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INFLUENCE OF CONTINGENCY FACTORS ON THE DEVELOPMENT OF SMART CITIES IN BRAZIL

INFLUÊNCIA DE FATORES CONTINGENCIAIS NO DESENVOLVIMENTO DE CIDADES INTELIGENTES NO BRASIL

INFLUENCIA DE FACTORES CONTINGENCIALES EN EL DESARROLLO DE CIUDADES INTELIGENTES EN BRASIL

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Abstract

Objective of the study: To analyze the influence of contingency factors (environment, structure, organizational size and organizational culture) on the 100 best-ranked Brazilian municipalities in the 2020 Connected Smart Cities Ranking.

Methodology/approach: Data were collected from: Atlas of Human Development in Brazil (AtlasBR); Federal Administration Council (CFA); Brazilian Accounting and Tax Information System for the Public Sector (SICONFI); Brazilian Institute of Geography and Statistics (IBGE), and Superior Electoral Court (TSE). The data refer to the year 2019. The statistical methods used were normality and homogeneity tests, correlation and multiple linear regression, with the aid of the IBM SPSS Statistics Version 2.0 software.

Originality/relevance: It focuses on how contingency factors influence the implementation of smart cities, producing quantitative evidence from the dependent variable with the independent variables.

Main results: Multiple linear regression showed that the selected variables explain 62.40% of what a smart city is. It evidences the positive and significant influence of the 'environment'; 'organizational structure' and 'size' contingency factors for cities with more than 50,000 inhabitants.

Theoretical/methodological contributions: The results contribute to the gap in empirical studies dealing with the contingency factors that affect municipalities in the sense of them becoming smart cities, and in the understanding of how these factors are related.

Social/management contributions: The implications reach the definition of factors that affect public policies, development of public governance practices and citizen engagement for the implementation of smart cities.

Keywords: Smart Cities. Critical factors. Contingency Theory. Brazilian cities.

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Resumo

Objetivo do estudo: Analisar a influência de fatores contingenciais (ambiente, estrutura, porte organizacional e cultura organizacional) nos 100 municípios brasileiros com melhor desempenho no Ranking Connected Smart Cities 2020.

Metodologia / Abordagem: Foram coletados dados do sistema Atlas do Desenvolvimento Humano no Brasil (AtlasBR); Conselho Federal de Administração (CFA); Sistema de Informações Contábeis e Fiscais do Setor Público Brasileiro (SICONFI); Instituto Brasileiro de Geografia e Estatística (IBGE) e Tribunal Superior Eleitoral (TSE). Os dados são referentes ao ano de 2019. Utilizou-se dos métodos estatísticos de teste de normalidade, homogeneidade, correlação e regressão linear múltipla com a utilização do software IBM SPSS Statistics Version 2.0.

Originalidade / relevância: Concentra-se na influência dos fatores contingenciais na implementação de cidades inteligentes, produzindo prova quantitativa baseada na variável dependente com as variáveis independentes.

Principais resultados: A regressão linear múltipla demonstrou que as variáveis selecionadas explicam 62,40% do que é uma cidade inteligente. Evidencia a influência positiva e significativa dos fatores contingenciais ambiente, estrutura e porte organizacional para as cidades acima de 50.000 habitantes.

Contribuições teóricas / metodológicas: Os resultados contribuem para a lacuna de estudos empíricos que tratam dos fatores contingenciais que afetam os municípios para se tornarem cidades inteligentes e no entendimento como esses fatores se relacionam.

Contribuições Sociais / Gestão: As implicações alcançam a definição dos fatores que afetam as políticas públicas, desenvolvimento de práticas de governança pública e do engajamento dos cidadãos para a implementação de cidades inteligentes.

Palavras-chave: Cidades Inteligentes. Fatores Críticos. Teoria da Contingência. Cidades Brasileiras.

Resumen

Objetivo del estudio: Analizar la influencia de los factores contingenciales (ambiente, estructura, tamaño de la organización y cultura organizacional) en los 100 municipios brasileños con el mejor desempeño en el Ranking Connected Smart Cities 2020.

Metodología/Abordaje: Se recogieron datos del sistema Atlas de Desarrollo Humano en Brasil (AtlasBR); Consejo Federal de Administración (CFA); Sistema de Informaciones Contables y Fiscales del Sector Público Brasileño (SICONFI); Instituto Brasileño de Geografía y Estadística (IBGE) y Tribunal Superior Electoral (TSE). Los datos se refieren al año 2019. Se utilizó los métodos estadísticos de prueba de normalidad, homogeneidad, correlación y regresión lineal múltiple con la utilización del software IBM SPSS Statistics Version 2.0.

Originalidad/relevancia: Se concentra en la influencia de los factores contingenciales en la implementación de ciudades inteligentes, produciendo prueba cuantitativa basada en la variable dependiente con las variables independientes.

Principales resultados: La regresión lineal múltiple demostró que las variables seleccionadas explican el 62,40% de lo que es una ciudad inteligente. Evidencia la influencia positiva y significativa de los factores contingenciales ambiente, estructura y tamaño de la organización para las ciudades de más de 50.000 habitantes.

Contribuciones teóricas/metodológicas: Los resultados contribuyen a la falta de estudios empíricos que traten de los factores contingenciales que afectan a los municipios para convertirse en ciudades inteligentes y en la comprensión de cómo esos factores se relacionan.

Contribuciones sociales/Gestión: Las implicaciones alcanzan la definición de los factores que afectan las políticas públicas, el desarrollo de prácticas de gobernanza pública y la interacción de los ciudadanos para la implementación de ciudades inteligentes.

Palabras-clave: Ciudades Inteligentes. Factores Críticos. Teoría de la Contingencia. Ciudades Brasileñas.

1 Introduction

Urban population growth is a movement that challenges local government administrations (Brandão & Joia, 2018) and hinders the sustainable development of cities (Chourabi et al., 2012). According to the United Nations (UN, 2019), about 55% of the world's population in 2018 lived in urban areas, and this rate is expected to increase to approximately 70% by 2050. With this expectation, municipalities need to prepare for this rise in urban population density.

In the late 1990s, a movement was created to defend the concern with the growth and urban planning of cities, through new public policies (Depiné, Ramos, Vanzin, Teixeira, & Fialho, 2017). The smart city concept thus emerged, but its understanding and application is not well defined for public administrators, lawmakers, or citizens (Albino, Berardi & Dangelico, 2015). Thus, new public policies aimed at smart cities have highlighted the relevance of using Information and Communication Technology (ICT) to improve the development of cities and take better advantage of resources, in addition to involving residents and promoting accountability (Abreu & Marchiori, 2020; Caragliu, Del Bo, & Nijkamp, 2011; Lee, Phaal, & Lee, 2013; Massonetto, Bachur, & Carvalho, 2020; Odendaal, 2003).

The intensified use of Information and Communication Technologies (ICTs) for the development of smart cities must not be dissociated from providing quality of life and prosperity to citizens, nor from enabling local development that generates smart outcomes (Aggarwal & Solomon, 2019; Almeida, Doneda, & Moreira da Costa, 2018). Smart outcomes encompass, for instance, the public finances and resilience of municipalities (Lima & Aquino, 2019).

In order to measure human development in the quality of life of a population, it is necessary to go beyond economic thinking and consider social, cultural and political factors (United Nations Development Programme [UNDP], 2015). Evidence from the literature has found that contingency factors can affect the performance of municipalities (Avellaneda & Gomes, 2017; Fiirst & Beuren, 2021; Goeminne & George, 2019; Jung & Kim, 2014; Sell, Beuren, & Lavarda, 2020). Contingency Theory assumes that contingency factors are the reasons that define the strategy and performance of organizations – and thereby, their efficiency (Donaldson, 2001).

According to this theory, applied to public sector organizations, the focus should be on the performance of service provision to the population (Christensen & Yoshimi, 2003; Woods, 2009). For instance, cities equipped with sensors and cameras collect huge amounts of data, but the real benefits for citizens are not perceived (Almeida et al., 2018). This denotes that, although the use of ICTs is a facilitating agent for the development of smart cities (Przeybilovicz, Cunha, & Meirelles, 2018), the population's nonawareness of it can be one of the critical factors in implementing the smart city project, along with the absence of political leadership in the change of administrators (Brandão & Joia, 2018).

With an initiative to empirically validate critical factors in the conception of a smart city, the Connected Smart Cities Ranking (CSCR) (2020) was chosen because it has mapped the cities with greater potential for development. This ranking consists of 70 indicators divided into 11 research sectors (mobility and accessibility, environment, urbanism, technology and innovation, health, safety, education, entrepreneurship, energy, governance, and economy) and uses its own methodology, named Marketing Quality Index [*Índice de Qualidade Mercadológica*] (IQM), carried out by the Urban Systems consulting agency since 2014. According to Urban Systems, the IQM is built when the objective is to prospect the best areas to open an enterprise without having existing units as reference, allowing the studied region the to be evaluated (Castro, 2020).

The CSCR methodology (2020) is aligned with the ISO 37122 standard (Sustainable cities and communities) (Abreu & Marchiori, 2020). This ISO standard establishes methodologies for a set of indicators, in order to guide and measure the performance of urban services and quality of life – that is, using the CSCR (2020) proves to be a viable option for understanding the characteristics of a smart city.

Considering these facts and supported by Contingency Theory (Sell et al., 2020; Woods, 2009), the research issue is stated as follows: What is the influence of contingency factors on the top 100 Brazilian municipalities in the CSCR (2020)? Thus, the objective of this research is to analyze the influence of contingency factors (environment, structure, organizational size and organizational culture) on the 100 Brazilian municipalities with the best performance in the CSCR (2020). To this end, multiple linear regression was used as the data analysis technique.

As such, this research empirically explores the gap in the contribution of contingency factors to the development of smart cities. The implications of this study cover the literature dedicated to the factors that characterize a smart city (Aggarwal & Solomon, 2019; Brandão & Joia, 2018; Caragliu et al., 2011; Chourabi et al., 2012; Depiné et al., 2017; Neirotti, De Marco, Cagliano, Mangano, & Scorrano, 2014; Nevado Gil, Carvalho, & Paiva, 2020; Periphèria, 2014; Przeybilovicz et al., 2018; Oliveira & Campolargo, 2015) and Contingency Theory, applied to the public sector (Avellaneda & Gomes, 2017; Goeminne & George, 2019; Macedo & Corbari, 2009; Park, 2019; Sell et al., 2020; Fiirst & Beuren, 2021), when discussing how contingency factors affect the characteristics of a municipality and may or may not contribute to the development of smarter cities.

In the Brazilian scenario, the results contribute to making it clear what factors affect municipalities when it comes to reaching smart city level. Although there is no consensus on the concept of the term smart city (Angelidou, 2014; Albino et al., 2015; Bibri & Krogstie, 2017), this article assists in characterizing a smart city in terms of the external and internal contingency factors of municipalities. Therefore, they contribute to the development of policies, finances and public governance, municipal resilience and citizen participation.

The study is divided into five parts: in the introduction, we present the objective and justification; in the second part, we elaborate on a theoretical framework referring to Contingency Theory and on the concepts of the term smart city; in the third, we explain the methodological procedures; in the fourth part, we discuss the results, the contingency factors that have an influence on and are statistically significant for the smartness level of municipalities. Finally, in the fifth part, we discuss the results, draw conclusions and suggest further studies on the subject.

2 Theoretical framework and hypotheses

Contingency factors have the potential to influence organizational efficiency, performance and behavior (Brignall & Modell, 2000; Greenwood & Hinings, 1976; Teisman & Klijn, 2008). The literature recognizes the following as internal contingency factors: technology, structure, strategy, organizational size, organizational culture and leadership; the environment is taken as an external contingency factor (Beuren & Fiorentin, 2014; Fagundes et al., 2010; Gonzaga, Frezatti, Ckagnazaroff & Suzart, 2016; Greenwood & Hinings, 1976; Oliveira & Callado, 2018; Sell et al., 2020; Wadongo & Abdel-Kader, 2014; Woods, 2009). According to Wadongo and Abdel-Kader (2014), the environment is an important factor for its imprecision, due to the the influence it has on internal factors, and is less controllable by organizations. For this reason, it is necessary to carry out different actions depending on the environment in which the municipality is inserted, since the specific characteristics of the space can influence the development of smart cities (Caragliu & Del Bo, 2012).

On ICTs, Przeybilovicz et al. (2018) conducted a study with 4,835 municipalities, using 39 variables divided into four dimensions and resorting to the municipalities' socioeconomic information as characterization. They divided the results into 4 groups: no-technology, citizenoriented, law-oriented, and ICT-equipped. The study found that municipalities that were classified in the ICT-equipped group (technology) had better socioeconomic indicators (environment) and greater potential to be considered smart cities. It reports as limitation the fact that the data were collected from a secondary source that does not completely show the use of ICTs in the municipalities.

Brandão and Joia (2018) analyzed the implementation of the Búzios Smart City [*Cidade Inteligente Búzios*] (CIB) project, with the main objective of making this city a smart one, using new technologies and digital tools in the management of the municipality (technology). The project highlighted problems with a change in political power (organizational leadership), which generated a lack of interest on the part of the population (organizational size), being considered irrelevant to the local community. Even though the municipality carried out a project to be equipped with ICT, its society factor – that is, the external contingency factor (environment) – did not contribute to the city being considered smart.

These studies show that, in order to achieve a high ICT level, it is necessary to consider local and regional peculiarities, such as legal and socioeconomic contexts, include the population in the process, and strengthen institutions (Lalovic, Djukanovic & Zivkvic, 2004). As a result, the concept of smart cities has expanded, recognizing other factors such as human capital, education and environmental issues as premises to bring about improvements to a city (Brandão & Joia, 2018). Technology-oriented implementation of smart cities is not wrong, but it does not encompass the human aspect (Oliveira & Campolargo, 2015).

On the human aspect for smart cities, the literature reflects on two domains: hard domain and soft domain. The hard domain of ICTs is central to the implementation of urban improvements, whereas in the soft domain the focus is on social engagement, citizen empowerment and the relationship of citizens with the environment (Neirotti et al., 2014; Periphèria, 2014), called Human Smart Cities.

For the development of Human Smart Cities, it is imperative to include equity, community autonomy, citizen well-being, and interest in the fundamental needs of human beings – which are the premises of the social dimension in a society (Toli & Murtagh, 2020), and the participation of the State is necessary to promote the social dimension, (Mendes, Ferreira, Abrantes, & Faria, 2018). The CSCR (2020) considered the social dimension in its indicators, such as checking access to mobility, sewage treatment and water distribution, doctors and hospital beds per inhabitant, etc. However, it is worth noting that the debate on the social dimension in smart cities is still under construction, and its impact on smart cities is divergent in the existing literature (Beck, da Silva Neto, Bezerra, Araújo, & Távora, 2020).

Moreover, soft domain prioritizes the use of available human capital, creating ecosystems, innovation and sustainability centers, jobs and new forms of participatory governance (Oliveira & Campolargo, 2015), so that infrastructure, both physical and digital, constantly relates to the human capital of the city (Rizzo, Concilio, Marsh & Molinari, 2013). On governance, Meijer and Bolívar (2016) identified in a bibliographic study three different emphases of governance in a smart city: (1) smart technology, smart people or smart collaboration, (2) transformative or incremental perspective, and (3) better outcomes or a more open process.

In the context of soft smart cities, Nevado Gil et al. (2020) used the Cities in Motion Index (CIMI) from IESE Business School to identify differences and similarities between cities in the European continent. The study used a quantitative analysis applied to 73 European cities in terms of economy, human capital, technology, environment, international impact, social cohesion, mobility and transport, governance, urban planning, and public management. Its results identified three clearly distinct groups: a group with high levels, a group with medium level, and a group that featured the lowest levels. There was evidence that the of smart city levels are related to geographic location (environment) – cities located in the western region obtained better results – and to the gender of rulers (organizational leadership) – cities governed by women achieved the best results in the CIMI ranking.

Giffinger et al. (2007) identified six characteristics of relevance to the concept of smart city: people, governance, economy, mobility, environment, and life. The first two characteristics are aimed at the other ones. This denotes that people (citizens) and governance (government) are the agents that make cities smart.

2.1 Research hypotheses

In accordance with the objective of this research and based on the literature review, five hypotheses are developed: one on external factors (environment), and four on internal factors (structure, size and organizational culture).

Regarding the 'environment' external contingency factor, the human development approach is geared towards people, their capabilities and opportunities – not only the resources or income they can generate – so that the essence is in human beings, not in economic growth (Silva, Silva, Souza, & Silva, 2015). Additionally, the search for maximizing well-being with available resources is one of the main challenges for public policy managers and citizens' interests (Scarpin & Slomski, 2007; Silva, Kuwahara, & Maciel, 2012), and this is due to the concern with public policies from the social sector, such as health and education (Silva et al., 2015). Thus, the Human Development Index – Municipal (HDI-M) is a relevant social development assessment metric, as it is the best-known measure of human development (Torres, Ferreira, & Dini, 2003); thus, hypothesis 1 is:

Hypothesis 1: Higher social development (HDI-M) has a positive influence on the development of a smart city.

The 'structure and technology' internal contingency factor (data management and ICTs), collaborates with public governance to enhance responses to the challenges faced by administrators (Barns, 2016). However, there is a lack of studies assessing the effects of adequate governance on economic growth, and of other public values on the development of smart cities (Meijer & Bolívar, 2016).

Providing quality of life to citizens through ICTs, enabling the population, allowing for interactions between administrators and citizens, contributes to the development of good municipal public governance (Lazzaretti, Sehnem, Bencke, & Machado, 2019). Governance can be understood in public entities as a system that determines the harmony of power involving citizens, elected representatives, top administration, managers and collaborators, always aiming to favor the common good over the interests of individuals or groups (Matias-Pereira, 2010).

Decree no. 9,203 of November 22, 2017, establishes public governance as "a set of leadership, strategy and control mechanisms mobilized to evaluate, direct and monitor management, with a view to conducting public policies and providing services of interest to society" (Brazil, 2017). By maximizing the human capital of their citizens, providing forms of participatory governance, cities become more human and intelligent (Oliveira & Campolargo, 2015), and the quality of governance is associated with efficiency in the public sector (Hwang & Akdede, 2011).

The literature shows several studies referring to the development of metrics for public governance and electronic public governance (Aquino, Silva, Vasconcelos, & Castelo, 2021; Mello & Slomski, 2010; Oliveira & Pisa, 2015; Ramos & Vieira, 2015; Silva, Borba, & Miranda, 2020; Vicente & Scheffer, 2014; Yong & Wenhao, 2012). This research uses the Municipal Governance Index [*Índice de Governança Municipal*] (IGM) (2021), prepared by the Federal Administration Council [*Conselho Federal de Administração*] (CFA), which consists of a metric of public governance in Brazilian municipalities comprising three dimensions: finance, management, and performance. Thus, hypothesis 2 is stated as follows:

Hypothesis 2: Good municipal public governance (IGM) has a positive influence on the development of a smart city.

Considering the 'organizational size' internal contingency factor, the provision of public goods and services creates positive externalities for the population due to economies of urbanization and agglomeration (Scarpin & Slomski, 2007). However, they can potentiate problems in territorial management, or technical, social, economic and organizational issues (Neirotti et al., 2014; Rolnik & Somekh, 2000; Sell et al., 2020).

According to Chourabi et al. (2012), the implementation of smart cities is emerging as the panacea to mitigate the adversities arising from urban population growth. With the same understanding, George, Van de Walle and Hammerschmid (2019) argue that larger cities are more likely to use management tools and positively influence public performance (Avellaneda & Gomes, 2017; Cavalcante, 2016; Fiirst & Beuren, 2021; Sell et al., 2020). Thus, hypothesis 3 is:

Hypothesis 3: A larger municipal population has a positive influence on the development of a smart city.

With respect to the 'organizational culture' internal contingency factor, Oliveira and Pisa (2015) indicate that the involvement of the population occurs mainly through participation in elections, making it vital for the construction of the social well-being of a society, idealizing with the concepts of a smarter, more humane city. According to Lavalle and Vera (2011), political engagement is consistent with the effect of integration – that is, of belonging to a society, contributing to legitimating political institutions and strengthening the formation of voter identity.

Civil behavior underwent changes after the enactment of the 1988 Federal Constitution of Brazil; society began to have greater participation in decision-making processes involving public policies (Brouchoud, 2010). One of the ways for citizens to exercise their democratic role is by participating in municipal elections; it is the instrument that voters use, prioritizing the convergence of their interests, goals and beliefs (Cavalcante, 2016). Thus, hypothesis 4 is:

Hypothesis 4: Greater electoral participation has a positive influence on the development of a smart city.

Regarding the 'structure' internal contingency factor, to Sell et al. (2020), the *per capita* Net Expenditure on Personnel Indicator [*Indicador de Despesa Líquida com Pessoal*] (IDP) influences the performance of municipalities in the state of Santa Catarina, showing that cutting personnel expenses will not increase their performance. On the other hand, Fiirst and Beuren (2021) found that municipal personnel expenses were not significant in the performance of municipalities in the state of Paraná. And Macedo and Corbari (2009) indicated a positive relationship as to the degree of municipal indebtedness, but the explanatory power of the indebtedness referring to this variable, IDP, was lower than expected, showing that personnel expenses are not the main responsible for municipal indebtedness in the analyzed period (1998 to 2006).

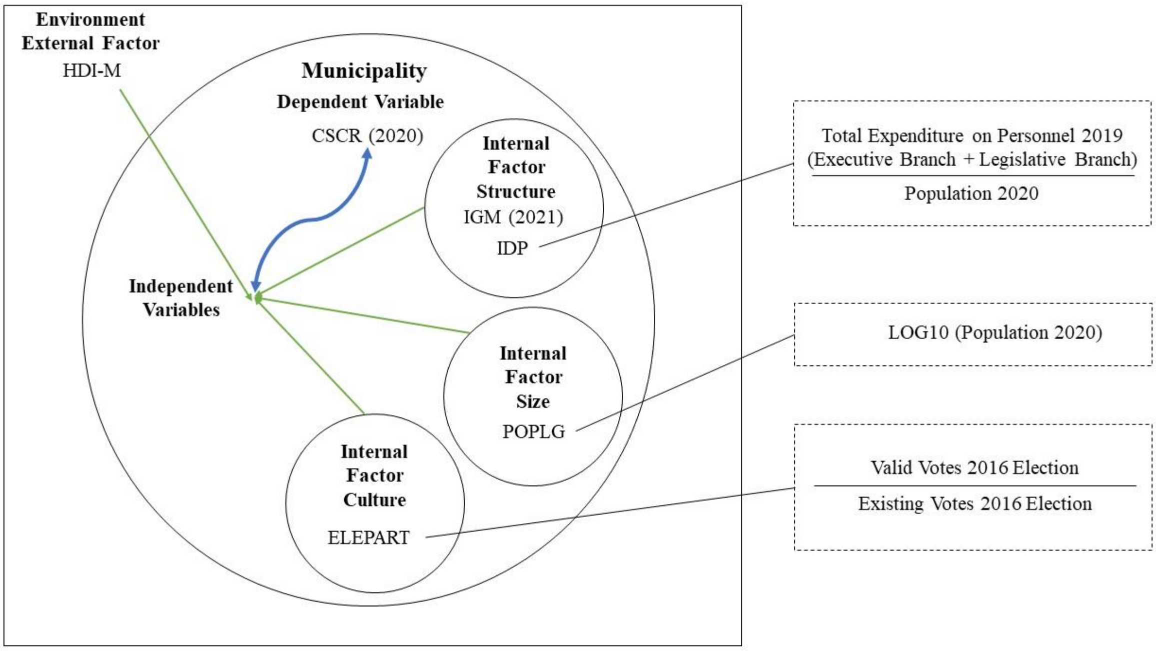
The 'structure' internal contingency factor can interfere with the efficiency and motivation of individuals, shaping the future of an organization (Chenhall, 2003). Saving money by firing servants, or even reduction with lack of readjustments, does not contribute to the definition of a smarter city, fitting only with the ideals of New Public Management (NPM) – effectiveness and efficiency through cost reduction (Christensen & Yoshimi, 2003). Therefore, hypothesis 5 is formulated as follows:

Hypothesis 5: Higher *per capita* expenditure on personnel has a positive influence on the development of a smart city.

Figure 1 shows, in a simplified manner, the hypotheses of the article.

Figure 1

Research hypotheses



Source: Prepared by the authors (2022).

3 Method

The methodological development of this research follows the empirical-analytical perspective, which consists of using techniques for collecting, processing and analyzing data with quantitative metrics. This perspective is in line with the objective, which is to analyze the influence of contingency factors (environment, structure, organizational size and organizational culture), with a sample consisting of the top 100 municipalities in the CSCR (2020). This ranking uses data from 2019 and was carried out by the Urban Systems consulting agency, involving a total population of 673 municipalities, that is, all Brazilian municipalities with more than 50,000 inhabitants.

The list of the 100 municipalities that make up the sample of this research is presented in Table 1, covering all geographic regions of Brazil.

Table 1

Sample used in the research

Population Category	Municipalities	No. of Municipalities
Between 50,000 and 100,000 inhabitants	Amparo (SP), Andradina (SP), Boituva (SP), Cajamar (SP), Congonhas (MG), Eusébio (CE), Itapema (SC), Itupeva (SP), Jaboticabal (SP), Jaguariúna (SP), Lençóis Paulista (SP), Mariana (MG), Nova Lima (MG), Ouro Preto (MG), Pato Branco (PR), Registro (SP), Viçosa (MG), Vinhedo (SP).	18
Between 100,001 and 250,000 inhabitants	Americana (SP), Araraquara (SP), Araras (SP), Balneário Camboriú (SC), Botucatu (SP), Cachoeiro de Itapemirim (ES), Caraguatatuba (SP), Chapecó (SC), Colatina (ES), Hortolândia (SP), Itabira (MG), Itajaí (SC), Itatiba (SP), Itu (SP), Itumbiara (GO), Jacareí (SP), Jaraguá do Sul (SC), Linhares (ES), Paulínia (SP), Poá (SP), Presidente Prudente (SP), Resende (RJ), Santana de Parnaíba (SP), São Caetano do Sul (SP), Sobral (CE), Toledo (PR), Três Lagoas (MS), Valinhos (SP).	28
Between 250,001 and 500,000 inhabitants	Barueri (SP), Betim (MG), Blumenau (SC), Cascavel (PR), Cotia (SP), Foz do Iguaçu (PR), Indaiatuba (SP), Ipatinga (MG), Jundiaí (SP), Limeira (SP), Macaé (RJ), Maringá (PR), Palmas (TO), Petrópolis (RJ), Piracicaba (SP), Praia Grande (SP), Santa Maria (RS), Santos (SP), São Carlos (SP), São José do Rio Preto (SP), São José dos Pinhas (PR), Uberaba (MG), Vitória (ES), Vitória da Conquista (BA).	24
Between 500,001 and 1,000,000 inhabitants	Campo Grande (MS), Caxias do Sul (RS), Cuiabá (MT), Florianópolis (SC), João Pessoa (PB), Joinville (SC), Juiz de Fora (MG), Londrina (PR), Natal (RN), Niterói (RJ), Osasco (SP), Ribeirão Preto (SP), Santo André (SP), São Bernardo do Campo (SP), São José dos Campos (SP), Sorocaba (SP), Teresina (PI), Uberlândia (MG).	18
More than 1,000,001 inhabitants	Belo Horizonte (MG), Brasília (DF), Campinas (SP), Curitiba (PR), Fortaleza (CE), Goiânia (GO), Manaus (AM), Porto Alegre (RS), Recife (PE), Rio de Janeiro (RJ), Salvador (BA), São Paulo (SP).	12
Total		**100**

Source: Connected Smart Cities Ranking (2020).

As for the variables, they are: the dependent variable (score obtained by the municipalities in the 2020 Connected Smart Cities Ranking); the independent variables, which are the contingency factors that are internal and external to the municipalities, as recommended by Contingency Theory; and the control variables (Table 2).

Table 2

Definition of the variables

Variable	Measure	Author
	DEPENDENT VARIABLE	
Connected Smart Cities Ranking	*Ranking developed by the Urban Systems consulting agency (CSCR)*	Study authors
	INDEPENDENT VARIABLE	
Environment	2010 Human Development Index - Municipal (HDI-M)	Sell et al. (2020); Vieira (2009)
Structure	2021 Municipal Governance Index (IGM) – 2019 data	Study authors
	Net Expenditure on Personnel *per capita* Indicator (IDP) – 2019 data	Avallaneda and Gomes (2015); Sell et al. (2020)
Organizational Size	Population Log (POPLG) – 2020 data	Avallaneda and Gomes (2015); Sell et al. (2020)
Organizational Culture	Participation in the 2016 Elections (ELEPART)*	Oliveira and Pisa (2015); Aquino et al. (2021)
	CONTROL VARIABLE	
Region (REG)	1 = North, 2 = Northeast, 3 = Midwest, 4 = Southeast or 5 = South	Baldissera (2018)
Capital (CAP)	1 = Capital or 0 = Not Capital	Baldissera (2018)
Political spectrum (SPEC)	Political Spectrum of the Mayor elected in 2016 1 = Left wing, 2 = Right wing or 3 = Center	Avallaneda and Gomes (2015); Sell et al. (2020); Vieira (2009)

*For the Brasília administrative region, the 2018 electoral participation was used.

Source: Prepared by the authors (2022).

Among the variables in Table 2, the Human Development Index – Municipal (HDI-M) was employed as an external contingency factor, referred to as environment; it is a comparative measure used to classify the degree of human development in the municipality, conceived by the United Nations Development Programme (UNDP), ranging from 0 to 1 – the closer to 1, the greater the city's human development. This index was chosen for assimilating in its calculations data on longevity, education and income, using metrics not assigned to the 70 indicators of the CSCR (2020), such as life expectancy at birth, education of the adult population, school flow of the young population, and per capita income.

Regarding the internal contingency factors, referred to as structure, the Municipal Governance Index (IGM) (2021) was used; it is carried out by the Federal Administration Council (CFA) and prepared on the basis of three dimensions, namely: finance, management and performance. This index was chosen due to the exclusivity of the theme – public governance – an important factor to be taken into account by a smart city. The IGM (2021) uses some data similar to those of the ranking, but has a different methodological approach for calculations. Still in the structure, the *per capita* Net Expenditure on Personnel Indicator (IDP) was used; it is the sum of the net expenses with personnel of the Executive and Legislative branches, divided by municipal population.

For population (POPLG), designated as organizational size, logarithmization was performed for the number of inhabitants in the municipality. Logarithmization is necessary due to the bias of the variable – that is, it has high peaks and a long tail, which can influence measures such as correlation and regression due to the peak of the distribution (Hair, Black, Badin, Anderson & Tathan, 2005). The Connected Smart Cities Ranking does not have population as an indicator, only population density, so it did not use population density.

In relation to organizational culture, Electoral Participation (ELEPART) was used. For the calculation, the valid votes from the first round of the 2016 elections were divided by the available votes from the same election, thus showing the effective participation of the population.

Since political and demographic aspects can influence management (Cavalcante, 2016; Greenwood & Hinings, 1976), control variables were added, such as the Brazilian demographic region (REG) of the municipality – North, Northeast, Midwest, Southeast or South. We also present as a control variable whether or not the municipality in question is or is not the state capital (CAP); in accordance with Carreirão (2006), the political parties of the mayors elected in 2016 were classified into left wing (1), right wing (2) and center (3) for control of the Political Spectrum of the 2016 mayoral elected (SPEC). The SPEC variable has a transitory bias and a short-term effect, given the creation of new parties during this timeframe, the end of coalitions and the creation of the electoral fund within the political reform that took place during the Michel Temer administration.

Regarding the method, ordinary least squares (OLS) were used, which represent a mathematical method that assures the straight line passing through the points in the scatter diagram is arranged in the best possible way (Hair et al., 2005). Thus, this is the econometric model:

$$\mathrm{CSCR_i} = \propto + \beta_1(\mathrm{HDI} - \mathrm{M_i}) + \beta_2(\mathrm{IGM_i}) + \beta_3(\mathrm{POPLG_i}) + \beta_4(\mathrm{ELEPART_i}) + \beta_5(\mathrm{IDP_i}) + \beta_6(\mathrm{X_i}) + \mathrm{e_i}$$

Where, “X” refers to the control variables, and “e” is the error term.

For analysis, data were structured in spreadsheets using Microsoft Excel®. Afterwards, the IBM SPSS Statistics Version 2.0 software was used to run the normality test (Kolmogorov-Smirnov and Shapiro-Wilk) and homogeneity test (Levene), in order to verify whether the data are parametric or non-parametric. After the characteristic of the data was defined, correlation was performed.

Next, multiple linear regression analysis was carried out with only the variables that were statistically significant, in order to verify the influence of variables with the CSCR (2020), making it possible to study the link between two or more explanatory variables, which are exposed in a linear manner, and a metric dependent variable (Fávero, Belfiore, Silva & Chan, 2009), and thereby test the hypotheses of this article. In order to verify the presence of heteroscedasticity, the Breusch-Pagan/Cook-Weisberg test and White's test were applied, and the Durbin-Watson test was used for autocorrelation.

Data were collected in August 2021, with the exception of the IGM (2021), which was made available at the end of 2021; therefore, the data referring to this variable were updated, as the 2021 IGM calculations use data from 2019. The following were used to collect the independent variables: HDI-M, taken from the Atlas system's electronic portal for Human Development in Brazil (AtlasBR) (2019); IGM (2021), conceived by the Federal Administration Council (CFA); POPLG, taken from the electronic portal of the Brazilian Institute of Geography and Statistics (IBGE) (2020); ELEPART, taken from the electronic portal of the Superior Electoral Court [*Tribunal Superior Eleitoral*] (TSE) (2016); IDP, taken from the electronic portal of the Brazilian Accounting and Tax Information System for the Public Sector [*Sistema de Informação Contábeis e Fiscais do Setor Público Brasileiro*] (SICONFI) (2019), carried out by the National Treasury Secretariat [*Secretaria do Tesouro Nacional*] (STN). And, for the control variables, REG and CAP were taken from the IBGE electronic portal (2020), while SPEC was taken from the TSE electronic portal (2016).

4 Results

In this section, we present the descriptive statistics, municipalities standing out in the descriptive statistics, normality and homogeneity tests, correlation matrix and, lastly, the result of the multiple linear regression. Table 3 shows the results related to the minimum and maximum values, mean and standard deviation of the dependent variable (CSCR) and of the independent variables (HDI-M, IGM, POPLG, ELEPART, IDP). Then, Table 4 highlights the municipalities in terms of descriptive statistics.

Table 3

Descriptive statistics

Variables	Minimum	Maximum	Mean	Standard deviation
CSCR	28.906	37.901	31.285	2.125
HDI-M	0.678	0.862	0.782	0.031
IGM	4.30	8.37	6.65	0.88
POPLG	4.74	7.09	5.47	0.49
ELEPART	0.4032	0.8567	0.6994	0.0788
IDP	847.64	6,044.83	1,912.87	823.30

Source: Prepared by the authors (2022).

Regarding the 100 best cities in the CSCR, the highest score (37.901) was obtained by the city of São Paulo (SP), and the lowest score (28.906), by Boituva (SP). On average, the municipalities had a score of 31.285. São Paulo, in addition to scoring highest in the CSCR, obtained the highest population logarithmization (POPLG), with the municipality of Eusébio (CE) having the smallest population. The standard deviation of the CSCR (2020) was 2.125, a high value compared to the other variables. The *per capita* Net Expenditure on Personnel Indicator (IDP) also showed a high standard deviation, 823.30, evidencing the existence of different realities among the 100 best-ranked municipalities.

With respect to the Human Development Index – Municipal (HDI-M), the highest score was obtained by the municipality of São Caetano do Sul (SP), while Vitória da Conquista (BA) had the worst score for this index. It is also noted that there was no high standard deviation in this variable. This information helped clarify that, despite the existence of different realities in Brazil, this does not repeat when data are presented through the HDI-M. It is verified that among the 5,570 municipalities in Brazil, the top 100 municipalities in the CSCR belong to the upper socioeconomic stratum – that is, they have a score between High or Very High, according to the methodology of the United Nations Development Programme (UNDP) (2015).

Table 4

Presentation of the municipalities standing out in the descriptive statistics

Variables	Minimum	Maximum	Mean
CSCR	Boituva (SP)	São Paulo (SP)	Viçosa (MG) Juiz de Fora (MG) Goiânia (GO)
HDI-M	Vitória da Conquista (BA)	São Caetano do Sul (SP)	Cascavel (PR) Caxias do Sul (RS) Pato Branco (PR)
IGM	Ouro Preto (MG)	São Bernardo do Campo (SP)	Itabira (MG) Americana (SP) Botucatu (SP)
POPLG	Eusébio (CE)	São Paulo (SP)	Limeira (SP) Petrópolis (RJ) Palmas (TO)
ELEPART	Araras (SP)	Sobral (CE)	Itatiba (SP) Betim (MG) Caraguatatuba (SP)
IDP	Salvador (BA)	Paulínia (SP)	Campinas (SP) Poá (SP) Rio de Janeiro (RJ)

Source: Prepared by the authors (2022).

São Bernardo do Campo (SP) had the best Municipal Governance Index (IGM), with Ouro Preto (MG) obtaining the lowest value. As for Electoral Participation (ELEPART), the municipality of Sobral (CE) had the highest one – 85.67% voted; on the other hand, the municipality of Araras (SP) had the lowest participation, with only 40.32%. Finally, Paulínia (SP) had the highest IDP, and the municipality of Salvador (BA), the lowest.

The dependent variable (CSCR) did not show normality in the data, with a significance of 0.000, both in the Kolmogorov-Smirnov test and in the Shapiro-Wilk test. For the homogeneity test, the data proved to be non-homogeneous by Levene's test, with a significance of 0.000. It is thus proven that the study data are non-parametric, that is, they do not meet normality or homogeneity. For this reason, the correct correlation to be used is Spearman's correlation test. This correlation model can be used when data fail to meet parametric assumptions (Field, 2009). Table 5 shows the results of the normality and homogeneity tests.

Table 5

Normality and homogeneity tests

Dependent Variable	Normality Test				Homogeneity Test (Levene)	
	Kolmogorov-Smirnov		Shapiro-Wilk			
	Statistical	Sig.	Statistical	Sig.	Statistical	Sig.
CSCR	0.170	0.000	0.876	0.000	14.396	0.000

Source: Prepared by the authors (2022).

The result of Spearman's correlation test, since the data presented are non-parametric, for the CSCR dependent variable, with the HDI-M, IGM, POPLG, ELEPART and IDP independent variables, and the REG, CAP and SPEC control variables, are shown in Table 6.

Table 6

Correlation matrix

Variables	CSCR	HDI-M	IGM	POPLG	ELEPART	IDP	REG	CAP	SPEC
CSCR	1								
HDI-M	0.584**	1							
IGM	0.297**	0.369**	1						
POPLG	0.514**	0.274**	0.284**	1					
ELEPART	-0.035	-0.182	-0.207*	-0.179	1				
IDP	0.239*	0.270**	-0.212*	0.336**	0.055	1			
REG	0.100	0.333**	0.254*	-0.128	-0.014	0.161	1		
CAP	0.355**	0.105	-0.028	0.616**	0.122	-0.133	-0.398**	1	
SPEC	-0.021	-0.054	-0.053	0.038	-0.145	0.088	0.099	-0.019	1

Legend: ** p<0.01; * p<0.05.
Source: Prepared by the authors (2022).

There is a moderate, positive correlation between the CSCR and HDI-M variables – 0.584, with a significance of 0.000 (p<0.01). The IGM variable, on the other hand, showed a weak positive correlation with the dependent variable, with a significance of 0.003 (p<0.01). As for the POPLG variable, the correlation is moderate, positive with the CSCR, with a coefficient of 0.514 and a significance of 0.000 (p<0.01). When it comes to the IDP variable, the correlation was weak and positive, with a significance of 0.017 (p<0.05) and a coefficient of 0.239. The only significant control variable was CAP, with a coefficient of 0.355 and significance of 0.000 (p<0.01).

The other variables were not significant, namely: the ELEPART variable (-0.035), the ‘organizational culture’ contingency factor, and the REG (0.100) and SPEC (-0.021) control variables.

Table 7 presents the results for the multiple linear regression model, which verifies the influence of contingency factors on position in the CSCR (2020). Only the variables that correlated with a significance of 1% to 5% (HDI-M, IGM, POPLG, IDP and CAP) were taken into account.

Table 7

Multiple Linear Regression

ANALYSIS OF ASSUMPTIONS						
Prob>F	*Adjusted R²*	*Durbin-Watson*	*Mean VIF*	*BP/CW Test*	*White's Test*	*No. Observations*
.000	.624	1.331	2.060	.017	.005	100
ANALYSIS OF INDEPENDENT AND CONTROL VARIABLES						
Independent Variables	*Coefficient*	*Standard Error*	*Random T*	*P-Value*	*95% Conf. Interv*	
HDI-M	25.661	4.933	5.202	0.000***	15.866	35.456
IGM	0.321	0.180	1.788	0.077*	-0.036	0.678
POPLG	1.711	0.405	4.223	0.000***	0.907	2.516
IDP	0.001	0.000	4.518	0.000***	0.000	0.001
CAP	0.956	0.477	2.005	0.048**	0.009	1.902
CONS	**-2.076**	**3.603**	**-0.576**	**0.566**	**-9.321**	**5.078**

***** p<0.01; ** p<0.05; * p<0.10.**

Source: Prepared by the authors (2022).

It is observed that the presented model, consisting of the 100 municipalities with the best positions in the CSCR, was statistically significant at the 1% level. The adjusted R² is 0.624, that is, the model explains 62.40% of the dependent variable in relation to the independent and control variables. The model did not present an autocorrelation problem by the Durbin-Watson test, with a value of 1.33 – greater than 1 and lower than 3 (Field, 2009). It showed no multicollinearity problem, VIF test (2.060 < 10), which indicates an increase in the variance of a regression coefficient (Fávero et al., 2009). The Breusch-Pagan/Cook-Weisberg test (BP/CW test) and White’s test indicate a problem of heteroscedasticity in the residuals, probably due to the existence of outliers, but the choice was made not to remove any municipality, given the objective of analyzing all 100 municipalities in the ranking. The normality test for the residuals showed statistical significance by the Kolmogorov-Smirnov

(0.200) and Shapiro-Wilk (0.739), thus ensuring the validity of the hypothesis tests for the regression model (P-value) (Fávero & Belfiore, 2021).

The HDI-M, POPLG and IDP variables showed statistical significance with a positive influence at the level of 1% ($p<0.01$), whereas the CAP control variable showed statistical significance with a positive influence at the level of 5% ($p<0.05$). Finally, the IGM variable showed statistical significance with a positive influence at the level of 10% ($p<0.10$). Thus, all variables used in the model were statistically significant, with a positive bias in relation to the CSCR dependent variable.

5 Discussion and conclusion

Multiple linear regression showed that the HDI-M, IGM, POPLG and IDP variables influence the municipalities' level of smartness. Table 8 presents the decisions for the tested hypotheses.

Table 8

Decision for the Tested Hypotheses

Hypotheses	Proposed relationships	Decisions
H_1	'Environment' contingency factor → HDI-M	Confirmed ($p<0.01$)
H_2	'Structure' contingency factor → IGM	Confirmed ($p<0.10$)
H_3	'Organizational size' contingency factor → POPLG	Confirmed ($p<0.01$)
H_4	'Organizational culture' contingency factor → ELEPART	Not Significant
H_5	'Structure' contingency factor → IDP	Confirmed ($p<0.01$)

Source: Prepared by the authors (2022).

In summary, the results of the analysis for the 100 best municipalities in the CSCR significantly evidenced that HDI-M (H1, external contingency factor – environment), POPLG (H3, internal contingency factor – organizational size) and IDP (H5, internal contingency factor – structure) are the contingency factors with a positive effect on the development of smart cities in Brazil, with a significance of 0.000 ($p<0.01$), confirming the result expected in these hypotheses and corroborating studies already conducted addressing the public sector (Fiirst & Beuren, 2021; Sell et al., 2020).

On the other hand, IGM (H2, internal contingency factor – structure) has a positive effect on the development of smart cities in Brazil, but with a significance of 0.077 ($p<0.10$), confirming the result expected in this hypothesis, but due to the relevance of the public governance theme, a level of significance similar to that of the other variables was expected. It is noteworthy that the sample refers to the 100 smartest cities in the CSCR (2020), so we are dealing with populous cities where the possibility of enforcement on managers is exercised in a superior way compared to the other municipalities, leading to greater social control, which can be reflected in a greater degree of public governance (Aquino et al., 2021). Public governance encompasses public policies and finances, control and accountability, with the purpose of generating outcomes, both in terms of improving the provision of services to citizens and the efficiency in using public resources (Secchi, 2009). The result corroborates the studies by Sell et al. (2020), where structure influences the performance of Santa Catarina's municipalities, but differs from the result of Fiirst and Beuren (2021), where structure was not significant.

Still on the NPM thinking, we can verify that the IGM variable has a significant correlation with the IDP, although weak and negative. It is believed that this result is due to the thought of austerity and cost reduction attributed in the IGM's methodology (2021), but which are not proposed as viable in their entirety for the interpretation of a smarter city, deserving further research for a better understanding.

Electoral participation (ELEPART) (H4, internal contingency factor – organizational culture) does not contribute to the development of smart cities in Brazil, since it does not have a significant correlation with the dependent variable and was excluded from the multiple linear regression, thus rejecting Hypothesis 4. The result reinforces the findings of Aquino et al. (2021), where popular participation is lower in larger cities, finding a statistically significant difference between the means of small and large municipalities in the participation indicator. The insignificance of the ELEPART variable, so to speak, confirms that participation has lost its polar position in the fabric of democratic criticism, losing its self-evident character (Lavalle & Vera, 2011).

Among the control variables, only CAP positively and significantly influenced the development of smart cities, with a significance of 0.048 ($p<0.05$). The region (REG) and mayor's political spectrum (SPEC) variables were not statistically significant in the correlation, and were excluded from the multiple linear regression, diverging from the study by Nevado Gil et al. (2020) when it comes to region, as cities located in western Europe obtained better results in the Cities in Motion Index (CIMI). However, it corroborates with the mayor's political spectrum, which also did not show statistical significance in the performance of smart cities on the European continent.

The municipality's HDI-M, with a correlation of 0.584 and a significance of 0.000 ($p<0.01$) in the regression, is related to the implementation of public policies that aim to increase the population's quality of life and contributes to the municipality's level of smartness, reinforcing the results of other studies linked to other dependent variables (public governance and performance) in relation to socioeconomic development (Aquino et al., 2021; Sell et al., 2020). Varela, Martins and Corrar (2009) obtained a positive association with socioeconomic indicators in relation to the amount of resources applied to social fields (health, education, culture, assistance and social security, among others). Thus, the results contribute to managers with the premise that investments that increase social development will also contribute to the development of a smart city.

However, an increase in HDI-M demands efforts not only from public entities, but also from private ones, which is a limitation of the study and of the very methodology of the CSCR (2020), as it does not take into account the Environmental, Social and Corporate Governance (ESG) of companies installed in the municipalities, and may be an object of future research. Society must find an environment conducive to opportunities, exploring its potential and living more creatively (Streitz, 2011), hence the importance of the private sector in the CSCR's methodology.

The POPLG variable influences the development of smart cities, showing that the larger the population of the municipality, the higher its level of smartness, corroborating the results found by Freitas and Luft (2014), that cities with larger populations have a better electronic governance index, which is an attribute of a smart city, according to the presented concepts. The result also contributes to the findings of Shapiro (2006), who identified that smart cities are conceptualized as metropolitan areas with a large portion of a college-educated adult population.

In Brazil, about 87.92% of the municipalities have a population of less than 50,000 inhabitants, and the POPLG variable showed a correlation of 0.514 and a significance of 0.000 ($p<0.01$) in the regression; the mean presented in the descriptive analysis was 5.47, that is, on average, the 100 best municipalities in the CSCR have approximately 300,000 inhabitants. However, only 95 municipalities in Brazil (1.71%) have this population size, so the CSCR (2020) has metrics that are incompatible with most Brazilian municipalities. One of the possibilities would be the creation of an alternative index, for small towns, such as the one conceived by Giffinger et al. (2007), which examines European municipalities with populations from 100,000 to 500,000 inhabitants.

Regarding the results presented in the correlation, the CSCR dependent variable with the Human Development Index – Municipal (HDI-M) independent variable obtained a moderate, positive and significant correlation. This suggests that the CSCR considers the socioeconomic side of the municipalities and does not focus only on the technological side, taking into account the well-being of the population. Therefore, the result shows that the cities ranked in the CSCR are not only smart, but also more humane (Neirotti et al., 2014).

The presented result differs from those of previous studies where the HDI-M was not significant in investment allocation (Rezende, Slomski, & Corrar, 2005) and in public spending as to generating social well-being (Silva et al., 2012). The downside of this result is that more developed populations depend less on the public sector (Vieira, 2009), which can cause the centralization bias of the infrastructure necessary for a municipality to be a smart city in the private sector, excluding the population that cannot pay for the service (Massonetto et al., 2020).

About the population logarithm (POPLG) independent variable, there was a moderate, positive and significant correlation – that is, it denotes that the larger the population, the higher the city's position in the CSCR, corroborating the literature on the influence of contingency factors, size, on the public sector (Avellaneda & Gomes, 2017; Cavalcante, 2016; Fiirst & Beuren, 2021; Sell et al., 2020).

The Capital (CAP) control variable presents a weak, positive and significant correlation with the CSCR variable, that is, being the state capital contributes to ranking in the CSCR. Capitals usually concentrate more skilled people, due to public agencies, universities, and, consequently, generate higher-added-value jobs and have better socioeconomic indices.

With regard to the *per capita* Net Expenditure on Personnel Indicator (IDP) variable, it presented a weak, positive and significant correlation with the dependent variable; it is suggested that the smarter the municipality, the greater its expenditure on personnel, which is contrary to the proposal of the New Public Management (NPM). There is still no consensus on what the NPM conceives, but the literature tends to consider some fundamental principles, such as managerialism, disaggregation, incentive, decentralization, debureaucratization, competition and privatization (Freitas, Silva, Vicente & Rosa, 2019), and personnel cost cuts are always guided by a vision of improving results, a vision with a private bias.

According to Pereira and Ckagnazaroff (2021), the NPM was not able to take on the challenges of knowledge-driven skills and service provision in the digital economy. There is a certain logic in this contradiction, as the role of the public sector is to provide services to the population, and only with good salaries and incentives can it attract more qualified and engaged personnel.

Studies developed in Brazil referring to smart cities aim to create solutions for problems that are mostly urban, with a focus on improving quality of life and sustainability, as well as to develop ICTs in order to assist in urban management (Lazzaretti et al., 2019).

This study did not intend to characterize what a smart city is; the implications for practitioners lie in the empirical evidence on some characteristics, based on Contingency Theory, on the analysis of the municipalities' level of smartness, evidencing indicators that can be used to grasp the concept of a smart city, thus contributing to the production of empirical studies that can collaborate with discussions about the city of the future (Glasmeier & Christopherson, 2015). Thus, it analyzed the influence of contingency factors on the performance of municipalities in the Connected Smart Cities Ranking (CSCR) (2020), conceived by the Urban Systems consulting agency.

From the results, followed by the discussion around them, it is concluded that the characterization of a smart city must consider both the municipality's technological aspect and human aspect. Managers should bear in mind that technology alone will not make a city smarter (Meijer & Bolívar, 2016). These aspects are present in contingency factors, mainly environment, structure and organizational size, so the set of contingency factors characterizes how smart a city can be.

6 Further considerations

Future research can better investigate the relationship of smart cities with the Public Service Motivation (PSM) literature, since, according to Dur and Zoutenbier (2014), "Public service motivation is often equated with a desire to serve the public interest or, more generally, with altruism".

It is therefore recommended that future studies integrate other variables to analyze a smart city. Further research can verify the improvement of public governance in the measurement of a smart city (Almeida et al., 2018; Araujo & Tejedo-Romero, 2017; Prado-Lorenzo, García-Sanchez & Cuadrado-Ballesteros, 2011) and determine the impacts that public governance causes on economic growth and other concepts (Meijer & Bolívar, 2016), proposing new indicators for the CSCR or for the methodology applied to the IGM (2021).

Another possibility of study refers to the result obtained in the correlation between the IGM and IDP variables (-0.212, with a significance at the level of 5%), discussing them from the perspective of application of the NPM. The question that remains from this result is: what is the efficiency limit reached by reducing personnel expenses when the intention is to make a municipality a smart city? How can public governance practices contribute to balancing personnel expenses and reaching smart city level? After all, is the smart city of the 21st century a new historical turning point in the private appropriation of the social product that passes through the urban space (Massonetto et al., 2020)?

This study had its limitations, including that of prioritizing 2019 data due to the unavailability of some information and possible changes in the municipalities' resource allocation due to the COVID-19 pandemic, not reflecting the application in times regarded as normal. The HDI-M and IGM variables are indices, so their use contributes to the problem of representation, since each index covers several dimensions, but reduces the measurement of specific characteristics that can be a key point in the analysis of the studied concept (Manly & Alberto, 2019).

The mayor's gender variable (male or female) was not considered, as in the study by Nevado Gil et al. (2020), due to the bias regarding the lack of female representativeness in Brazilian politics, especially in the Executive branch. For illustration purposes, of the top 100 cities in the CSCR (2020), 97 of the mayors were male, and only 3 were female. In the study by Nevado Gil et al. (2020), which took into account 73 European cities, 52 (71.23%) were male, and 21 (28.77%) were female.

Authors' contributions

Contribuição	Rabito, D.H.F.	Sanches, S.L.R.	Carvalho, L.M.G.	Paiva, I.C.S.
Contextualization	X	X	X	X
Methodology	X	X	X	X
Software	X			
Validation	X	X	X	X
Formal analysis	X	X	X	X
Investigation	X	X	X	X
Resources	X		X	X
Data curation	X	X	X	X
Original	X	X		
Revision and editing	X	X	X	X
Viewing	X	X		
Supervision	X			
Project management	X			
Obtaining funding	---------	---------	---------	---------

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