of knowledge management and social relations, as management tools that support ambidextrous strategies SC alliances (Ferraris et al., 2019). Integrating educational institutions to produce intellectual capital for sustainability in Caguas, Puerto Rico, analyzes efforts to develop SC characteristics in a municipality in Puerto Rico. For the evaluation of the initiatives, the Knowledge Management Cycle theory was used, which is composed of the stages: acquisition, refinement, direction, application, contribution, and among other steps (Ortiz-Fournier et al., 2010).

The paper *Open innovation in smart cities: Civic participation and co-creation of public services*, studies the role of information sciences in the co-creation of public services, seen as a crucial process in the advent of the knowledge society. It also highlights the importance of sharing tacit knowledge and citizen participation in decision-making (Mainka et al., 2016). Still, on knowledge sharing, the article *Automated discovery and integration of semantic urban data streams: The ACEIS middleware*, combines the benefits of IoT innovations to leverage SCs. Above all, it positively evaluates the collection of knowledge that will serve as a source of data and information (Gao et al., 2017). Complementing the previous two papers, the article *The role of universities in the knowledge management of smart city projects* builds a framework to analyze the role of universities in SC knowledge management. Relevant points were found on the role of universities, especially about intermediation, management, and knowledge transfer (Ardito et al., 2019).

To analyze the interference of experience in the development of cities, the article *Measuring influence of internationalized universities on smart city development in terms of human capital and urban aspects* investigates the relationship between the number of foreign students at a Russian university and the changes in the human capital of students. It also verifies

whether these relationships and changes have an impact on student engagement in local life, contributing to the development of SC (Kazantsev & Zakhlebin, 2014). The work *Measuring the value and the role of soft assets in smart city development*, on the other hand, argues that the advancement of SC projects depends on the combination of an intelligent structure, technological innovation, and the use of flexible assets. The authors propose to describe and analyze a structure to measure flexible assets in the implementation of SC initiatives. Flexible assets were categorized into classes of organizational capital, social capital, training, and capital related to knowledge (Wataya & Shaw, 2019). Lima (2020) proposes a pyramid with dimensions extracted from the study with 18 companies that, when designing their activities, used elements characteristic of Smart Cities. They suggest that as you move to the top of the pyramid, that is, from the most rigid to the softest elements, the role of technology becomes less important and gives way to skills such as leadership, empathy, and social intelligence.

Finally, *Identifying and supporting exploratory and exploitative models of innovation in municipal urban planning; key challenges from seven Norwegian energy ambitious neighborhood pilots* investigates the causes of the difficulty of knowledge transfer in energy projects that meet the requirements proposed by citizens in Norway. The loss of knowledge, from the perspective of the citizens, and what happens in the exchange processes of companies providing public services, influencing costs, schedules, and quality of services. The use and reuse of knowledge, and the appropriate transfer of knowledge, keep the SC model organic and sustainable (Nielsen et al., 2019).

## Discussion of the results

Several authors indicate the expansion of initiatives to encourage citizen participation, combined with the search for knowledge transfer and data transparency (Batty et al., 2012; Deakin & Al Waer, 2011; Osman, 2019; Tang et al., 2015; Klein, Klein & Luciano, 2018). Such perspectives demonstrate alignment with KM processes, especially about the process of converting tacit to explicit knowledge (Takeuchi & Nonaka, 2009). Fostering citizen participation can be understood from the perspective of KM as a way of making explicit and storing the tacit knowledge that is in the possession of people, and thereby providing access to a rich source on the main problems of the city.

It was also possible to observe an expansion in the scope of participation that, in addition to citizens' involvement, calls for the integration of the four components of the quadruple helix (van Waart et al., 2016). By calling the responsibility of the four propeller stakeholders -



government, society, universities, and companies – the authors resize the role of the government in smart cities initiatives, outlining the sustainability and competitiveness of cities as common objectives (Matos et al., 2017). Such proposal reinforces the need for better knowledge management among the four entities so that they can join efforts and act with a common goal, and it is relevant that they use each other's knowledge bases to reduce overlaps and expand the potential for problem-solving and project-based learning (Ardito et al., 2019; Bakker et al., 2010) As an example of the importance of making companies aware of their role in assisting the development of SC, we can mention the difficulty of knowledge transfer in projects when public service partners or assigns are replaced, which causes loss of knowledge which, in the citizens' perspective, causes an increase in costs, changes in schedules and a decrease in the quality of services. In this sense, it is worth mentioning that the main responsible for the use and reuse of knowledge are companies because even if the government intercedes or imposes rules for the transition, a good part of the knowledge will only be transferred at the disposition and initiative of the partner or assignee (Nielsen et al., 2019). Knowledge sharing will only be truly successful when looking at both relational and organizational processes, with due complexity, simultaneously (Bakker et al., 2010).

To illustrate the resizing of government activities and to represent the scope of action of other entities, a prescriptive framework for SC research that uses the components of KM based on the sample articles of this literature review was proposed. Such components were grouped in the quadruple helix, as shown in Figure 7.

**Figure 7** – Proposal for a prescriptive framework for SC research supported by KM

Components	Description
<i>Companies</i>	
Partners knowledge management	Create protocols that allow the sharing and storage of knowledge generated by its activities as a partner company and provider of public services, avoiding the loss of knowledge.
Partnership with IT companies	Establish partnerships with governments to develop technological solutions.
Usage of SC features	Companies must design their activities using the characteristic elements of Smart Cities, to understand, according to the progression of the pyramid, that from the most rigid elements they lose space to the softest ones.
<i>Government</i>	
Data mining	Create a structure that allows the collection, processing, and analysis of large amounts of data as a way to encourage decision-making and the evaluation process.
Knowledge management cycle	Cyclically manage knowledge, understanding that it is a continuous and endless process.
Mapping of real necessities	Avoid sociotechnical imagery, focusing on real needs, and apply technology when it proves useful for the intended purpose.
Project management	Structure the management system to allow quick learning, evaluating actions within the limits of the project, and allowing quick corrections.
Rules and data clustering	Both data and information must be transformed into blocks of knowledge, as well as rules that, in addition to being identified, must be encoded in a single processable language.
<i>Society</i>	
Knowledge sharing	Share knowledge and facilitate data production and collection.
Citizens participation	Contribute to the process of building solutions, whether evaluating or suggesting, thus reducing the cycle of learning and error.
Culture	Develop a culture that contributes to collaborative development.
Open access data	Demand the opening of data by the government, as it is the means by which social control can be carried out.
<i>Universities</i>	
Ambidexterity	Assume the commitment to foster innovation, providing incentive structures for innovation that help in the connection between knowledge and practice.

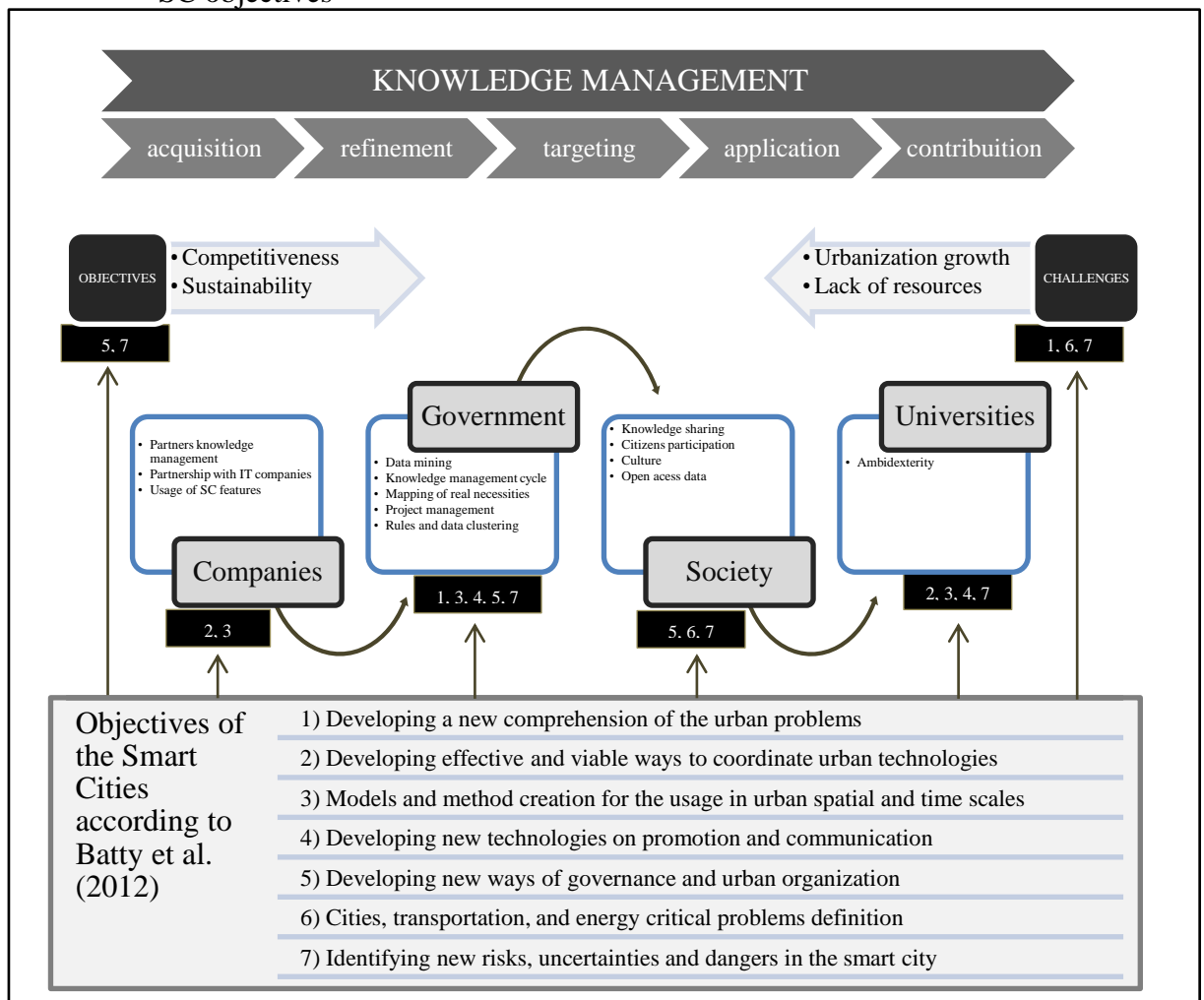
**Source:** Authors' analysis of the sampled articles.

Some perspectives still consider that knowledge is not properly valued in SC initiatives aimed at innovation, and technological tools occupy the prominent space. Such a claim is related to the effect of the socio-technical imaginary, which has the characteristic of prioritizing the use of IT tools despite their real needs and problem-solving. Such misalignment can put the relationship between IT and KM in conflict, which must be harmonious since the greatest advantage of such tools can be precisely to give rise to the needs of knowledge sharing. Knowledge is positioned today as the basis of the economy, using technology to facilitate SC actions. There is a defense of a greater incentive to KM related to ambidextrous alliances that, when associated with SC projects, can expand participation and open innovation, given the

government's limitation in this regard (Sepasgozar et al., 2019; Sotres et al., 2019; Orłowski et al., 2016; Angelidou, 2015; Bresciani et al., 2018; Mainka et al., 2016).

To illustrate the interaction between KM and the SC initiatives proposed in the prescriptive framework of Figure 7, linked to the objectives of the SC proposed by Batty et al. (2012), a graphic representation was elaborated in Figure 8. It is noted that all the listed objectives are present in the support offered to CI by the KM processes. Also, they are convergent with the challenges and objectives selected in the data analysis of the articles present in the sample of the literature review.

**Figure 8** – Representation of the prescriptive framework and its relationship with KM and SC objectives



**Source:** Authors' analysis of the sampled articles.

It is important to note that the studied authors reinforce the promotion of monitoring actions based on large-scale data analysis, being advisable that this be done in real-time. In this sense, we can infer the concern with the validity of the data, and consequently, the knowledge

generated based on them. Thus, if one considers the context of a large metropolis with simultaneous occurrences, recurring demands and multiple variables, monitoring with past data can mean the loss of opportunity to test solutions in real-time (Osman, 2019; Carvalho et al., 2014).

### **Final remarks and research agenda**

Regarding the semi-systematic analysis of the selected articles, it can be concluded that there are relationships between KM and SC initiatives. Considering that the majority of articles were published in 2019, and with the number of citations identified, even in recent articles, it can be inferred that there is scientific interest and relevance in the association of the themes.

The knowledge-sharing process is covered in most of the works, which represents a strong indication of the presence of KM in SC projects. The qualitative method was more widely used in the studies, indicating that it is necessary to carry out complementary studies to expand the scope between the themes and a safer definition of the intersections that have scientific relevance. With the definition of the scope, the next step is the development of more consistent frameworks that allow analyzing and understanding the relationship between the variables studied.

However, even if the themes SC, management, and knowledge sharing are inseparable, the number of researches in SC that address KM is still not very significant, which justifies the elaboration of the research agenda suggested in Figure 9. Sometimes, the initiatives SC are understood only as of the use of ICTs in cities, without considering that what makes the process of making them more intelligent permeates several elements, among them, human knowledge and its different stages of consolidation and sharing. In this sense, the following agenda intends to present different perspectives and elements inherent to SC and KM to be explored by the academy.

**Figure 9** – Proposed research agenda on KM in SC

Construct or research question	Methodological approach	Units of analysis/ observation	Practical/theoretical implications
What variables affect the implementation of KM in SC?	Exploratory research, multiple case studies, longitudinal studies.	Citizens, public agents, KM process, technologies used, motivations of Stakeholders.	Understanding the application of KM in SCs, proposed by the literature, within the framework of the triad of people, processes, and technology.
How can KM deployment models be adapted to SC?	Applied research, Survey, case studies	KM process, city management process, information management systems.	Adaptation of KM implantation models to SC cases.
How does KM influence the results of SC?	Applied research, Survey, action research.	Citizen, public agents, KM processes.	Measure the influence of KM on IC results, as a way to define the real importance of this approach.
How can government transparency influence KM in SCs?	Exploratory research	Motivations of governments, motivations of citizens, and other public agents.	Understand whether guidance for transparency practices can contribute to or inhibit KM.
Can the use of IT tools in SCs inhibit the participation of people in social vulnerability?	Survey	The use of IT tools related to SC initiatives by different groups of citizens.	Measure the relationship between technology and citizen participation.
To what extent can the interests of public agents impact KM in SC initiatives?	Survey	Motivations of public agents and action reports.	Understand the effects of personal interests, characteristic of Brazilian governments, in the correct implementation of KM.
How do IT companies formulate solutions for SCs as for KM in SCs?	Case study, <i>Grounded-theory</i>	The occurrence of conflicts of interest between the proposals of the IT companies, the needs of the cities, and the KM.	Study how IT companies formulate customized projects for <u>SC</u> initiatives and the premises of social inclusion.
How does the discontinuity or succession of multiple SC projects in the same city impact KM?	Case study, Ethnography	Influence of political and market factors in discontinuity decisions and the adoption of new SC projects.	Identify the impacts and methods of KM.
Can the culture of cities influence knowledge sharing?	Experimental research	Culture, values, ethics, and conduct of SC initiative actors.	Study the behavior of actors and citizens in the KM process of smart cities.

**Source:** Authors' analysis of the sampled articles.

The managerial contributions of the articles are incipient, requiring the development of a greater number of studies that establish justified guidelines for research involving KM as an SC facilitator. The research agenda prepared by the authors indicates the need for more

quantitative studies that can be developed as a way to test hypotheses that measure and typify the existence and impact of the relationship between KM with the improvement of SC initiatives. Quantitative studies will be able to investigate the size of the effect of KM actions on SC initiatives, paving the way for the production of practical and applicable solutions. With qualitative studies, it would be interesting to study cases of conflict of interest between the socio-technical imagery of cities with the proposals of IT companies that develop solutions for SC. Also, analyze whether there are market impacts of such companies on the development of the projects. Impacts that city culture can have on knowledge sharing. To study whether, in cases of discontinuity or succession, several SC projects in the same city affect KM. This research was limited to the search terms used, so future research may explore the expansion of the sample with other terms related to the themes.

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