SUSTAINABLE SMART CITIES: THE EUROPEAN CASE

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Abstract

Smart cities are emerging all over the world and are a promise to combat various problems currently faced by cities. This context makes smart cities a relevant topic for research. This study aims to identify which factors influence the development of sustainable smart cities. The empirical study uses a sample with 73 European cities and applies a multiple linear regression. The results suggest differences between smart cities in Europe, such as; smarter cities are located geographically in the western region and are governed by women. This study provides an academic and empirical study on smart cities and contributes to a better explanation of a still under explored theme.

Keywords: Smart Cities, Europe, Sustainability, Factors.

1. Introduction

In recent decades, the concept of "smart city" (SC) has been gaining more and more importance in the literature regarding international policies (Albino et al., 2015). The unceasing growth of cities and improvements in quality of life have been key elements for the future of society. Cities play a key role in social and economic aspects around the world and have a notable impact on environmental problems (Mori and Christodoulou, 2012). For this reason, smart cities work in networks with the aim of promoting political and social efficiency, allowing economic, political, urban, cultural and social innovation (Carvalho, 2017), nurtured by growing population flows that seek opportunities in cities for work and personal growth. In addition, they produce various business opportunities, allowing collaboration between different public and private sectors (Nevado et al., 2020). According to the United Nations (UN) in 2050, the world population will have increased by two billion people, with 70% living in urban areas. According to the UN, this increase in the population in cities may be a problem, since cities consume 75% of the world's energy and produce 80% of greenhouse gases. Despite this, cities favour innovation, knowledge and creativity, which is why a balance must be sought between social, economic and environmental aspects, as well as that of the citizens themselves. According to the European Parliament (2014), smart cities are classified according to six main dimensions: smart economy, smart governance, smart mobility, smart environment, smart people, and smart living (Villarejo, 2015).

Upon reviewing the literature, we found various studies on the definition, creation and use of indicators for the measurement and evaluation of smart cities (Nevado et al., 2018). Therefore, various approaches, objectives and methodologies can be found to diagnose and classify smart cities. Although there are no cities yet where urban systems and services are interconnected, many cities around the world have already become smart and sustainable. Information and communications technologies (ICTs) are responsible for accelerating the process for a city to become intelligent, thus fulfilling one of the 17 Sustainable Development Goals (SDGs) of the UN (De Guimarães et al., 2020), specifically SDG 11, whose objective is to achieve sustainable cities and communities. In this way, the aim is to create cities that reduce environmental impact, in addition to reflecting on models of access to resources, resource and energy management, transportation, etc. (Longo et al., 2014; Patsakis et al., 2015).

In 2012, the European Commission (EC) carried out a specific initiative for the development of smart cities called the "Association for European Innovation on Smart Cities and Communities" (EIP-SCC) (https://eu-smartcities.eu/), which brings together cities, industries, small and medium-sized companies, and financial and research entities with the aim of improving life in cities through more sustainable integrated solutions through concrete challenges of the city through different political areas and ICTs. For its part, the IESE Center for Globalization and Strategy is worthy of highlighting; it annually produces a ranking through the Cities in Motion index where it analyses the level of development of 174 cities in 80 countries in nine dimensions (Berrone and Ricart, 2020). The smartest cities in the world are London, New York and Paris. Globally, Europe continues to dominate the ranking, with 27 cities among the 50 smartest in the world, followed by 14 cities in North America, five in Asia and four in Oceania.

In this context, this study focuses on SC, due to the importance that these cities have for the economy and sustainable development, and aims to identify the factors that may favour their development. To do this, and based on the objectives of the European Union (EU, 2020), which include developing and redeveloping smart cities and communities, we use data from the Cities in Motion index (CIMI, 2017) for 73 European cities.

To achieve the proposed objectives, a multiple linear regression of the levels of smart cities is proposed. The analysis of the factors influencing the development of sustainable SCs is at a relatively early stage of development. That is why our study contributes to the existing literature on regional development and smart cities and, in our case, in the European context. The work is structured as follows. After this introduction, a review of the literature on the regional development of SCs is carried out, from which the hypotheses of the study are drawn. Later, the methodology used, the descriptive analysis and the results obtained are given. The work concludes by summarizing the main aspects of the current problems and future challenges of smart cities.

2. Literature review

Although there are many definitions of the “smart city”, to date there is no globally accepted definition (Al Nuaimi et al., 2015). According to Meijer and Bolívar (2016) there are three different types of definitions of “smart city”: smart cities understood as cities that use smart technologies themselves (technological approach), smart cities understood as cities with smart people (focus on human resources) and smart cities as cities with smart collaboration (governance approach). Therefore, there is no single model to frame a smart city or a one-size-fits-all concept (O'Grady and O'Hare, 2012). In the literature review, multiple concepts can be found, among which the one defined by Caragliu et al. (2011, p. 70) stands out: 'We believe a city to be smart when investments in human and social capital and traditional … a city to be smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance'.

The term appears for the first time in the 1990s. Here, the term pays special attention to the importance of ICTs with respect to modern infrastructures within cities (Meijer and Bolívar, 2016). One of the first organizations to focus on the study of smart cities was the California Institute for Smart Communities, with the aim of seeing how a city could be designed to implement ICTs (Alawadhi et al., 2012). Years later, the Center of Governance at the University of Ottawa criticized this idea, as it was too technique-oriented (Albino et al., 2015). Despite this, the concept of "smart city" spread in the early years of the 21st century, and is a phenomenon that has been growing to this day. Thus, authors such as Nam and Pardo (2011) focused on investigating the meaning of the term "smart" in this context, understanding this as a system adapted to the needs of users. Others like Harrison et al. (2010) stated that the term "smart city" refers to "instrumented, interconnected and intelligent city", understanding intelligence as the inclusion of complex analysis, modelling, optimization and visualization services to make better operational decisions. Some, for their part, postulate that the smart city concept often acts more like a label (Van Den Bergh and Viaene, 2015; Glasmeier and Nebiolo, 2016).

Organizations such as the UN or the European Union (EU) coincide in pointing out the main feature of smart cities: the use of ICTs in managing the challenges of cities with the purpose of improving the living conditions of the citizens who live in them and promoting their personal development. Thus, the OECD Oslo Manual (EUROSTAT, 2005) highlights the role of innovation in ICT sectors by providing a set of tools to identify consistent indicators, setting up an analysis framework for researchers on innovation in cities. Authors such as Hollands (2008) emphasize that smart cities require not only the use of ICTs, but also the contribution of different groups of people, collecting what smart cities are (smart people and governance) and what they intend to achieve (economy, mobility, environment and smart life). For their part, the International Telecommunications Union (ITU) and the United Nations Economic Commission for Europe (ECE) also add the concept of "sustainability": "a smart and sustainable city is an innovative city that uses ICT to improve the quality of life, the efficiency of urban operations and services and competitiveness, while ensuring that the needs of present and future generations are met with respect to economic, social, environmental and cultural aspects".

As a result of all the above, it can be affirmed that the concept is extremely complex, and, in addition to the physical infrastructure, includes the human and social factors which are essential for its existence (Aguilera et al., 2013). In this way, many researchers have separated the concept into many characteristics and dimensions (Albino et al., 2015). In the review of previous literature, we found different classifications of the dimensions associated with different aspects of human life that partly affect common characteristics of smart cities. Giffinger et al. (2007) identify four components of the smart city: industry, education, participation and technical infrastructure. For Komninos et al. (2011) smart cities are associated with four dimensions: the application of a wide range of electronic and digital technologies; the use of ICTs to transform life and work; the integration of ICTs into the infrastructure of cities; and the union of ICTs with people to generate innovation, learning and knowledge. Since then, the list has been expanding, identifying six main components (Giffinger and Gudrun, 2010): smart economy, smart society, smart governance, smart mobility, smart environment, and smart well-being, which Lombardi et al. (2012) associate with different aspects of urban life (see Table 1).

Table 1. Dimensions of Smart Cities

Dimensions of a Smart City	Related aspects of urban life	Objectives
smart economy	Industry	Achieve greater competitiveness and productivity in cities, based on innovation and the creation of a strong, dynamic and sustainable economy, through the use of ICTs by companies, the promotion of entrepreneurial initiative and the promotion of creativity, in direct relation to the knowledge-based economy.
smart people	Education	Focus on society and human capital as a fundamental integral part of the city whose society has "learned to learn", carrying out actions to prevent excessive energy consumption and pollution. The aim is to enhance the quality of life in the city, making it more competitive and sustainable.
smart governance	E-democracy	Centre the management of the city itself with participation and transparency towards the citizen. The aim is to improve the quality and efficiency of the services provided by public administrations through digitized processes, generating a transparent and rapid access to public information.
smart mobility	Logistics and infrastructure	Ensuring the accessibility and sustainable mobility of transport and communication through the use of ICTs. In addition, it must ensure public access to the internet for all its citizens.
smart environment	Efficiency and sustainability	Achieve environmental sustainability, optimizing energy consumption and managing resources efficiently.
smart living	Safety and quality	Offer a higher level and adequate use of services, improving the quality of life of the population, creating a virtuous circle of economic and social well-being.

Source: Own elaboration from Lombardi et al. (2012)

3. Design of the investigation

3.1. Sample selection

The selected population is made up of 73 European cities whose levels of smart cities for the year 2017 were studied and classified by the IESE Business School, one of the most important business schools in the world, which in recent years has published an index of cities which is objective, exhaustive, comprehensive and guided by the criteria of conceptual relevance and statistical rigour. The 2017 edition of CIMI includes 180 cities, 73 of them capitals, representing 80 countries. The breadth of the project establishes the CIMI as one of the city indexes with the broadest geographic coverage available today. In addition, to calculate the index, the authors included 79 indicators that provide a comprehensive view of each city.

CIMI has empirically validated the conceptual model developed from 79 indicators that provide a complete vision of each city, grouped into ten key dimensions to determine its efficiency: economy, human capital, technology, environment, international impact, social cohesion, mobility and transport, governance, urban planning and public management. All the indicators are linked to a strategic objective that leads to a new form of local economic development: the creation of a global city, the promotion of entrepreneurship, and innovation, among others.

3.2.Methodology

To achieve the objective of this study and following Laswad et al. (2005), Moura et al. (2014) and Alcaraz-Quiles et al. (2015), among others, we propose a multiple linear regression of the CIMI and the ten dimensions that make up the index, based on three variables: gender, geographic location, and political ideology. Thus, an explanatory analysis is carried out in order to identify the factors that affect smart city levels in European cities. All estimates will be made using SPSS software version 20.

3.3.Model specification

To carry out the contrast of the hypotheses raised in previous sections, multivariate regression techniques were used. Through a multiple linear regression, using the ordinary least squares (OLS) method, the following models were estimated, one of the global index for the 73 European cities (CIMI) and the rest with the values of each of the ten dimensions of which the CIMI is composed.

$$\boldsymbol{ICMI_j = \beta_0 + \beta_1 Gender_j + \beta_2 Localization_j + \beta_3 Ideology_j + \varepsilon_j}$$

$$\boldsymbol{D1_j = \beta_0 + \beta_1 Gender_j + \beta_2 Localization_j + \beta_3 Ideology_j + \varepsilon_j}$$

$$D2_j = \beta_0 + \beta_1 Gender_j + \beta_2 Localization_j + \beta_3 Ideology_j + \varepsilon_j$$

$$D3_j = \beta_0 + \beta_1 Gender_j + \beta_2 Localization_j + \beta_3 Ideology_j + \varepsilon_j$$

$$D4_j = \beta_0 + \beta_1 Gender_j + \beta_2 Localization_j + \beta_3 Ideology_j + \varepsilon_j$$

$$D5_j = \beta_0 + \beta_1 Gender_j + \beta_2 Localization_j + \beta_3 Ideology_j + \varepsilon_j$$

$$D6_j = \beta_0 + \beta_1 Gender_j + \beta_2 Localization_j + \beta_3 Ideology_j + \varepsilon_j$$

$$D7_j = \beta_0 + \beta_1 Gender_j + \beta_2 Localization_j + \beta_3 Ideology_j + \varepsilon_j$$

$$D8_j = \beta_0 + \beta_1 Gender_j + \beta_2 Localization_j + \beta_3 Ideology_j + \varepsilon_j$$

$$D9_j = \beta_0 + \beta_1 Gender_j + \beta_2 Localization_j + \beta_3 Ideology_j + \varepsilon_j$$

$$D10_j = \beta_0 + \beta_1 Gender_j + \beta_2 Localization_j + \beta_3 Ideology_j + \varepsilon_j$$

Likewise, an error term (Ɛ) has been incorporated, which collects the incidence that the indices have on the effects not explained by the independent variables.

4. Results and Discussion

Table 2 shows the results related to the effect that the gender of the governing person, the geographical location of the cities and the political ideology of the representatives of the government of a city have on the smart city level of European cities, and on each of its dimensions. As can be seen in Table 2, the global model, where the influence of the proposed variables on the total smart city level is measured, has an explanatory power of 45.7% for a confidence level of 99% (value of $p < 0.01$). Of the three proposed variables, gender and geographic location are statistically significant for a confidence level of 95% and 99%, respectively, and are negatively associated with the dependent variable. With respect to the gender variable, this indicates that European cities governed by women reach better positions in the smart cities ranking than those governed by men. Although the literature suggests some differences between men and women in governance, studies on leadership and gender in CIs are still in their early stages. For this reason this study provides relevant and novel information on one of the factors that favours the development of smart cities, the gender of the governing party.

On the other hand, regarding the geographic location variable, the results confirm that European cities belonging to the western region occupy the best positions in the smart cities ranking. We can therefore affirm that there is a significant relationship between the levels of smart cities and the region to which European cities belong. These results are consistent with the literature since, as referenced above, it identifies Western Europe as more prosperous and more industrialized than Eastern Europe. For its part, the political ideology of the rulers of European cities lacks econometric relevance. However, these results are contradictory to the works of other authors such as those of Prado-Lorenzo et al. (2011), who obtained evidence that the political ideology of the ruling parties affected the sustainability of cities. Specifically, they concluded that a leftist ideology negatively affects the development of cities.

In relation to the models of the levels of smart cities in each of the ten dimensions, it can be observed that, in general, they have a low explanatory capacity (between 10% and 20%), except for the economy, governance and urban planning, which reach high percentages (46%, 64.4% and 36.4%, respectively) for confidence levels of 99% (p values < 0.01). On the other hand, in general terms, two of the three selected factors have an important effect on each of the dimensions of the IQ levels. The gender of the person who rules in European cities affects the dimensions represented by the economy, human capital, the environment, international projection, social cohesion, governance and urban planning. The same occurs with the variable “Region”, which affects eight of the ten dimensions. European cities concentrated in the western region obtain better results as smart cities in the dimensions that affect the economy, human capital, technology, international projection, social cohesion, mobility and transport, governance and planning urban.

Finally, the variable political ideology lacks explanatory capacity in all dimensions of the smart city level except urban planning, where it reaches a significance level at 95% confidence (p = 0.018). According to these results, a left-wing ideology in the governments of European cities would favour their positions in the ranking in terms of the sustainability of the environment and its inhabitants.

Taking the results obtained for these eleven models into account, we can conclude that the gender of the person who governs and the geographical situation of the city favour the SC levels of European cities.

Table 2. Regression results

Explanatory variable	Global model		Model 1 Economy		Model 2 Human capital		Model 3 Technology		Model 4 Environment		Model 5 International projection	
	β	t (Sig.)	β	t (Sig.)	β	t (Sig.)	β	t (Sig.)	β	t (Sig.)	β	t (Sig.)
Constant	97.41	12.74 (0.000)	107.648	13.805 (.000)	95.573	10.045 (.000)	109.012	10.154 (.000)	57.784	6.236 (.000)	96.458	8.154 (.000)
Gender	-17.50	-2.129 (.037**)	-28.166	-3.358 (.001***)	-20.253	-1.979 (.052*)	.576	.050 (.960)	-17.020	-1.708 (.092*)	24.561	1.930 (.058*)
Region	-45.85	-5.821 (.000***)	-41.086	-5.111 (.000***)	-22.200	-2.263 (.027**)	-26.353	-2.381 (.020**)	-10.890	-1.140 (.258)	-43.616	-3.577 (.001***)
Ideology	6.85	1.082 (.283)	8.180	1.266 (.210)	-.269	-.034 (.973)	4.000	.450 (.654)	7.156	.932 (.355)	2.458	.251 (.803)
F-statistic	19.346		19.604		4.621		2.637		2.290		5.948	
F-sig	.000***		.000***		.005***		.056*		.086*		.001***	
R^2	.457		.460		.167		.103		.091		.205	

Significance at the level 0.10*. Significance at the level 0.05**. Significance at the level 0.01***

Table 2. Regression results (Continuation)

Explanatory variable	Model 6 Social cohesion		Model 7 Mobility and transportation		Model 8 Government		Model 9 Urban planning		Model 10 Public management	
	β	t (Sig.)	β	t (Sig.)	β	t (Sig.)	β	t (Sig.)	β	t (Sig.)
Constant	78.867	7.554 (.000)	101.222	8.285 (.000)	127.233	17.393 (.000)	77.215	8.865 (.000)	121.392	10.711 (.000)
Gender	-31.729	-2.826 (.006***)	-1.290	-.098 (.922)	-19.114	-2.430 (.018**)	-16.380	-1.748 (.085*)	-12.232	-1.003 (.319)
Region	-29.874	-2.776 (.007***)	-38.583	-3.064 (.003***)	-69.741	-9.248 (.000***)	-36.915	-4.111 (.000***)	-18.802	-1.609 (.112)
Ideology	8.728	1.009 (.317)	-4.056	-.401 (.690)	-.377	-.062 (.951)	17.523	2.427 (.018**)	4.004	.426 (.671)
F-statistic	8.265		3.698		41.571		13.143		1.898	
F-sig	.000***		.016**		.000***		.000***		.138	
R^2	.264		.139		.644		.364		.076	

Significance at the level 0.10*. Significance at the level 0.05**. Significance at the level 0.01***

6. Conclusions

This work has allowed us to obtain empirical evidence and contribute to the generation of knowledge about smart cities, given the lack of research with this orientation so far. Thus, an existing gap in the academic literature is covered, since the analysis of the factors that influence the development of smart cities is in a relatively early stage of development, making study of it necessary and interesting.

Regarding the analysis of the associated factors, evidence has been found that shows that the levels of smart cities are related to the geographical location of the cities and the gender of the governors. However, it has not been possible to verify any type of association with the political ideology of the governing team. We can conclude, therefore, that those cities located in the western region obtain better results as CI. The same occurs with cities governed by women, which achieve the best results in the smart cities ranking. Finally, the fact that city government representatives have conservative or progressive ideologies does not seem to be decisive for cities to reach high positions in the ranking.

Finally, we point out that this study highlights the need to develop future lines of research, among which we propose to expand the sample in order to carry out comparative analyses at the level of countries and continents, as well as to analyse the reasons and motivations that may lead to cities obtaining high of smart city levels.

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