Paakat
Revista de tecnología y sociedad

Proposal for a smart city index for municipalities in Argentina

Propuesta de un índice de ciudad inteligente para municipios de Argentina

http://dx.doi.org/10.32870/Pk.a11n21.629

María Verónica Alderete*
https://orcid.org/0000-0002-9617-7526
Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina

Received: March 26, 2021
Accepted: August 16, 2021

ABSTRACT

The development of smart cities has yielded into a desirable objective among many cities around the world. International indexes of smart cities focus on large urban cities without interest on intermediate cities of developing countries. This paper pretends to fill this gap by proposing a smart city index for the capital cities in Argentina, together with Buenos Aires City and Bahia Blanca. The index is compound of four dimensions: Environment, Governance, Society and ICT, and Mobility and Transport which are based on a set of indicators. Data emerges from official websites and national statistics. In the case of Bahia Blanca, a wider smart city index with subjective indicators from an online survey is built. Alternative versions of the index, weighted (according to the vision of citizens, enterprises and politicians) and non-weighted are provided. Results show that the cities of Bahia Blanca, Ciudad Autonoma de Buenos Aires and Cordoba are the third smartest cities in Argentina.

Keywords
Smart cities;
municipalities;
Argentina

RESUMEN

El desarrollo de ciudades inteligentes se ha convertido en un objetivo deseable en muchas ciudades del mundo. Los índices internacionales se focalizan en las grandes urbes sin atención a las ciudades intermedias de países en desarrollo. Este trabajo tiene como objetivo cubrir este espacio mediante la propuesta de un índice de ciudad inteligentes para capitales de provincia de Argentina, junto a Ciudad de Buenos Aires y Bahía Blanca. A partir de un conjunto de indicadores, se incluyen cuatro dimensiones en el índice: ambiente, gobernanza, sociedad y TIC, y movilidad y transporte. Los datos surgen de la exploración de sitios web oficiales y estadísticas nacionales. En el caso de Bahía Blanca, se construye un índice más amplio con indicadores subjetivos provenientes de una encuesta en línea. Se ofrecen diferentes versiones del índice, sin ponderadores y ponderado, según la visión de las empresas, los políticos y los ciudadanos de la localidad. Los resultados muestran que Bahía Blanca, Ciudad Autónoma de Buenos Aires y Córdoba son los tres municipios más inteligentes del país.

Palabras clave
*Ciudades inteligentes;
municipios; Argentina*

* PhD in Economics from the Universidad Nacional del Sur, Bahía Blanca, Argentina. She holds the position of associate researcher of the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), at the Instituto de Investigaciones Económicas y Sociales del Sur. Its main research areas are the information and knowledge society (electronic commerce, electronic government, ICT), technological change and socioeconomic development. E-mail: mvalderete@iiess-conicet.gob.ar

Introduction

The world's urban population is expected to grow by approximately 60% between 2015 and 2050 (United Nations Organization, 2018). If this growth is taken into account, it is to be expected that solutions will be sought to ameliorate or explore solutions to address the problems of contemporary citizenship. In this regard, new information and communication technologies (ICT) are an instrument to advance towards smart cities that provide the best solutions in issues related to sustainable energy and sustainable use of spaces, citizen participation and collaboration, digitization of public administration processes, among others. In addition, cities need indicators to set their goals and track and monitor their performance progress (International Organization for Standardization, 2018).

Over the past decades, many governments around the world have strived to improve the efficiency of public services through ICT (El-Haddadeh *et al*., 2019; Kamal, Weerakkody & Irani, 2011). Governments especially in advanced ICT countries such as Estonia, Republic of Korea and Singapore have achieved better utilization of ICT. At the same time, there has been a growing interest in achieving sustainable urban development within the framework of building smart cities. In this sense, an environmentally smart city is one where citizens develop sustainable and scalable practices, such as garbage recycling, efficient energy use, among others (Angelidou, 2017; Belanche, Casaló & Orús, 2016).

In cities such as London and Stockholm, improvements in urban air quality have been achieved through the modernization of traffic control systems and the prohibition of entry of the most polluting cars. In Singapore, traffic data is available in real time, thanks to the information sent by its 20,000 cabs. In turn, technological development centers to implement these technologies are being set up in cities such as Helsinki, Dublin, Amsterdam, New York, Yokohama (Japan), Shenyang (China), Sisak (Serbia) and Lavasa (India). In Latin America, the city of Curitiba in Brazil is an example of a “smart city”.

However, the experiences of smart city projects in non-global cities have not been studied. This has generated a gap in the literature and underestimated the initiatives developed in cities in developing countries such as Argentina. Gaps in access and use of ICTs would explain the low participation of citizens in smart activities (Novo-Vázquez & Vicente, 2019).

In Argentina, data reflect the existence of ICT access gaps. 75.8% of individuals use the Internet, but only 17.8% have a fixed broadband subscription. In contrast, mobile band subscription is more widespread, with 80% (International Telecommunication Union, 2018). In this sense, municipalities play a role in mitigating this digital divide by providing access opportunities to the entire population, for example through free Wi-Fi policies in public places.

Then, policies that tend to universalize access to ICTs will have their consequent impact on the construction of smart cities (Lupiañez-Villanueva and Faulí, 2017; Mora, Bolici and Deakin, 2017), such as the digital hotspots in Argentina. Intranational smart city indexes would capture the level of ICT diffusion and "smart" citizen actions, such as e-commerce, e-government that will be specific to each city (Alderete, 2019).

The objective of this paper is to propose a smart city index for the provincial capital municipalities of Argentina, together with the Autonomous City of Buenos Aires (CABA, by its acronym in Spanish) and Bahía Blanca. Although the sample of cities analyzed does not represent the total population of cities in Argentina, it constitutes a homogeneous group in terms of their institutional relevance because they are provincial capitals.

Likewise, they are mostly intermediate cities, that is, centers of economic exchange for the development of certain rural and smaller urban areas, of social and cultural interaction (Manzano & Velázquez, 2015), which present conditions conducive to local development initiatives (Prieto, Schroeder & Formiga, 2011) and are less visible cities than large urban agglomerations (Bellet & Llop, 2004).

The sample analyzed allows comparison with other indexes on related topics such as the Municipal Transparency Index of Argentina (ITMA, by its acronym in Spanish). In turn, the city of Bahía Blanca is included because it is one of the most transparent and open cities in Argentina. According to the Open Data Index (ODI) of the Open Knowledge Foundation, Bahía Blanca leads the group of cities in Argentina in 2021,[1] and has occupied in recent years the top positions along with CABA.

To this end, the different aspects or dimensions that characterize a smart city are analyzed based on objective indicators. In the case of Bahía Blanca, subjective indicators from an online survey are also included. Based on these indicators, the municipalities of Argentina are described and compared according to the importance attributed by the municipal governments and their citizens to the issues inherent to a smart city.

The paper is structured as follows. First, the theoretical framework that explains the smart city concept is defined and an empirical review on the measurement of smart cities is carried out. Second, the state of the art is described in relation to the best known smart city indexes in the world and the region for subsequent comparison with the proposed index. Third, the methodology and data source for the construction of the smart city index is explained. Fourth, the results obtained are shared, both the score in the different versions of the index, as well as its relationship with the geographical area analyzed. Then, the proposed index is discussed and compared with other indexes on the subject. Finally, the conclusions of the work are established.

Theoretical framework

In recent years there has been extensive research on the importance of generating intelligent cities or Smart Cities. Although the concept is new and there are multiple definitions, two different visions can be distinguished. On the one hand, a technological perspective that focuses on the role of ICTs as a means to deepen and strengthen access to public information and make services in a city more efficient (Caragliu & Del Bo, 2019; Belissent & Girón, 2013; Nam & Pardo, 2011). On the other hand, that which adopts a broader perspective by introducing notions linked to sustainable economic growth, quality of life, participatory governance, and emissions reduction (Anthopoulos, Janssen & Weerakkody, 2019; Silva, Khan & Han, 2018; Albino, Berardi & Dangelico, 2015).

Smart city projects face the challenge of accommodating short-term political interests in the context of a community with long-term interests (Angelidou, 2017).

In this line, Jolías and Prince (2016) indicate that a city with intelligence is not the same as a smart city, which refers to a much more holistic and integrative approach, where technology is a necessary, but not sufficient factor to solve problems, improve efficiency and develop the quality of life of citizens. There is a certain consensus among some academics to understand that Smart Cities are a holistic and integral construction that requires the active participation of several actors.

Simultaneously assessing aspects of quality of life, both objective and subjective, allows comparisons between different cities (Kaminitz, 2020; Faria *et al*., 2018). In this way, different cultural and social contexts and subjective well-being, which may or may not be moving in the same direction, are taken into account. For example, good objective living conditions with low levels of subjective satisfaction, or vice versa.

Suman (2017) starts from the idea of analyzing data arising from environmental monitoring (transportation, etc.) of a city (open data portal) to be analyzed in combination with data coming from the citizen perception survey. In this way, the link between active transparency/Smart City data and citizens' perceptions, conditions and activities is investigated. Analyzing this link or whether it exists is useful to better target the city's Smart City policies.

In recent years, publications emerged where citizens' perceptions of urban innovations are central to Smart City evaluations (Macke *et al*., 2018; Marsal-Llacuna *et al*., 2015). Macke *et al*. (2018) start from a broad smart city vision based on the perception of the quality of life of the inhabitants of Curitiba, Brazil. Among the quality of life indicators, the authors include measures of an objective and also subjective nature.

By introducing subjective indicators, the paper considers the weight of citizen evaluations, which distances the city from the conception of the literature and the awards

obtained that define it as one of the smartest cities in the world. The authors find that, despite Curitiba being recognized as one of the smartest cities in the world, the locality presents unsatisfactory citizen evaluations regarding the characteristics that define it as smart. In relation to a city's performance indicators, the simultaneous evaluation of objective and subjective dimensions allows comparing cities with different sociocultural contexts (Macke *et al*., 2018).

Marsal-Llacuna *et al*. (2015) propose the construction of quality of life indicators in Europe based on Eurostat data with both objective and subjective information from citizen perception surveys of 321 cities. While quality of life is not synonymous with smart city, it is closely linked to its definition in a broad sense. Quality of life is a key element for smart city development (Addanki & Venkataraman, 2017; Joshi, Saxena & Godbole, 2016; Nam & Pardo, 2011).

Lytras, Visvizi & Sarirete (2019) argue that connections between smart city concept research and challenges in cities are necessary. The authors consider it indispensable for the parties involved in the creation of smart cities to take into account both the needs (activities) of citizens and their perceptions and expectations. It is also studied whether citizens' perspectives and expectations are in line with the conception and response given by suppliers, politicians and entrepreneurs (service providers). Among the conclusions, it is found that citizens show different perceptions of the different types of services.

Several studies show that the inhabitants of smart cities are committed to the development of sustainable and scalable practices such as waste recycling, efficient use of energy resources, among others (Chourabi *et al*., 2012; Khansari, Mostashari & Mansouri, 2014; De Jong *et al*., 2015; Belanche, Casaló & Orús, 2016). In this regard, there are no works to date in Argentina that explore the level of citizen involvement in smart practices.

Alderete and Díaz (2020) analyze e-government in the city of Bahía Blanca, Argentina, and find that a quarter of respondents do not participate in e-government; 38.5% participate in e-government at the informational level; 24% at the interactive level and 12.5% at the transactional level. On the other hand, Alderete (2020) determines that higher levels of ICT use, as well as knowledge of the concept and the topic of smart cities, allow a greater number of smart practices to be achieved.

State of the art: smart city indexes

Currently, emerging and intermediate cities and municipalities aim to apply the smart city model to be better prepared for their population growth and the contemporary challenges they bring (Bouskela *et al*., 2016). All smart cities face similar challenges, such as improving the quality of life of citizens, developing knowledge-based societies and reducing the digital

divide (Alderete, 2019; Silva, Khan & Han, 2018; Kitchin, 2014). One way to detect or identify smart cities is through Smart City indices.

The Smart City Index analyzes 109 cities around the world by assessing efforts and achievements to adopt technologies that improve the quality of life of citizens. It is prepared by the Smart Cities Observatory of the Global Competitiveness Center of the Institute for Management Development (IMD), together with the Singapore University of Technology and Design.

This indicator is constructed according to residents' perceptions based on two pillars of analysis: structure (infrastructure available to the locality) and technologies (technological provisions and services available to residents) (IMD Global Competitiveness Centre Smart Cities Observatory and Singapore University of Technology and Design, 2019).

Each of these pillars is composed of five key areas: health and safety, mobility, activities, opportunities for work and school, and governance. Only seven of the 109 cities that make up the Smart City Index are Latin American locations. In the case of Argentina, only Buenos Aires is included.

The IESE Cities in Motion Index (ICIM) is published annually by IESE Business School, the Business School of the University of Navarra. The 2020 index was calculated for 174 cities in 80 countries, of which 79 are capital cities (45%). In turn, 101 indicators were analyzed along nine dimensions: human capital, social cohesion, economy, governance, environment, mobility and transportation, urban planning, international projection and technology. The index incorporates both objective and subjective data for a better understanding of each city. Subjective indices include the Global Happiness Index, the Corruption Perception Index and the Democracy Index.

Smart city indexes, such as the SCI and the ICIM, place cities in developed countries in the top ranking (Alderete, 2019). However, there is scarce evidence of smart city indexes for non-global cities such as Bahía Blanca or any intermediate municipality in developing countries. Regarding the governance issue, which constitutes one of the smart city dimensions, in Argentina there are the Open Data Index of the Open Knowledge Foundation and the Municipal Transparency Index of Argentina, ITMA (Ciucci *et al*., 2019). In it, Bahía Blanca ranks among the top positions. In turn, there is not much empirical evidence of smart city perception indices in Latin America, and no evidence has been found in Argentina.

While there are several smart city indexes (mostly focused on capital or global cities), there are not many intra-national indices comparing cities within a country (Martinez, 2020). In the Latin American region, there is as a precedent the Smart Cities Ranking of Chile, carried out in 2014, without continuity of publication. The index was compiled with information collected from 28 objective indicators, around six different axes

(environment, mobility, government, economy, society and quality of life) for cities with more than 200,000 inhabitants.

There are Connected Smart Cities, of the Urban System consulting firm in Brazil. It is a platform that involves companies, entities and governments with the aim of studying the nature of innovation and improvements for smarter and more connected cities. The index is composed of eleven different dimensions based on data from 70 objective indicators. In this regard, it should be noted that the cities with the best performance according to the ranking are also those with the best positioning in the technology and innovation dimension, but not in the environment.

In Argentina, there is the well-known Quality of Life Index, published by Guillermo Velázquez (Institute of Geography, History and Social Sciences) in collaboration with Alejandro Zunino (Instituto Superior de Ingeniería de Software Tandil), both from the National Council of Scientific and Technical Research (CONICET, by its acronym in Spanish)) and the Universidad del Centro de la Provincia de Buenos Aires. However, quality of life is a concept related to people's well-being, but not necessarily mediated by ICTs, and therefore, it is not exactly a smart city index. This index is based on two large groups of indicators: socioeconomic and environmental. The socioeconomic components account for 60% of the weight of the index and the environmental components for 40%.

Methodology

For the construction of the smart city index, an exploratory analysis of the official websites of the provincial capital municipalities of Argentina, together with CABA and the city of Bahía Blanca is developed. The analysis was carried out during the month of February 2021. If in the first instance the information was not found on the official websites, a Google search was subsequently carried out. In addition, secondary sources of information were used. In particular, data corresponding to the Permanent Household Survey of the National Institute of Statistics and Census (INDEC, by its acronym in Spanish), both the survey and the ICT module, from the fourth quarter 2019 (table 1).

First, different aspects or objective indicators proposed according to the review of smart city indexes were selected. Then, the smart city index (ICI) was constructed based on these indicators and, subsequently, a comparative analysis between municipalities was performed. The index was calculated based on different methodologies: without weighting and with weighting. This differentiation arises in order to examine whether the vision or perception of the different actors in the city, whether business, government or citizen, has an impact on the position of the respective city of residence. If building a smart city is a joint and long-term goal (Angelidou, 2017), the different visions must be weighed.

For the construction of the weighted index, weights arising from the opinion of different stakeholders such as citizens, businesses and politicians from primary information sources of the municipality of Bahía Blanca were used. It is evident that the weightings are specific to each group analyzed (Ahvenniemi *et al*., 2017). For example, politicians or officials, companies and citizens are groups with different priorities and each will assign a higher weight according to their sought-after objective (governance in the case of politicians, technology in the case of technology companies, and so on).

In the case of citizen perception, the data comes from an online survey addressed to the followers of Facebook Moderniza Bahía. It collects information on the perception of the smart city concept as well as the activities carried out by citizens. This survey was elaborated within the framework of a research project of the Economics Department of the Universidad Nacional del Sur, with the support for its dissemination of the Secretariat of Modernization of the Municipality of Bahía Blanca. The survey, disseminated between April and May 2019, has collected 98 observations from a sample for finite populations (N= 16400 as of April 2019).

The population size in Bahía Blanca is 301,572 inhabitants, according to data from the last population census of 2010. The projected population for 2020 reaches 310,095 inhabitants (Ministry of Economy of the Province of Buenos Aires, 2016). It would be costly to obtain a representative sample of such a population. For this reason, it was decided to limit the universe to the followers of the social network Facebook Moderniza Bahía and to obtain a representative sample of this population. It is important to clarify that the sample, therefore, is biased and its results will only be representative of that population and should not be extrapolated to the total population of Bahía Blanca.

The form used in the context of the smart cities project is an adaptation of several sources on the topic e-government and Smart Cities (Weerakkody *et al*. 2016; Alshehri *et al*., 2012; Teo, Srivastava & Jiang, 2008), it also collects information on respondent profile, smart cities and e-government. It is mostly closed-ended questions with Likert-scale responses.

In the case of the weighting assigned by the companies, the information is obtained from another survey addressed to SMEs in Bahía Blanca linked to the following institutions: Polo Tecnológico del Sur, Parque Industrial, Cámara Argentina de Comercio Electrónico (CACE, by its acronym in Spanish) Regional Sur and companies participating in the Fondo Tecnológico Argentino (FONTAR, by its acronym in Spanish), of Bahía Blanca. This survey is part of the research project "Innovation in industrial and service SMEs in Bahía Blanca within the framework of the Smart City model" of the National Technological University (UTN, by its acronym in Spanish) in Bahía Blanca.

In the case of the perception of officials, we resorted to an interview developed in June 2019 to the Secretariat of Modernization and Open Government of Bahía Blanca.

Finally, only in the case of the municipality of Bahía Blanca, there is information available to include subjective indicators to the index. In this way, a smart city index is constructed with both objective and subjective indicators.

Results

Indicators proposed by dimension

A series of indicators are listed for each of the dimensions based on the literature review and the state of the art (table 1). The scoring criteria for indicators from official websites are 0 if not present; 1 if fully present; 0.5 if partially present (e.g., green dots are listed, but not geolocated). Indicators obtained from national statistical information sources, such as INDEC, are expressed as a percentage (from 0 to 1). Approximately the same number of indicators is used to give equal importance to all dimensions of the smart city concept. If a topic or aspect of reality is measured with many indicators, it is suggested that this topic is considered considerably more relevant than the rest (Ahvenniemi, 2017).

Table 1. Indicators proposed by dimension

Dimension	Indicator	Source
Environment	Data / Wooded Census	Municipal website, Google
	Environment apps	Municipal website, Google
	Information on urban tree pruning	Municipal website, Google
	Environmental monitoring platform	Municipal website, Google
	Geolocation of green / clean points	Municipal website, Google
	Awareness campaigns last year	Municipal website, Google
	Waste management projects	Municipal website, Google
Governance	Active Transparency Index (ITAM, for its acronym in spanish)	Ciucci *et al.*, 2019
	Open Data Index (ODI)	Open Knowledge Foundation
	Single window (commercial qualifications)	Municipal website, Google
	Interaction app between local government and citizens	Municipal website, Google
	Presence in official social networks	Social networks
	Covid Open Data	Municipal website, Google
Society and ICT	App on points of tourist-cultural interest	Municipal website, Google

Dimension	Indicator	Source
	Teaching courses through the virtual campus	Municipal website, Google
	Public wifi zones / digital points	Municipal website, Google
	% of households with internet access	INDEC
	% households with PC	INDEC
	% population +25 years with completed secondary education	INDEC
Mobility and transportation	Own parking meter system	Municipal website, Google
	Parking mobility app	Municipal website, Google
	Public transport payment system (bus) through SUBE	Municipal website, Google
	Bus route (georeferenced map)	Municipal website, Google

For the construction of the unweighted index, we proceeded to sum up all the values of the indicators. Then, the index is expressed as a percentage with respect to the total, it is taken into account that there are 23 indicators in total and that the possible values for each indicator range from 0 to 1, since they are all on the same scale.

Among the objective indicators of the governance dimension is the Municipal Active Transparency Index (ITAM, by its acronym in Spanish) published by Ciucci *et al*. (2019), which presents data on active budgetary transparency and passive transparency. It was calculated on a sample of 25 cities in Argentina (provincial capitals together with CABA and Bahía Blanca). For its construction, municipal websites were explored to determine the presence or absence of budgetary and public expenditure information, as well as the existence of a centralized system for managing requests for information and the publication of responses for public use.

In turn, the Open Data Index (ODI) is introduced as a governance indicator of the ICI. As Ciucci *et al*. (2018) explain, the central objective lies in verifying whether the data being published comply with an open and reusable digital format. Like the ODI, the proposed ICI includes the Covid open data publication.

Economic indicators such as gross local product or average income are not considered in the index. The argument is raised by Alderete (2019) regarding that smart city initiatives, especially in the fields of economy, are conditioned by the level of development of countries. Macroeconomic indicators condition the economic development capacity of their respective cities. Even if this were not the case, it is assumed that the greater availability of financial resources does not necessarily imply a higher degree of intelligence.

In addition, the methodology of the Smart Cities Index already mentioned is followed, where there is no explicit area of economics.

Unweighted Smart City Index

The top three municipalities in Argentina according to ICI are Bahía Blanca, CABA and Córdoba (table 2), with values above the average (58.37).

Table 2. Smart City Index (ICI) without weighting

Municipality	Unweighted index
Bahía Blanca	94.37
CABA	90.22
Córdoba	80.39
Resistencia	73
La Plata	72.87
Viedma	66.32
Paraná	66.08
Formosa	62.35
Mendoza	61.78
Santa Rosa	60.95
San Luis	59.39
Neuquén	58.56
Posadas	58.56
San Juan	57.82
Santa Fe	52.82
Corrientes	52.65
Ushuaia	49.56
Jujuy	48.89
Tucumán	48.43
Rawson	46.13
Salta	43.21
La Rioja	42.22
Catamarca	40.61
Río Gallegos	36.61
Santiago del Estero	35.43
Average ICI	58.37

If the composition of the index is analyzed, it is noted that the four dimensions are consistent in placing Bahía Blanca among the smartest cities (table 3). CABA is present in the top positions in all dimensions except mobility and transportation. This point is a consequence of the absence of a mobility app in CABA at the time the information was collected.

Table 3. Ranking of municipalities according to dimension

	Enviroment	Governance	Social and ICT	Mobility and transportation
Best positioned	Bahía Blanca CABA Resistencia	CABA Córdoba Bahía Blanca	CABA Bahía Blanca Mendoza	Bahía Blanca La Plata Santa Rosa
Worst positioned	Tucumán Santa Fe	Río Gallegos Jujuy	Santiago del Estero Catamarca	Río Gallegos Santiago del Estero

ICI comparison by geographic area

It is noted that the cities of the Buenos Aires Province and Center regions lead the ranking, while the cities with lower index values belong to the Northwest Argentina and Patagonia regions (table 4). These differences are statistically significant according to variance analysis (table 5).

Table 4. Unweighted mean ICI by region.

Region	Average	N	Dev. typ.
Provincia de Buenos Aires (PBA)	74,9200	4	23,70573
Centro	66,4367	3	13,78327
Cuyo	59,6667	3	1,98948
Noreste Argentino (NEA)	61,6425	4	8,55957
Noroeste Argentino (NOA)	43,3400	4	6,49953
Patagonia	51,6271	7	10,66243
Total	58,3724	25	15,36091

Table 5. ANOVA

	Sum of squares	gl	Root mean square	F	Sig.
Inter-groups	2560.571	5	512.114	3.136	0.031
Intra-groups	3102.413	19	163.285		
Total	5662.984	24	675.399		

Weighted Smart City Index

Weighting

In both the survey directed to citizens of Bahía Blanca and the survey of companies, respondents are explicitly asked what characteristics they believe are necessary to be a smart city, with multiple choice answers:

- Efficiency of the transportation system
- Access to basic services
- Better urban governance
- Ecological environment
- Inclusion
- Technological resources
- Renewable energy
- Infrastructure security
- Access to data (big data)
- Government transparency

These options are grouped into the different general dimensions of the IC concept: transportation and mobility, governance, environment, and society and ICT. The dimensions are then ordered according to the frequency of response they obtained, and greater weight is given to those with the highest percentage in decreasing order. This leads to weighting the dimension of governance, society and ICT, and transport and mobility more heavily than environment (table 6).

Table 6. Percentage of responses for CI dimensions according to the actor

Dimensions	Companies	Citizens
Environment	67,6%	54,2%
Governance	85,3%	81,3%
Society and ICT	64,7%	66,7%
Mobility and transportation	67,6%	40,6%

- The dimensions in order of importance for companies are governance, environment (same as transport), society and ICT.

- The dimensions in order of importance for citizens are governance, society and ICT, environment, transport and mobility.

In the case of the opinion of civil servants, an interview developed in June 2019, at the Secretariat of Modernization and Open Government, Bahía Blanca, Argentina, was used. The clearest objectives that have been sought are transparency, digital inclusion and access to better public services. These objectives have been achieved through the following means: digital points, free Wi-Fi, online and published information requests, transportation services with Wi-Fi and security, among others. The municipality has been active in the pursuit of digital inclusion, by implementing the "Bahía Wi-Fi" program, with which more than 50 free Wi-Fi points were established in the city (Quartuci, 2021).

With this information, the following weights were assigned to each dimension respecting the order of preferences indicated (table 7).

On average, all sectors agree that the governance dimension is the most important dimension for building a smart city.

Table 7. Weighted for each dimension according to the actor's perception

	Companies	Citizens	Politicians
Environment	0,25	0,20	0,10
Governance	0,40	0,40	0,40
Society and ICT	0,10	0,30	0,30
Mobility and transportation	0,25	0,10	0,20

On the other hand, in the case of the weighted index, first the indicators by dimension (environment, governance, social and ICT and transport) were summed, thus obtaining 4 subtotals. Subsequently, a weighted sum of these subtotals is made according to the perception of each stakeholder (table 3):

In the case of the ICI according to the citizen's perspective, the formula is:

0.20*Subtotal_Environment+0.40*Subtotal_Governance+0.30*Subtotal_Social and ICT+0.10*Subtotal_Transportation

Since the maximum possible value of this weighted sum is 6, the index was expressed as a percentage of the maximum. Similarly, the index was constructed according to the perception of companies and politicians.

On average, the weighting from the citizens' viewpoint overestimates the index, while the companies' viewpoint underestimates it (table 8). However, these numerical differences have no impact on the order or ranking of the cities (table 9).

Table 8. Weighted Smart City Index (ICI)

Municipality	ICI_citizens	ICI_politicians	ICI_companies
Bahía Blanca	92.88	87.88	91.75
CABA	91.72	87.55	87.23
Catamarca	44.20	43.37	41.82
Córdoba	82.87	78.70	80.82
Corrientes	54.98	54.15	47.23
Formosa	55.92	55.92	56.55
Jujuy	47.93	43.77	42.62
La Plata	69.93	69.10	70.08
La Rioja	42.72	42.72	38.68
Mendoza	68.03	67.20	58.38
Neuquén	54.72	53.05	52.05
Paraná	63.37	62.53	61.18
Posadas	54.02	54.02	52.45
Rawson	49.90	47.40	39.48
Resistencia	65.22	61.88	66.78
Río Gallegos	38.18	35.68	33.53
Salta	47.72	45.22	41.87
San Juan	58.17	58.17	57.17
San Luis	58.30	55.80	54.02
Santa Fe	53.37	58.37	55.60
Santa Rosa	55.07	55.90	54.52
Santiago del Estero	39.50	36.17	34.83
Tucumán	46.20	47.87	42.57
Ushuaia	48.12	49.78	44.85
Viedma	61.72	61.72	61.75
Average	57.79	56.56	54.71

Table 9. Best and worst municipalities according to ICI

	ICI_citizens	ICI_politicians	ICI_companies
Smartest	Bahía Blanca CABA Córdoba	Bahía Blanca CABA Córdoba	Bahía Blanca CABA Córdoba
Less smart	Río Gallegos Santiago del Estero La Rioja	Río Gallegos Santiago del Estero La Rioja	Río Gallegos Santiago del Estero La Rioja

It is also verified that the weighting does not modify the order of the cities considered the smartest. A certain difference is only observed in the cities identified as less intelligent with the unweighted index. The type of weighting has no impact on the order.

ICI with objective and subjective indicators: the case of Bahía Blanca

The survey addressed to the citizens of Bahía Blanca collects objective data on the behavior of the population regarding the development of smart activities (waste sorting, e-government, e-commerce). In turn, it captures information on citizens' perception of Bahía Blanca as a smart city and their knowledge of the smart city concept (subjective data).

After the incorporation of these indicators in the index, Bahía Blanca regresses in absolute terms (table 10). The index with subjective indicators is lower (83.84) than the original index without subjective indicators (94.37). It is not possible to compare with the rest of the municipalities, since subjective information is not available for them.

Table 10. Objective and subjective indicators that make up ICI

Dimension	Indicators	Bahía Blanca
Environment	1) Data/Woodland Census	1
	2) Environment apps	1
	3) Information on urban tree pruning	
	4) Environmental monitoring platform	1
	5) Geolocation of green / clean points	1
	6) Awareness campaigns last year	1
	7) Waste management projects	1
	8) % population that classifies waste	0.412
	Subtotal environment	6.412
Governance	9) Active Transparency Index (ITAM)	0.625
	10) Open Data Index (ODI)	0.99
	11) Single window (commercial qualifications)	1
	12) Application of interaction between local government and citizens	1
	13) Presence in official social networks	1
	14) Covid Open Data	1
	15) % population that performs electronic government	0.75
	Subtotal governance	6.365
Society and ICT	16) App on points of tourist-cultural interest	1
	17) Teaching courses through the virtual campus	1
	18) % population +25 years with completed secondary education	0.73
	19) Public Wi-Fi zones in different areas of the city and the delegations	1

Dimension	Indicators	Bahía Blanca
	20) % of households with internet access	0.84
	21) % of households with PC	0.62
	22) % population that performs electronic commerce	0.69
	Subtotal society and ICT	5.88
Mobility and transportation	23) Own parking meter system	1
	24) Parking mobility app	1
	25) Public transport payment system (bus) through SUBE	1
	26) Bus route (georeferenced map)	1
	Subtotal mobility and transportation	4
Perception	27) % population considers the city to be smart	0.25
	28) % population knows about the smart city concept	0.57
	ICI index	23.477
		83.8464286

Discussion

The information obtained with the proposed ICI, although related to other indexes such as the ODI, presents not only methodological but also conceptual differences. With respect to the areas considered of interest by the ODI, although they coincide to a large extent with the ICI (table 11), the focus of analysis is not the same, since the ODI only focuses on the degree of openness of the data, while the ICI captures information on the actions/activities developed in the municipality with a view to improving these areas with the assistance of ICTs.

Table 11. ICI comparison with other indices

Index	Number of cities	Scale	Overall dimensions	Dimensions in common with ICI	% Common dimensions
ICIM Cities in Motion	181	1-181 (ranking)	Governance, urban planning, technology, environment, international scope, social cohesion, mobility and transportation, human capital, economy	Governance, technology, environment, mobility and transportation, human capital	55
Smart City Index	100	0-10	Health and safety mobility, activities, opportunities (work and school), and governance analyzed in two pillars: structure and technology	Health, mobility, activities, governance, opportunities (school)	71

Index	Number of cities	Scale	Overall dimensions	Dimensions in common with ICI	% Common dimensions
Ranking of Smart Cities in Chile	57 communes	0-90	Environment, mobility, government, economy, society and quality of life	Environment, mobility, government, society	66
Connected Smart Cities	673	0-69,5	Mobility and accessibility, environment, urban planning, technology and innovation, health, safety, education, entrepreneurship, energy (mainly renewable sources), governance and economy	Mobility and accessibility, environment, technology and innovation, education, energy and governance	54

Unlike the Smart City Index, the ICI combines objective indicators with subjective indicators in terms of citizen perception. The Smart City Index distributes localities into four groups according to the UN Human Development Index score of their countries. In the case of the ICI, since they are municipalities of the same country, this classification does not make sense.

The CIMI collects information on a wide variety of indicators that are not entered in the ICI. Among the reasons are the lack of access to these data for each municipality in Argentina or the lack of variability. For example, all provincial capital municipalities in Argentina have primary health care plans, so there is no heterogeneity in this aspect.

In the case of the ICI, there are no economic statistics at the local level in Argentina that can be compared. In the case of the ICIM (IESE), Buenos Aires shows positive results in the dimensions of urban planning and environment, and in the spheres of international projection and governance. However, its poor economic performance is the reason why it cannot lead the Latin American region.

The objective statistics for each city in each dimension are complemented with subjective statistics for the case of Bahía Blanca. The idea is to examine whether these data can influence the ranking of municipalities, government decision-making, or the formulation of policies, from environmental to preventive policies. In this way, policies are built from the bottom up.

Unlike other indexes such as those of Chile or Brazil, in this case the municipalities that occupy the top positions in each of the dimensions discussed are also those that occupy the top positions in the smart city index. For example, the ranking report

for Chile shows that Santiago occupies first place because it is the city with the best infrastructure in Chile and receives numerous investments that boost its economy. However, it is not very understandable that a city achieves the first positions of smart city when it is poorly positioned in terms of environment. In that sense, the proposed ICI index has certain strengths.

Conclusions

In Argentina, the ICT access gap is one of the causes that explain the ICT use gap. However, the greater use of ICTs does not guarantee that the population is involved in the development of intelligent activities. For example, in the case of Bahía Blanca, where 84% of the population has access to the Internet at home, it is not verified that 80% of the population is involved in activities considered smart, such as waste sorting at source or e-government.

Smart city indices should measure the development of smart activities rather than the availability of ICTs, which are a necessary but not sufficient condition. Moreover, public policies should not only mitigate the digital divide but also generate awareness campaigns regarding the concept of smart and the role of citizens in the construction of local policies.

However, there are several barriers to the construction of smart cities. From technical (scarcity of open or shared public data or interoperable equipment), legal (threat to citizens' privacy in the case of the Internet of Things), social (the digital divide, the role of non-users of technology, citizen involvement or engagement), to governmental (the aversion of governments to involve citizens in policies, the risk of opportunism of commercial providers).

Taking into account that there is an apparent correlation between the economic dimension and the technological dimension, and since it is to be expected that the capital and most populated cities have greater economic resources than the rest, it is considered appropriate not to include economic indicators in the construction of the index. In this, the same methodology of the Smart Cities Index is followed.

This paper offers a smart cities index for a group of municipalities in Argentina. The main contribution lies in offering a smart city index, so far non-existent, to compare among intermediate cities in Argentina. Although some of the dimensions analyzed are similar to other indexes such as the ODI or the SCI, the proposed ICI index introduces both objective and subjective indicators on the actions developed by both local governments and citizens around the smart city concept.

This makes it possible to evaluate local policies from below and to weight the opinion of the different actors. In turn, the results find that, regardless of the consideration of

different weights, the proposed index is robust in terms of the order of merit or positioning of the municipalities considered in the study.

Among the limitations of the work there is the small number of municipalities under analysis, which does not exceed 25 cities. Another aspect is that there is no way to compare the values of the index with subjective indicators for other municipalities due to the lack of data or surveys in other cities. However, the analysis is considered relevant and could be replicated in other municipalities in the country and the region.

REFERENCES

Addanki, S. C. & Venkataraman, H. (2017). Greening the economy: A review of urban sustainability measures for developing new cities. *Sustainable Cities and Society*, *32*, 1-8.

Ahvenniemi, H.; Huovila, A.; Pinto-Seppä, I. & Airaksinen, M. (2017). What are the differences between sustainable and smart cities? *Cities*, *60*, 234-245.

Albino, V.; Berardi, U. & Dangelico, R. M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. *Journal of Urban Technology*, *22*, 3-21.

Alderete, M. V. (2019). Exploring the Smart City indexes and the role of macro factors for measuring cities smartness. *Social Indicators Research*, *147*, 567-589.

Alderete, M. V. (2020). Determinants of Smart City commitment among citizens from Bahía Blanca, Argentina. ICPR-Américas 2020, Bahía Blanca, diciembre de 2020.

Alderete, M. V. & Díaz, L. (2020). ¿Participa la ciudadanía en el gobierno electrónico? El caso de la ciudad de Bahía Blanca, Argentina. *Documentos y Aportes en Administración Pública y Gestión Estatal (DAAPGE*), *34*, 77-102.

Alshehri, M.; Alhussain, T.; Drew, S. & AlGhamdi, R. (2012). *The Effects of Website Quality on Adoption of E-Government Service: An Empirical Study Applying UTAUT Model Using SEM.* 23rd Australasian Conference On Information Systems Website Quality and E-Government Service 3-5 Dec 2012, Geelong.

Angelidou, M. (2017). The Role of Smart City Characteristics in the Plans of Fifteen Cities. *Journal of Urban Technology*, *24*(4), 1-27.

Anthopoulos, L.; Janssen, M. & Weerakkody, V. (2019). A Unified Smart City Model (USCM) for Smart City Conceptualization and Benchmarking. In I. Management

Association (ed.), *Smart Cities and Smart Spaces: Concepts, Methodologies, Tools, and Applications* (pp. 247-264). IGI Global.

Belanche, D.; Casaló, L. V. & Orús, C. (2016). City attachment and use of urban services: Benefits for smart cities. *Cities*, *50*, 75-81.

Belissent, J. & Girón, F. (2013). *Service Providers Accelerate Smart City Projects. Forrester Research Report.* Cambridge, MA: Forrester Publication.

Bellet, C. & Llop J. M. (2004). Miradas a otros espacios urbanos: Las ciudades intermedias. *Revista Electrónica de Geografía y Ciencias Sociales*, *8*(165), 1-28.

Bouskela, M.; Casseb, M.; Bassi, S.; De Luca, C. y Facchina, M. (2016). La rutahacia las *smartcities*: Migrando de una gestión tradicional a la ciudad inteligente. BID. https://publications.iadb.org/bitstream/handle/11319/7743/La-ruta-hacia-las-smart-cities-Migrando-de-una-gestion-tradicional-a-la-ciudad-inteligente.pdf

Caragliu, A. & Del Bo, C. (2019). Smart innovative cities: The impact of Smart City policies on urban innovation. *Technological Forecasting and Social Change*, *142*, 373-383.

Chourabi, H.; Nam, T.; Walker, S.; Gil-Garcia, J. R.; Mellouli, S.; Nahon, K. & Scholl, H. J. (2012). Understanding smart cities: An integrative framework. In *2012 45th Hawaii International Conference on System Sciences* (pp. 2289-2297). IEEE.

Ciucci, F.; Díaz, L.; Alderete, M. V. & Linares, S. (2019). Construcción de un índice para medir la transparencia municipal: Buenos Aires, Bahía Blanca y las capitales de provincia de argentina. *Revista Iberoamericana de Estudios Municipales*, *20*, número especial.

De Jong, M.; Joss, S.; Schraven, D.; Zhan, C. & Weijnen, M. (2015). Sustainable–smart–resilient–low carbon–eco–knowledge cities; making sense of a multitude of concepts promoting sustainable urbanization. *Journal of Cleaner Production*, *109*, 25-38.

El-Haddadeh, R.; Weerakkody, V.; Osmani, M.; Thakker, D. & Kapoor, K. K. (2019). Examining citizens' perceived value of internet of things technologies in facilitating public sector services engagement. *Government Information Quarterly*, *36*(2), 310-320.

Faria, P. A. M.; Ferreira, F. A.; Jalali, M. S.; Bento, P. & António, N. J. S. (2018). Combining cognitive mapping and MCDA for improving quality of life in urban areas. *Cities*, *78*, 116-127.

International Standardization Organization. (2018). ISO 37120: Sustainable development of communities. Indicators for city services and quality of life.

International Telecommunication Union. (2018). *Measuring the information society report: Volume 2*. Geneva: International Telecommunication Union.

Jolías, L. & Prince, A. (2016). Definiendo un modelo de Smart Cities para el contexto argentino. En Paellán, N. *Ciudades inteligentes. El aporte de las TIC a la comunidad. Casos testigo y la visión del sector privado*. CICOMRA, Cámara de Informática y Comunicaciones de la República Argentina.

Joshi, S.; Saxena, S. & Godbole, T. (2016). Developing Smart Cities: An integrated framework. *Procedia Computer Science*, *93*, 902-909.

Kamal, M.; Weerakkody, V. & Irani, Z. (2011). Analyzing the role of stakeholders in the adoption of technology integration solutions in UK local government: An exploratory study. *Government Information Quarterly*, *28*(2), 200-210.

Kaminitz, S. C. (2020). Looking Good or Feeling Well? Understanding the Combinations of Well-Being Indicators Using Insights from the Philosophy of Well-Being. *Social Indicators Research*, *150*, 1-16.

Khansari, N.; Mostashari, A. & Mansouri, M. (2014). Impacting sustainable behavior and planning in smart city. *International Journal of Sustainable Land Use and Urban Planning*, *1*(2).

Kitchin, R. (2014). The real time city? big data and smart urbanism. *Geojournal*, *79*, 1-14.

Lupiañez-Villanueva, F., & Faulí, C. (2017). *Ciudades inteligentes. Evaluación social de proyectos de Smart Cities*. Montevideo: cet.la.

Lytras, M. D., Visvizi, A. & Sarirete, A. (2019). Clustering Smart City services: Perceptions, expectations, responses. *Sustainability*, *11*(6), 1669.

Macke, J.; Casagrande, R. M.; Sarate, J. A. R. & Silva, K. A. (2018). Smart City and quality of life: Citizens' perception in a Brazilian case study. *Journal of Cleaner Production*, *182*, 717-726.

Marsal-Llacuna, M. L.; Colomer-Llinàs, J. & Meléndez-Frigola, J. (2015). Lessons in urban monitoring taken from sustainable and livable cities to better address the Smart Cities initiative. *Technological Forecasting and Social Change*, *90*, 611-622.

Martínez Stanziani, M. (2020). *Índices de Ciudades Inteligentes: construcción y análisis de un indicador para la ciudad de Bahía Blanca* (tesis de licenciatura). Departamento de Economía, Universidad Nacional del Sur. Bahía Blanca, Argentina.

Manzano, F. A. & Velázquez, G. A. (2015). La evolución de las ciudades intermedias en la Argentina. *Geo UERJ*, Rio de Janeiro, *27*(1), 258-282.

Ministerio de Economía de la Provincia de Buenos Aires. (2016). Proyecciones de población por municipio provincia de Buenos Aires 2010-2025. Dirección Provincial de Estadística. http://www.estadistica.ec.gba.gov.ar/dpe/images/Proyecciones_x_municipio_2010-2025.pdf

Mora, L.; Bolici, R. & Deakin, M. (2017). The first two decades of smart-city research: A bibliometric analysis. *Journal of Urban Technology*, *24*(1), 3-27.

Nam, T. & Pardo, T. A. (2011). *Smart City as urban innovation: focusing on management, policy and context.* Trabajo presentado en ICEGOV2011, Proceedings of the 5th International Conference on Theory and Practice of Electronic Governance, 185-194. Tallinn, Estonia.

Novo-Vázquez, A. & Vicente, M. R. (2019). Exploring the Determinants of e-Participation in Smart Cities. In M. P. Rodríguez Bolívar, L. Alcaide Muñoz (eds.). *E-Participation in Smart Cities: Technologies and Models of Governance for Citizen Engagement*. Public Administration and Information Technology, 34, Springer: Cham.

Observatorio de Ciudades Inteligentes del Centro de Competitividad Mundial del IMD y Universidad de Tecnología y Diseño de Singapur. (2019). *Smart City Index*. https://www.imd.org/research-knowledge/reports/imd-smart-city-index-2019/

Organización de las Naciones Unidas (2018). *Las ciudades seguirán creciendo, sobre todo en los países en desarrollo*. Nueva York, Estados Unidos: Noticias ONU. https://www.un.org/development/desa/es/news/population/2018-world-urbanization-prospects.html

Prieto, M.; Schroeder, R. & Formiga, N. (2011). Ciudades intermedias: dinámica y perspectivas: el caso de Bahía Blanca - Argentina. *Revista Geográfica de América Central*, *2*(47E), 1-17.

Quartuci, E. (2021). Gobierno Abierto e Innovación. El caso del gobierno de Bahía Blanca. In Herrero, A. y Vila, J. M. (comps.). *Gobierno abierto e innovación publica: los pilares de la nueva agenda de gobernabilidad*. Ciudad de Buenos Aires: UAI Editorial.

Silva, B. G.; Khan, M. & Han, K. (2018). Towards sustainable smart cities: A review of trends, architectures, components, and open challenges in smart cities. *Sustainable Cities and Society*, *38*, 697-713.

Suman, A. B. (2017). *In search for the value of connectivity. Accountable citizens fostering accountable governance via connectivity: the case of environmental health policies.* 2017 IEEE International Conference on Cloud Engineering, 298-303.

Teo, T.; Srivastava, S. & Jiang, L. (2008). Trust and electronic government success: An empirical study. *Journal of Management Information Systems*, *25*(3), 99-131.

Weerakkody, V.; Irani, Z.; Lee, H.; Hindi, N. & Osman, I. (2016). Are U.K. Citizens Satisfied With E-Government Services? Identifying and Testing Antecedents of Satisfaction. *Information Systems Management*, *33*(4), 331-343.

[1] https://2021.indicedatosabiertos.org/