Revista Brasileira de Gestão e Desenvolvimento Regional
G&DR. V. 19, N. 1, P. 467-485, Jan-Abril/2023. Taubaté, SP, Brasil.
ISSN: 1809-239X

ANÁLISE DOS DETERMINANTES DO NÍVEL DE INTELIGÊNCIA EM *SMART CITIES*

ANALYSIS OF INTELLIGENCE LEVEL DETERMINANTS IN SMART CITIES

Received: 12/24/2021
Accepted: 02/18/2023

Roberto Birch Gonçalves [1]
Fábio Verruck [2]
Vanice Verônica Endres [3]

Resumo

A gestão aplicada às cidades tem buscado otimizar ao máximo seus recursos e melhorar sua capacidade de desenvolvimento, proporcionando melhor qualidade de vida a seus ocupantes. Este estudo objetiva identificar os fatores que apresentam maior impacto na gestão das cidades, considerando-se os indicadores utilizados para mensurar as smart cities CIMI (Cities in Motion Index). Para tanto se procedeu, como metodologia de pesquisa, a uma pesquisa exploratória com abordagem quantitativa, selecionando-se uma amostra de cinquenta e duas cidades, considerando o universo de cento e sessenta e cinco avaliadas no estudo. Esta amostra foi selecionada seguindo critérios como população, ranking no CIMI e disponibilidade de dados abertos. Após a aplicação de métodos de análise exploratória e de regressão verificou-se que os principais determinantes do nível de inteligência nas cidades são inovação e estabilidade política.

Palavras-chave: Smart cities; Índice CIMI; Competitividade; Inovação.

Abstract

The management applied to cities has sought to optimize their resources as much as possible and improve their capacity for development, providing a better quality of life for their inhabitants. This study aims to identify the factors that have the greatest impact on city management, considering the indicators used to measure smart cities CIMI (Cities in Motion Index). To this end, exploratory research with a quantitative approach was carried out, a sample of fifty two cities was selected

[1] PhD in Business Administration (UFRGS). Professor at the University of Caxias do Sul. Caxias do Sul – RS, Brazil. E-mail: rbgoncal@ucs.br
[2] PhD in Business Administration (UFRGS). Professor at the University of Caxias do Sul. Caxias do Sul – RS, Brazil. E-mail: fverruck@ucs.br
[3] Bachelor of International Trade (UCS). Caxias do Sul – RS, Brazil. Email: vaniceendres@gmail.com

out of one hundred and sixty-five evaluated in the study. Such a sample was selected according to criteria such as population, ranking in CIMI and availability of open data. After applying exploratory and regression analysis methods, it was found that the main determinants of the level of intelligence in cities are innovation and political stability, which were able to explain 84.59% of the data variation.

Keywords: Smart cities; CIMI Index; Competitiveness; Innovation

Introduction

Cities are possibly the most important social, economic, cultural and defensive structures that humanity has ever produced (HARRISON et al., 2010). The concept of cities is complex and diverse, as there are many definitions that express their literal meaning and their purpose, since they play a key role for social and economic development all around the world (ALBINO; BERARDI; DANGELICO, 2015). Big cities have continuously evolving into contemporary metropolises that concentrate human and social activity, designed to support and develop the physical environment and their citizens (CAVADA; HUNT; ROGERS, 2014). In 2025, it is estimated that about 60% of the world's population, or 4.6 billion people, will live in urban areas (CARAGLIU; BO; NIJKAMP, 2011).

In developed countries, urban population can represent up to 81% of the total population (GLASMEIER; CHRISTOPHERSON, 2015), forcing governments to manage an increasing number of technical, social, physical and organizational issues that arise as a consequence of too many people living in physically limited areas (ALAWADHI et al., 2012). Such growth brings about new challenges that demand for the restructuring and readaptation in different areas, as a way to provide city residents with basic services, especially transportation, communication and education in a sustainable way (GLASMEIER; CHRISTOPHERSON, 2015). As a means to overcome these problems, city managers and scholars of different fields have been working on a way to integrate information technology with urban planning, under a framework called smart cities.

The idea of smart cities has become increasingly present in scientific literature and international policies (UNITED NATIONS, 2014). The term was used for the first time in the 1990s with the intent to express the importance of new technologies aiming at the structural modernization of cities (ALBINO; BERARDI; DANGELICO, 2015). Since there is no single definition of smart cities (BENT et al. 2017), approaches vary according to the culture, priority and history of the cities themselves, including not only infrastructure, but also human and social factors (GALÁN-

GARCÍA; AGUILERA-VENEGAS; RODRÍGUEZ-CIELOS, 2014). While some cities have saturated traffic and need intelligent solutions to control it (ARHAB; JAHAN; OUSSALAH, 2021), others may not have this domain as a critical point and prioritize, for example, aspects of governance and health (GAMA; ÁLVARO ; PEIXOTO, 2012).

Barrionuevo, Berrone and Ricart (2012) proposed a conceptual framework for smart cities that incorporate six key domains, namely: economic; human; social; environmental and institutional. In turn, Berrone and Ricart (2018) after identifying these key domains, used them in the preparation of an annual publication called CIMI (Cities in Motion Index), which consists of a set of indicators used for the analysis and measurement of the development of smart cities. The authors also emphasize the importance of the international presence of these cities given the intensity of competition between international metropolises, large cities that seek to prosper must first reach a prominent place in the world, building an international presence by attracting tourism and foreign investment (BARRIONUEVO; BERRONE; RICART, 2012). Given the above, the objective of this study is to identify the determining factors that significantly impact the level of intelligence in cities.

Theoretical background

Although the use of the term “smart city” has increased over the past years, there is still no clear and consensual understanding of the concept among professionals and academia (CARAGLIU; DEL BO; NIJKAMP, 2011; ALAWADHI et al., 2012). This lack of definition about the term "smart city" is due, in part, to the fact that it is a recent area of study, therefore it is not yet intensely used in the spatial planning literature or in urban studies (LOMBARDI et al., 2012). Caragliu, Del Bo and Nijkamp (2011) claim that a city is smart when investments in human capital, social capital and traditional (transport) and modern (ICT) communication infrastructure, drive sustainable economic growth and a high quality of life, with an intelligent management of natural resources, through the active participation of the government.

Following this line of thought, Holland (2014) states that smart cities are urban arrangements that use digital infrastructures to improve economic and political efficiency and allow social, cultural and urban development. In this sense, the term would designate cities that manage to develop technologically and economically in a sustainable way and at the same time generate quality of life for the inhabitants and efficiency in urban operations. Nevertheless, conceptual variation can occur according to the point of analysis around the objectives, ethics, potential and limitations present in smart cities (GLASMEIER; CHRISTOPHERSON, 2015).

The consequences of these different approaches are that they lead to various measuring instruments, with concurrent methods for determining the level of smartness in a city. Giffinger et al. (2007), for example, propose to establish a standard based on specific factors they call domains. That way, a smart city can be categorized based on different dimensions, with its domains being analyzed according to the development and needs of each city. The base domains that Giffinger et al. (2007) propose are: (i) Economy; (ii) Population; (iii) Governance; (iv) Mobility; (v) Environment; (vi) Quality of Life. On the other hand, Cohen (2014) developed a model called the "Smart Cities Wheel". The wheel is a holistic framework created to consider the main domains and indicators present in smart cities. The framework comprises six dimensions, each with three key subdivisions that present additional specific indicators and actions for each work area.

Berrone and Ricart (2018) published the Cities in Motion Index (CIMI), based on an assessment of 165 cities selected to rank their performance. The authors also argue that smart cities generate business opportunities and possibilities for collaboration between the public and private sectors. For this, an ecosystem network must be developed, which involves members of institutions, government, universities, specialists and research centers, among others (BERRONE; RICART, 2018). Still according to Berrone and Ricart (2018) it is necessary to understand and articulate nine dimensions: Economy, Human Capital, Social Cohesion, Environment, Governance, Urban Planning, International Dissemination, Technology and Mobility and Transport. Smart cities are based on these elements in order to promote the best possible quality of life for their inhabitants. These domains and indicators allow measuring and classifying smart cities, ranking the results according to their performance in each dimension.

Measuring the Intelligence in Smart Cities

A city's competitiveness is driven by its innovation capacity, which drives fundamental transformations (ANTHOPOULOS, 2014), even if public managers present difficulties to innovate themselves (TAYLOR BUCK; WHILE, 2017). With rapid industrialization and modern services, mainly services provided to industry, which are intensive in technology and human capital, smaller cities gradually become metropolises, with a necessary expansion of infrastructure and technologies to position themselves on the global stage. Metaxas (2010) points out that competitiveness has grown in the last two decades, and it is common for cities, regions and nations to assess their performance and promote adjustments to position themselves in relation to other urban centers, including providing internalization advantages to attract foreign companies. (BAKICI; ALMIRALL; WAREHAM, 2012).

The classification of cities, as a consequence, has become a central instrument for assessing the attractiveness of urban regions. One of the first attempts was by Giffinger et al. (2007), who took into account geographic extension, population and economic performance. They used a sample of 70 cities with a population index between 100 and 500 thousand inhabitants, classifying them with 74 evaluative indicators, 48 (65%) based on local or regional data, and 26 (35%) based on national data. The scoring method used by Giffinger et al. (2007) was the z transformation, which allows transforming all indicator values into standardized values with a mean of zero and a standard deviation of one. This method has the advantage of considering heterogeneity within groups and maintaining their metric information.

For Caragliu, Del Bo and Nijkamp (2011) the most representative indicators of a smart city should be: GDP per capita in PPP; Employment in the entertainment industry; Multimodal accessibility; Length of the public transport network; e-government; Human capital. Adopting a different perspective, Cohen (2014) devised another study stipulating evaluative indicators called domains. They applied the methodology in 120 cities worldwide, 30 cities in each of the following regions: Europe, Americas and Asia-Pacific. Cohen (2014) analyzed the responses and scored each city considering the six domains (Environment; Mobility; Governance; Economy; People and Quality of Life), forming a figure called the wheel of smart cities assigned to their respective indicators. Each component domain of the wheel contains three subcomponents, so there are 18 total subcomponents, with 62 indicators. Using the collected data, he also applied the z-score mathematical formula to compare data in different units. Thus, the ability of a city to measure its level and compare itself with other more or less developed ones allows for more assertive strategies aimed at its development. However, many of the indicators that analyze urban development are not standardized, and numerous attempts have been made to develop a standard of indicators to rank cities at national, regional and international levels (BERRONE, RICART; 2018).

Berrone and Ricart (2018) used scoring parameters to classify 165 cities included in their

2018 CIMI analysis. After analysis and application of international methodologies for comparing indicators, the authors reached a consensus score for each CIMI index: (i) economy: 1; (ii) human capital: 0.521; (iii) mobility and transportation: 0.516; (iv) environment: 0.859; (v) social cohesion: 0.571; (vi) international performance: 0.564; (vii) technology: 0.394; (viii) governance: 0,444; (ix) urban planning: 0,538. Following the cities assessment, the authors performed a classification based on the score achieved by each one of them, reaching the following classification: Cities with high performance (A) present an index greater than 90 points; cities ranked as relatively high (RA) showed a performance between 60 and 90; the average (M) cities had a score between 45 and 60; and low (B) presented an index below 45.

Berrone and Ricart's (2018) initiative was to develop a ranking among cities, using a standard of global indicators, with the support of private companies, local governments and educational institutions, with the aim of promoting changes at the local level and also developing innovative ideas and tools that make cities more sustainable and smart. The cities of New York, London and Paris were the top three cities scored in the overall cumulative ranking developed in the CIMI survey by Berrone and Ricart (2018), these cities also performed significantly in isolated domains: New York (Economy, Urban Planning and Mobility and Transport), London (Human Capital), Paris (International Performance). Other top performers in isolated domains were: Helsinki (Social Cohesion), Reykjavik (Environment), Bern (Governance) and Hong Kong (Technology).

Table 1 shows the position of the six best Brazilian cities evaluated by the CIMI Index (a total of 165 cities), in general ranking order, highlighting the best index in each isolated domain.

Table 1 – Position of Brazilian cities in the CIMI ranking

DOMAIN	São Paulo	Rio de Janeiro	Curitiba	Brasília	Salvador	Belo Horizonte
General rank	116	126	135	138	147	151
Economy	155	160	161	163	164	162
Human capital	103	94	139	138	129	132
Social cohesion	145	154	123	144	142	136
Environment	90	102	65	82	86	120
Governance	121	77	132	25	140	142
Urban planning	34	36	116	127	120	134
International performance	28	47	122	91	134	136
Technology	72	88	117	142	152	140
Transport and mobility	88	133	109	61	132	149

Source: adapted from Berrone and Ricart (2018).

The city of São Paulo has the best performance in four domains, denoting the strength of the capital of São Paulo. However, in a deeper analysis, it is noticed the great distance of Brazilian cities for a positioning among the 20 smartest cities.

Method

The initial population defined for investigation in this study consisted of the 165 cities previously analyzed and ranked in the CIMI 2018 study. The selection of the sample of 52 smart cities was carried out by filtering the cities that had the following characteristics: (i) being ranked in the 2018 CIMI edition; (ii) presenting a population size between 1 and 5 million inhabitants; (iii) providing open data for at least 80% of the selected indicators. These criteria were determined in order to guarantee equivalence of the comparison parameters between the analyzed cities, since it is known that factors such as population size and data availability directly impact public transport, health and leisure policies, items used as a reference for measuring the level of intelligence of the cities in the sample.

Cities that did not fit one or more characteristics described were eliminated from the final sample. The set of selected indicators (Table 2) presents thirty individual indicators, pertinent to different dimensions that make up the structure of a city. Within this model, it is possible to observe that one or more indicators share similar purposes, for this reason the indicators were grouped. In the criterion used for the evaluation, the level of intelligence of each city was considered as the dependent variable for the analysis, this data was collected from the publication CIMI 2018.

Table 2 – List of dimensions, indicators and respective sources

Dimensions	Indicators	Source
Government	Corruption control	The World Bank (2018)
	Political stability	The World Bank (2018)
	Government effectiveness	The World Bank (2018)
	Governmental Technological development index	The World Bank (2018)
	Time required to open a business (days)	The World Bank (2018)
	Crime rate	Numbeo (2018)
	Number of foreign consulates	Embassypages.com (2018)
	Number of conferences in the city (2018)	ICCA (2018)
Logistics	Number of air routes available in the city	Open Flights (2018)
	Airports in the city or within a radius of up to 150km	Google Maps (2018)
	Volume of passengers at the airport(s)	Euromonitor International (2018)

Dimensions	Indicators	Source
	Quality of highways and roads in general	Global Economy.com (2018)
	Port access	WPS (2018)
	Port size	WPS (2018)
Human capital	Percentage of population aged 15 and over with high school education	Euromonitor International (2018)
	Percentage of population aged 15 and over with higher education	Euromonitor International (2018)
	Gini Index	Euromonitor International (2018)
	Number of universities ranked in the Global Universities Rankings	USNEWS (2018)
	Persons owning a personal computer	Euromonitor International (2018)
	Percentage of households with internet access	Euromonitor International (2018)
	Volume migration	Euromonitor International (2018)
	Innovation index	Innovation Cities 2018)
	Number of foreigners living in the city	Euromonitor International (2018)
Economy	Inflation Index	Euromonitor International (2018)
	Export Volume	Euromonitor International (2018)
	GDP per capita	Euromonitor International (2018)
	GDP Growth (2017 to 2018)	Euromonitor International (2018)
	Percentage of employed population	Euromonitor International (2018)
	Percentage of economically active population	Euromonitor International (2018)
	Per capita productivity in dollars per year	Euromonitor International (2018)

Source: the authors (2019).

Data were collected from secondary sources, such as official pages of the analyzed cities, online databases and other sources referenced in this study. After collecting the information, a database was created in which all data referring to each indicator were tabulated for each city. Then, a previous analysis of the volume of data obtained was carried out, eliminating those that did not subsidize a minimum amount for analysis.

After this previous classification, data were individually examined through exploratory analysis, and the indicators that in this first analysis showed significance in relation to the dependent variable were submitted to the stepwise multiple regression method. For the stepwise multiple regression method, three iterations were performed, thus seeking to achieve greater reliability. To observe the existence of multicollinearity, each variable was excluded one by one, recalculating the regression, not finding any major change in the index, which would be an important observation in terms of multicollinearity. In addition, the variables did not show high intensity correlations. In this way, we sought to arrive at a more reliable model, identifying which indicators are relevant to the level of intelligence of cities. The results of the exploratory analysis and the application of the stepwise multiple regression method are shown in the results section below.

Results

The process for analyzing data began with the verification of the raw data and its validation. Subsequently, the statistical analyzes described in this section were performed. To carry out the statistical analyses, the Statistical Package for the Social Sciences IBM® SPSS® software, version 22, was used.

Exploratory data analysis

Initially, the model of indicators covered 30 individual indicators relevant to different dimensions that make up the structure of a city (Table 2). Analyzing the data presented in Table 3, it can be observed that the indicators related to GDP growth and port access are less significant in terms of the intelligence level of cities. Although Caragliu, Del Bo and Nijkamp (2011) strongly relate the development of smart cities with the improvement in GDP, while Hollands (2014) points out that the highest GDPs will be precisely in smarter cities. This fact shows an apparent mismatch between literature and the perception of respondents in the empirical study. However, it is clear that a higher GDP allows for better investments in pursuit of economic development, strongly impacting technology and other aspects, but the perception of this is lost because the search for an improvement in GDP is natural.

However, the other indicators have a higher degree of relevance to intelligence level. Thus, it is possible to cite some indicators whose representativeness is more pronounced, among them political stability, per capita GDP and the number of available air routes, containing the best results in relation to the level of intelligence of cities. For clarification purposes, Table 3 shows the analysis of the indicators related to the dimensions previously mentioned.

Table 3 - Indicators used in the study

Indicator	Coefficient	Standard error	t	Significance	Adjusted r^2
Political stability	0.40246	0.05635	7.142	4.00e-09 ***	0.5
Port access	4.432	4.317	1.027	0.31	0.00108
Port size	5.779	1.461	3.955	0.000246 ***	0.2265
Quality of highways and roads	7.033	1.431	4.914	1.04e-05	0.3164
Number of air routes available in the city	0.08716	0.01480	5.891	3.44e-07	0.4027

Indicator	Coefficient	Standard error	t	Significance	Adjusted r^2
GDP per capita	0.60483	0.08731	6.928	8.59e-09	0.4845
GDP Growth (2017 to 2018)	-0.2679	0.9922	-0.27	0.788	-0.01889
Number of conferences in the city (2018)	0.20643	0.03715	5.556	1.33e-06	0.3886
Government effectiveness	0.53093	0.04787	11.092	5.78e-15 ***	0.7093
Governmental Technological development index	100.220	9.548	10.497	3.93e-14 ***	0.6859
Corruption control	0.43004	0.04393	9.789	4.07e-13 ***	0.6547
Airports in the city or within a radius of up to 150km	4.025	1.447	2.782	0.00766 **	0.1187
Number of universities ranked in the Global Universities Rankings	5.227	1.085	4.819	1.44e-05 ***	0.3077
Inflation Index	-0.6922	0.3779	-1.832	0.0731	0.04499
Gini Index	-71.60	26.55	-2.697	0.0106 *	0.145
Number of foreigners living in the city	0.014322	0.00669	2.138*	0.0398	0.09257
Volume migration	0.08099	0.13538	0.598	0.552	-0.01301
Time required to open a business (days)	-0.5802	0.1713	-3.388	0.0014 **	0.1732
Percentage of population aged 15 and over with high school education	0.4821	0.1945	2.478	0.01803 *	0.122
Innovation Index	1.660	0.140	11.855	5.29e-16 ***	0.7362
Volume of passengers at the city airport(s)	5.001e-04	8.639e-05	5.789	4.94e-07 ***	0.394
Per capita productivity in dollars per year	1.754e-04	2.130e-05	8.236	8.35e-11 ***	0.572
Percentage of economically active population	1.4946	0.3302	4.526	3.85e-05 ***	0.2804
Percentage of population aged 15 and over with higher education	0.5739	0.1746	3.287	0.002 **	0.1789
Percentage of households with internet access	0.57570	0.08233	6.993	6.8e-09 ***	0.4893
Persons owning a personal computer	0.51349	0.07186	7.146	3.95e-09 ***	0.5003
Percentage of employed population	0.8713	0.1381	6.308	7.84e-08 ***	0.4368

Source: the authors (2019).

Thus, after the exploratory analysis, a total of twenty-four indicators showed in their performance accentuated significance in relation to the level of intelligence of the cities.

Stepwise multiple regression analysis

Considering the need for a better measurement of the relationship between the data and the dependent variable, the multiple stepwise regression method was applied for the indicators that showed greater significance in terms of the intelligence level of the cities in the exploratory analysis. This method restricts the set of indicators to subgroups, leaving only those that demonstrate a higher level of relevance to the level of intelligence and discarding those that do not offer the same representativeness, thus intending to obtain a greater degree of assertiveness in the classification of indicators.

During the application of this method, three iterations were carried out between the set of indicators remaining in the exploratory analysis and the level of intelligence of each city. The results of the stepwise multiple regression analysis in the first and third iterations are presented in this section, since data from the second iteration did not contribute to the final understanding of the results. Table 4 presents the results obtained after the first iteration for the indicators with statistical significance.

Table 4 - First iteration results

INDICADORES	Estimate	Standard error	F stat	Significance
Political stability	1.341e-01	5.447e-02	2.461	0.0264 *
GDP per capita	-1.722e-01	6.826e-02	-2.522	0.0235 *
Innovation index	1.061e+00	4.511e-01	2.352	0.0327 *
Governmental Technological development index	5.098e+01	2.362e+01	2.159	0.0475 *

Source: the authors (2019)

When analyzing the data contained in Table 4, it is possible to verify the indicators that represent the Government's Innovation Index and Technological Development Index stand out from the others. In the third iteration, the indicators were reduced to a group of only two variables that together centralize the highest percentage of relevance to the degree of intelligence of the cities. Thus, the final model was established, consisting of two indicators that together comprise 84.59% of explanation (adjusted r^2) for the level of intelligence of cities. The indicators that demonstrate this performance are shown in Table 5.

Table 5 - final results of stepwise regression

Indicators	Estimate	Standard error	F stat	Significance
Intercept	-11.77883	4.44087	-2.652	0.0108*
Political stability	0.21548	0.03597	5.991	2.59e-07***
Innovation	1.29605	0.12302	10.535	4.47e-14***

ADDITIONAL INFORMATION	
Residual standard error	5.136 with 48 degrees of freedom
Multiple R-square	0.8521
Adjusted R-square	0.8459
F statistic	138.2
Significance	< 2.2e-16

Source: the authors (2019)

Discussion

The concept of Smart Cities has emerged in academic literature as a description of the ways in which a city integrates information technologies with the management of public services in order to generate more automatized processes and, consequently, increase citizens' wellbeing (LOMBARDI et al., 2012). As a consequence of this view, the most cited definitions of the concept (i.e. ZANELLA et al., 2014, JIN et al., 2014, NEIROTTI, 2014, BOTTA, 2016) reportedly focus on the technical and operational features, in detriment of a more systemic and managerial approach. This may be a problem, as it leads city managers to focus on the acquisition and implementation of new technologies instead of looking at the benefits they are intended to provide (GREENFIELD, 2013). The CIMI itself reinforces these eminently technological approach, leading managers to believe that the level of intelligence is acquired from mainly material factors such as the presence of ports or international airports.

As a consequence, the adoption of some technological paradigms in the context of a Smart City is often hampered by the absence of a business model and a consistent and widely accepted long-term view capable of leveraging the necessary investments to deploy these technologies in cities (LAYA et al., 2013, ZANELLA et al., 2014). What makes cities smart is not only their capacity to automate routine functions through technology; but, instead, it is the way these automated processes generate data that enable monitoring, understanding, analyzing and planning the city with the intent to improve the efficiency, equity and quality of life for its citizens in real time (BATTY et al., 2012). It also leads to the conclusion that the number of so-called ''smart'' initiatives launched by a municipality is not, by itself, an indicator of city improvement. This implies that it is not always the case that cities better equipped with ICT systems are better or more efficient (NEIROTTI, 2014).

Therefore, the difficulty in establishing a link between effort and performance in these kinds of projects tends to lead the discussion to a political arena where subjective issues may prevail. As a consequence, the adoption of some technological paradigms in the context of a Smart City is oftentimes hampered by the absence of a clear and widely accepted business model capable of leveraging the investments necessary to deploy these technologies (LAYA et al., 2013, ZANELLA et al., 2014). This calls, therefore, for the inclusion of governance arrangements as the aggregating factor that, in fact, transforms a Smart City from a set of isolated solutions into what it is supposed to be, namely a system of systems (GARDNER, 2016; PRAHARAJ; HAN; HAWKEN, 2018; RUHLANDT, 2019).

This article shows that, in order to be smart, cities need to provide an adequate environment to support smart decisions. That means implementing solutions which adapt to citizens' needs and, above all, which are coherent with the city's available resources. It also demonstrates that taking into account the two variables that showed to have the highest influence over the level of smartness in a city (political stability and innovation) is a way to optimize decision-making efforts and, at the same time, avoiding the common pitfalls that often arise with trending concepts. Under this governance principle, the intelligence level of a city must describe its ability to bring together all the available resources to effectively and integrally solve its own specific problems, not just an indicator that counts technological devices and physical resources.

Consequently, it is not a surprise that innovation appeared as a significant factor to determine a city's level of intelligence. This is in line with existing research, which defends that the transformation to smarter cities will require innovation in planning, management, and operations (LOMBARDI et al., 2011; WINKOWSKA et al, 2019). Berrone and Ricart (2018) also regard innovation as the most comprehensive indicator to measure the city development.

Analyzing the method used to formulate this indicator, it was observed that three factors are designed to map the development of each city in the innovation process, they are: (i) interconnection, which is configured as a measure of the city's connections with global markets, taking into account geography, economics (such as exports and imports), technology, market size, geopolitical factors, and diplomacy; (ii) human infrastructure, which encompasses transport infrastructure, finance, universities, hospitals, railways, roads, laws, commerce, startups, healthcare and telecommunications; and (iii) cultural assets, which represents the culture of a city, measured by artistic communities, civic organizations, museums, music events, galleries, political protests, local literature, media, information availability and sports (INNOVATION CITIES, 2018).

In addition to innovation, it is noticeable the impact that political stability demonstrates to have in a city's level of smartness. This makes sense when one regards the transformation of a smart city as the result of an incremental process where small changes will continuously sum up to finally result in a robust and consistent result. Such transformation is only possible if there is a persistent long term view and planning, which can be provided if the political system is stable, with no turmoil or big changes across the way.

Conclusion

The study area explored in this research provided a perception about a relatively new concept, which involves the process of improvement and innovation of a city. The process of turning into a smart city improves decision making quality by its managers, enhances citizens' wellbeing and allows for a more efficient and sustainable use of resources. As a consequence of such improvements, smart cities attract more qualified human capital and, therefore, enter a virtuous cycle of economic development.

As a result of the research applied in this article, political stability and innovation demonstrated to have a central role for the development of smart cities, explaining 84.59% of the variation in the level of intelligence among cities in the sample. It is noteworthy to emphasize that the factors with the highest influence are not related to technical factors, but to structural and cultural factors of the city.

Looking forward in the political dimension, possibly the main obstacle is the attribution of decision-making power to different actors. An alternative to remove this obstacle would be to institutionalize the entire decision-making and execution process, concentrating the strategic planning and management of smart city aspects in a single dedicated department in the city (VILAJOSANA et al., 2013). While traditional city management is about urban planning, smart city management implies coordination between various stakeholders that interact in different characteristic subsystems – transport, health, education, environment, etc. (WEISI; PING, 2014). Thus, the stability of the political institutions that manage the urban environment have a great influence over the quality of life and, consequently, on the level of intelligence in the city.

In the case of innovation, it is stressed that the ability of cities to develop solutions to their own problems also has a fundamental influence on the results obtained. Therefore, instead of looking for ready-made solutions, smart cities are characterized by their capacity of analyzing local problems and finding innovative answers to them. This engine leverages growth and encourages an improvement in the quality of life of the population. The need to balance social development and economic growth in a context of high urbanization is the main driver of the worldwide interest in smart cities. Improving the use of energy, health, transport, education and services implies designing a strategy that integrates all these sectors into a global and well-articulated systemic vision.

As a limitation, it is important to mention that the present study was restricted to evaluating the interdependence between indicators collected from more than one secondary data source, which makes it difficult to standardize the collected data, and there may be variation in the result between one variable and another, even if both are evaluated through the same method. It was also noted that the amount of data available at the municipal level is relatively smaller, compared to the volume available at the national and state levels. The maturity of cities regarding issues related to intelligence, as it is a relatively new topic, is still inconsistent in some points, so some cities still have a minimum flow of open information, which generates a certain limitation in the amount of data and selected indicators.

Managerial implications

This survey can be used as support for future research that may be carried out with greater specificity in the context of city businesses. Still, it is believed that for this study to be successfully carried out, cities need to collaborate by providing easy access to the information necessary for the creation of an evaluation model that provides managers with the necessary tools to leverage cities in their intelligence process.

Considering that innovation and political stability are the fundamental premises for the development of cities in their path to become smarter, it is essential to mention how innovation can be fostered at the municipal level. Therefore, it is possible to list some measures for its realization, such as: (i) investment in education, specifically in teaching institutions that have research centers, thus boosting the expansion of projects related to innovation in cities; (ii) creation of governmental programs that instigate the attraction of talents, as is already done in several cities around the world; (iii) reduction of barriers, for relations that are not only commercial, since the expansion of connections with culture and foreign markets can provide an increase in interrelationships in cities; (iv) investment in programs and tools related to ICT, to be used as an auxiliary source in the city's development process, providing modernization of various structures that make up the city.

This holistic implementation of the Smart Cities concept does not need to be done all at once, given the breadth such a project would entail. In addition, cities often have initiatives that, even if conducted in isolation, are already subject to a certain level of governance, otherwise they would be impossible to manage. The proposal adopted here, therefore, states that the process of becoming a smart city follows an incremental path that requires greater levels of integration as it progresses.

References

ALAWADHI, S. et al. Building understanding of smart city initiatives. In: **Electronic Government: 11th IFIP WG 8.5 International Conference, EGOV 2012, Kristiansand, Norway, September 3-6, 2012. Proceedings 11**. Springer Berlin Heidelberg, 2012. p. 40-53. Available at: https://link.springer.com/chapter/10.1007/978-3-642-33489-4_4 Accessed in: 19 de ago. 2018.

ALBINO, V.; BERARDI, U.; DANGELICO, R. M. Smart Cities: Definitions, Dimensions, Performance, and Initiatives. **Journal of Urban Technology**, [*S. l.*], v. 22, n. 1, p. 3-21, 2015. http://dx.doi.org/10.1080/10630732.2014.942092

ANGELIDOU, M. **Smart cities**: A conjuncture of four forces. *Cities,* [*S. l.*], v. 47, p. 95-106, 2015.http://dx.doi.org/10.1016/j.cities.2015.05.004

ARHAB, N.; JAHAN, M. S.; OUSSALAH, M. Car Parking User's Behavior Using News Articles Mining Based Approach. **Transportation Research Procedia**, v. 55, p. 26-33, 2021.http://dx.doi.org/10.1186/s40537-022-00627-x

BAKICI, T.; ALMIRALL, E.; WAREHAM, J. A Smart City Initiative: The Case of Barcelona. **Journal of the Knowledge Economy**, [*S. l.*], v. 4, n. 2, p. 135-148, 2012.https://doi.org/10.1007/s13132-012-0084-9

BARRIONUEVO, J. M.; BERRONE, P.; RICART, J. E. Smart Cities, Sustainable Progress: Opportunities for Urban Development. **IESE Insight**, n. 14, p. 50-57, 2012. Available at: https://www.researchgate.net/profile/Pascual-Berrone/publication/276088190_Smart_Cities_Sustainable_Progress_Opportunities_for_Urban_Development/links/563f9a3908ae8d65c0150f53/Smart-Cities-Sustainable-Progress-Opportunities-for-Urban-Development.pdf Accessed in: 10 de Jun. 2018.

BATTY, M. et al. Smart cities of the future. **The European Physical Journal Special Topics**, v. 214, p. 481-518, 2012

BENT, E.; CROWLEY M.; NUTTER, M.; WHEELER, C. Getting Smart About Smart Cities. **Urban Sustainability Directors Network,** San Francisco, CA, p.1-38, jan. 2017. Available at: https://us.sustain.org/wp-content/uploads/2017/01/Smart-Cities-RG.pdf Accessed in: 27 abr. 2018.

BERRONE, P.; RICART, J. E. IESE Cities in Motion Index. **IESE Cities in Motion Strategies,** Barcelona, v. 3, n. 1, p. 1-78, 2018. Available at: https://media.iese.edu/research/pdfs/ST-0509-E.pdf Accessed in: 27 abr. 2018.

BOTTA, A. et al. Integration of cloud computing and internet of things: a survey. **Future generation computer systems**, v. 56, p. 684-700, 2016.

CARAGLIU, A.; DEL BO, C.; NIJKAMP, P. Smart Cities in Europe. **Journal of Urban Technology,** [*S. l.*], v. 18, n. 2, p. 65-82, 2011.

CAVADA, M.; HUNT, D. V. l.; ROGERS, C. D. F. Smart Cities: Contradicting Definitions and Unclear Measures. **World Sustainability Forum 2014 – Conference Proceedings Paper***,* Birmingham, UK, v. 1, n. 1, p. 1-12, 2014.

COHEN, B. **Methodology for 2014 Smart Cities Benchmarking**. Fast Company, New York, v. 1, n. 1, p. 1-1, nov. 2014. Available at: https://www.fastcompany.com/3038818/the-smartest-cities-in-the-world-2015-methodology. Accessed in: 27 abr. 2018.

EMBASSYPAGES.COM. **Embassies & Consulates Around the World.** 2018. Available at: https://www.embassypages.com/ Accessed in: 30 abr. 2018.

EUROMONITOR INTERNATIONAL. **Cities.** 2018. Available at: https://www.euromonitor.com/cities . Accessed in: 30 abr. 2018.

GALÁN-GARCÍA, J. L.; AGUILERA-VENEGAS, G.; RODRÍGUEZ-CIELOS, P. An accelerated-time simulation for traffic flow in a smart city. **Journal of computational and Applied Mathematics,** [*S. l.*], v. 270, p. 557-563, nov. 2014.

GAMA, K.; ALVARO, A.; PEIXOTO, E. Em Direção a um Modelo de Maturidade Tecnológica para Cidades Inteligentes. **Viii Simpósio Brasileiro de Sistemas de Informação (sbsi 2012) Trilhas Técnicas,** Recife, v. 1, n. 1, p.150-155, jan. 2012.

GIL, A. C. **Métodos e Técnicas de Pesquisa Social.** 7. ed. São Paulo: Atlas, 2019.

GIFFINGER, R. et al. Smart Cities. Ranking of European medium-sized cities. Centre for Regional Science, Vienna University of Technology. **Cited on**, p. 4, 2007.

GLASMEIER, A.; CHRISTOPHERSON, S. Thinking about smart cities. **Cambridge Journal of Regions, Economy and Society**, [*S. l.*], v. 8, n. 1, p. 3-12, 2015. Available at: https://olc.worldbank.org/system/files/Smart%20Cities%20CJRES%20021415.pdf Accessed in: 15 mai. 2018.

GOOGLE MAPS. **Google Maps.** 2018. Available at: http://www.google.com.br/maps Accessed in: 30 abr. 2018.

GREENFIELD, Adam. **Against the Smart City: A Pamphlet. This is Part I of" The City is Here to Use"**. Do projects, 2013.

HAIR JR., J. F.; BLACK, W. C.; BABIN, B. J.; ANDERSON, R. E. **Multivariate data analysis.** 7. ed. Prentice Hall: London, 2009.

HARRISON, C. *et al.* Foundations for Smarter Cities. **IBM Journal of Research and Development,** [*S. l.*], v. 54, n. 4, p.1-16, jul. 2010. http://dx.doi.org/10.1147/JRD.2010.2048257

HOLLANDS, R. G. Critical interventions into the corporate smart city. **CambridgeJournal of Regions, Economy and Society***,* [*S. l.*], v. 8, n. 1, p.61-77, 2014.

ICCA. **International Congress and Convention Association.** 2018. Available at: <https://www.iccaworld.org/>Accessed in: 30 abr. 2018.

INNOVATION CITIES. **Innovation Cities™ Index 2018:** Global. 2018. Available at: https://www.innovation-cities.com/innovation-cities-index-2018-global/13935/ Accessed in: 30 ago. 2018.

JIN, J. et al. An information framework for creating a smart city through internet of things. **IEEE Internet of Things journal**, v. 1, n. 2, p. 112-121, 2014.

LAYA, A.; BRATU, V.; MARKENDAHL, J. Who is investing in machine-to-machine communications?.*Proc. 24th Eur. Reg. ITS Conf.*, pp. 20, Oct. 2013.http://hdl.handle.net/10419/88475

LETAIFA, S. B. How to strategize smart cities: Revealing the SMART model. **Journal of Business Research**, [*S. l.*], v. 68, n. 7, p. 1414-1419, 2015.

LOMBARDI, P. *et al.* Modelling the smart city performance. **Innovation: The European Journal of Social Science Research**, [*S. l.*], v. 25, n. 2, p. 137-149, 2012.

MALHOTRA, N. K. **Pesquisa de marketing**: uma orientação aplicada. 7. ed. Porto Alegre: Bookman, 2019.

METAXAS, T. Cities competition, place marketing and economic development in South Europe: The Barcelona case as FDI destination. **Theoretical and empirical researches in urban management**, v. 5, n. 5 (14, p. 5-19, 2010.

NUMBEO. **Cost of Living.** 2018. Available at: https://www.numbeo.com/cost-of-living/. Accessed in: 09 out. 2019.

OPEN FLIGHTS. **Openflights.org.** 2018. Available at:<https://openflights.org/>. Accessed in: 11 out. 2019.

PRAHARAJ, S.; HAN, J. H.; HAWKEN, S. Urban innovation through policy integration: Critical perspectives from 100 smart cities mission in India. **City, culture and society**, v. 12, p. 35-43, 2018. https://doi.org/10.1016/j.ccs.2017.06.004

TAYLOR BUCK, N.; WHILE, A. **Competitive urbanism and the limits to smart city innovation**: The UK Future Cities initiative. Urban studies, v. 54, n. 2, p. 501-519, 2017.

THE GLOBAL ECONOMY. **Roads quality - Country rankings.** 2018. Available at: <https://theglobaleconomy.com/rankings/roads_quality> Accessed in: 15 out. 2019.

THE WORLD BANK. **World Bank Open Data:** Free and open access to global development data. 2018. Available at: https://data.worldbank.org/ . Accessed in: 17 out. 2019.

UNITED NATIONS. **Our urbanizing world**. Populations facts. UN Department of Economic and Social Affairs, New York, New York. 2014. Available at: <http://www.un.org/en/development/desa/population/publications/pdf/popfacts/PopFacts_2014-3.pdf> . Accessed in: 09 out. 2019.

USNEWS. **Best Global Universities.** 2018. Available at: https://<www.usnews.com/education/best-global-universities>. Accessed in: 13 out. 2019.

VILAJOSANA, I. et al. Bootstrapping smart cities through a self-sustainable model based on big data flows. **IEEE Communications magazine**, v. 51, n. 6, p. 128-134, 2013.

WEISI, F. U.; PING, P. E. N. G. A discussion on smart city management based on meta-synthesis method. **Management Science and Engineering**, v. 8, n. 1, p. 68-72, 2014.

WINKOWSKA, J.; SZPILKO, D.; PEJIĆ, S.. Smart city concept in the light of the literature review. **Engineering Management in Production and Services**, v. 11, n. 2, 2019.

WPS – SOURCE WORLD PORT. **Navigable Rivers & Inland Waterway Systems.** 2018. Available at: <http://www.worldportsource.com/>. Accessed in: 25 set. 2019.