Smart Cities and Financial Sustainability

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Smart city initiatives have become recurrent strategies used by local governments to provide better services, improve their managerial effectiveness, and increase citizen participation in cities' decision-making processes. Great potential exists to use data, information, and communication technologies (ICT) more extensively to improve city operations. However, depending on the size and financial situation of the cities, some smart city initiatives could be considered investments that are too expensive and not easy to maintain in the long term. If city governments want to achieve most of the benefits arising from the intense use of technology and data, building financially sustainable smart cities should be seen as a priority.

Keywords: financial sustainability ; budgeting ; financial management ; smart city ; sustainable city ; ICT infrastructure ; long-term capital decisions

1. Introduction

The literature on smart cities includes different definitions of sustainability. The first definitions of sustainability referred almost exclusively to the conditions of equilibrium between human activities and their impact on the natural environment [1]; today, the term refers more broadly to the duration of the effects derived from the smart city initiative over time [2] and the long-term impacts of this type of project on the environmental, social, political, and economic aspects of a city [3][4]. However, the financial sustainability (FS) aspect of smart cities has been neglected and requires more investigation, particularly in relation to the long-term impact of these types of projects.

An example of this increasing concern about the FS of smart cities is the European Commission's initiative, entitled "European Innovation Partnership on Smart Cities and Communities" (EIP-SCC). This initiative attempts to build a joint investment program for European smart city projects by involving investors, city governments and other public agencies, small- and medium-sized enterprises, and other actors from society in discussing and finding financially sustainable solutions (for more information, see: https://eu-smartcities.eu/sites/default/files/2018-06/EIP-SCC_TOWARDS%20A%20JOINT%20INVESTMENT-Paper.pdf (accessed on 12 May 2020)). This project also attempts to identify new market and business models for financing infrastructure and services for smart cities in a sustainable way over time (e.g., crowdfunding, community investment, and the digital social market). A set of indicators and measurements are used to guide funding toward the more financially sustainable and viable smart city initiatives.

The assessment of smart cities' FS takes into consideration not only how local governments perform over time when adopting this type of initiative but also how economic and social contexts may influence their adoption in general [5][6], as well as how these contextual factors may influence investments and spending on an ICT infrastructure in particular [7][8]. Several international organizations have proposed the adoption of FS strategies and policies in the public sector as a form of collective monitoring tool for strengthening financial discipline and preventing financial and economic crises [6][9][10][11][12][13], but the application of an FS framework for local or municipal governments that are adopting large and enduring ICT projects, such as smart city initiatives, is still a work in progress.

2. Smart Cities and Sustainability

Many definitions of a smart city and its components exist. The term "smart city" encompasses a collection of diverse technological developments used to improve cities, through specific tools and applications approaching the topic from a holistic viewpoint [14][15]. Batty [16] (pp. 483–484) pointed out that smart city projects are spaces where ICTs have merged with traditional infrastructures, coordinating and integrating the use of new digital technologies to transform the environment toward a new urban model.

Smart city initiatives require collaborative efforts across multiple levels and functions of government authorities, businesses, citizens, and other actors to improve the quality of life of its inhabitants [17][18]. Therefore, smart city projects

attempt to adopt a holistic approach including several dimensions or axes of development [19][20][21][22]. Six main axes guide smart city initiatives around the world: smartness for the economy, people, governance, mobility, environment, and living [23]. A smart city must develop each axis as an aspiration goal toward continuous improvement. These axes represent a global vision of all aspects of a connected society within the urban space in the future from a more holistic perspective [14]. Whatever the goals established for a smart city initiative, it requires critical investments and budget allocations to acquire the necessary resources, such as people, materials, and ICTs for implementing this type of holistic project.

In addition to data and ICT, there are other important components for smart city projects related to organizational capabilities, policies, and the context in which the smart city initiative is embedded [4][24]. In fact, there are definitions of "smart city" that include the roles of governments, citizens, businesses, and other important social actors in this type of project [25][26][27][28]. In addition to data, technology, and the built infrastructure, smart city initiatives include aspects related to the environment, policies, services, openness to citizen participation, and partnerships with private and nonprofit organizations [29][30]. Important aspects of government policies include investment, spending, and the allocation of key resources.

Smart city research also emphasizes the environmental aspect of sustainability [1][29][31]. The rapid adoption of mobile and sensor technologies, as well as the diversity of Internet applications and social media available, extended the scope of smart city projects to saving energy, supporting environmental care, or improving urban mobility [32]. Many modern urban sites have taken advantage of emerging technologies, extending the concept of sustainability into other dimensions, such as improving living conditions and citizen engagement [33][34]. More broadly, the term "sustainability" has also been identified as the ultimate test of a smart city's strategy for success from a more integral and systematic perspective, in terms of the duration of its results over time [2]. It evaluates outcomes over time, not only focusing on technical or environmental changes but also on a broader perspective of results (e.g., financial health or social justice). Consistently, sustainability now refers to long-term impacts on the environmental, social, political, and economic aspects of a smart city [3][4][35].

Environmental sustainability represents an essential component of the smart city conceptualization. Protecting the environment is recognized as one of the most important characteristics of smartness [33]. However, as mentioned before, other types of sustainability exist, such as social, political, economic, and financial sustainability [36]. Social sustainability refers to a future focus on the improvement of a just society over time [37]. As Castillo, Price, Moobela, and Mathur [38] (p. 39) noted, social sustainability can be defined as "ensuring the well-being of current and future generations, by recognizing people's right to belong to and participate as valued members of a community." Economic sustainability focuses on the uneven distribution of the benefits of digital innovation among citizens and the efficiency of technology in practice [39][40]. Political sustainability positions smartness as a mechanism for reconciling conflicting policy ideals and agendas in urban policymaking, regarding mutually recognized problems and solutions, among different stakeholders [41]. Finally, FS refers to a set of criteria to identify how smart city projects affect the finances of governments and citizens in the long term [42]. FS could also be seen as the ability of a local government to meet its financial and service obligations after investing in smart city projects [43].

Today, the use of the term "sustainability" often includes various strategies to improve the use of public infrastructure, engage citizens in local governance, save energy, foster economic growth, attract business and innovation, protect the environment, and help government officials to learn and innovate [25][44]. The emphasis on sustainability has represented an essential feature in the implementation of several examples of smart city initiatives around the world. Furthermore, several international certification bodies have proposed relevant standards for smart city initiatives, in order to characterize an appropriate set of properties for this type of project. The International Electrotechnical Commission (IEC), the International Telecommunication Union (ITU), and the International Organization for Standardization (ISO) have collaborated to create a uniform set of rules, standards of good practice, and technical cooperation mechanisms around the concept of the smart city. Many of them constitute an international consensus on best practices for smart cities from the holistic viewpoint of sustainable cities and communities (for examples of these reviews, please see [45][46][47]). This is a list of some of the most well-known standards that are specifically applicable to smart cities:

- ISO/TS 37151 defines the principles and requirements for performance metrics for a smart community infrastructure (May 2015).
- ISO 37101:2016 establishes the requirements for a management system for sustainable development communities (July 2016).

- ISO/TR 37152:2016 outlines the basic concept of a common framework for the development and operation of smart community infrastructures (August 2016).
- ISO/IEC 30182 describes and gives guidance for a smart city concept model as the basis for interoperability, along with its component systems (May 2017).
- ISO 37120:2018 defines and establishes methodologies for a set of indicators for city services and quality of life by which to measure sustainable cities and communities (July 2018).
- ISO 37122 specifies and establishes the definitions and methodologies for a set of indicators for smart cities (May 2019).
- ISO 37123 complements ISO 37122 for resilient cities (December 2019).
- ISO/IEC 21972 is the standard that establishes the general principles and guidelines for an upper-level ontology for smart cities (January 2020).

These ISO standards complement each other and others dedicated to energy efficiency and savings, transport (traffic safety), water efficiency management systems related to drinking water and wastewater services, public infrastructure, security and resilience in the case of disaster and emergencies, healthcare, and decent standards of living, among others. Several studies have compared and articulated this family of ISO standards and indicators for smart sustainable cities (see **Figure 1**) [45][46][47].

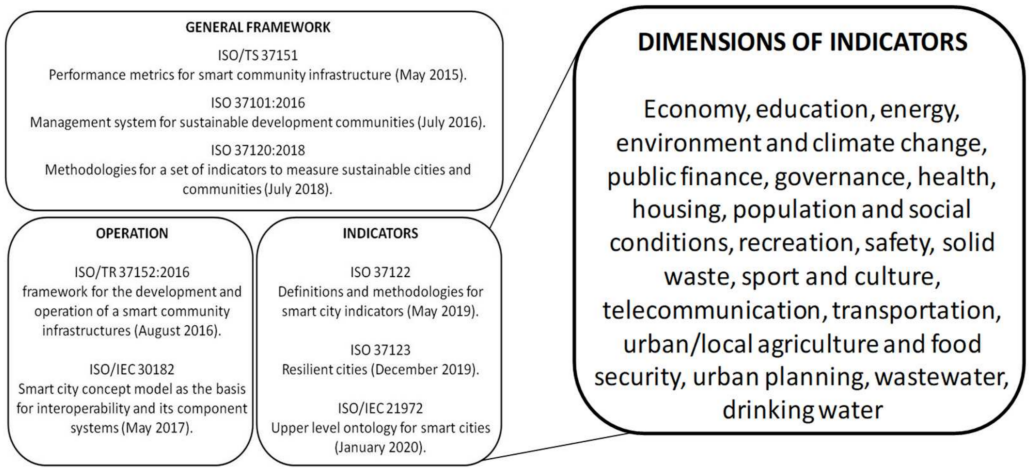

Figure 1. The family of ISO standards for the smart city. Source: authors' own elaboration, based on [45][46][47].

The association between actions and results in each of these dimensions and indicators is particularly important due to the financial spending and investments in smart city initiatives from a city's budget. Understanding how financially sustainable the portfolio of smart city initiatives is over time becomes an essential task for city officials and the city's citizens [33]. As such, this research focuses on the budgetary and financial dimensions of sustainability as they are crucial for smart city initiatives. The following section explains FS in more detail and why it should be seen as an essential tool by which to assess smart city success. It also presents a financial framework that could help city governments to better assess the FS of their initiatives, considering the financial condition of the government, smart city operation over time, ICT infrastructure, and contextual indicators that are compatible with the dimensions and indicators for smart cities from the family of ISO standards.

3. FS for Smart Cities

Assessing the financial condition of governments has become an important topic due to several economic and financial crises in the 1970s, 1980s, in 2008, along with the ongoing crisis that started in 2020 as a result of the COVID-19 pandemic [48][49][50]. The term "financial sustainability" is related to the assessment of the financial condition, fiscal health, fiscal stress, and/or financial performance of a government over time, considered within a complex context [5]. It refers to the ability of a government to meet its financial and service obligations from a systematic perspective, wherein public finances are embedded within complex economic, political, and social contexts [49][51]. It also represents the ability of a government to interact with this context in order to meet present and future financial commitments and achieve an effective service delivery without incurring excessive debt, engaging in budget gimmicks, or using evasive tactics [6] (p.

3962) [52] (p. 7) [53] (pp. 1–2). Analyzing FS from a systematic perspective means, for example, identifying the potential risks from the economic and social contexts and adapting fiscal, budgetary, and debt policies according to that government's context. This type of FS assessment is known as the systemic perspective of the financial condition of governments because it embeds financial condition in its social, economic, and political contexts. The FS framework adopts a systemic perspective within three spheres (see **Figure 2**): (1) the financial condition of a government, (2) its environment, which includes economic, political, demographic, social, budgeting, accounting, spending needs, revenue wealth, and ICT aspects, among others, and (3) the interactions between the first two spheres over time [49][51].

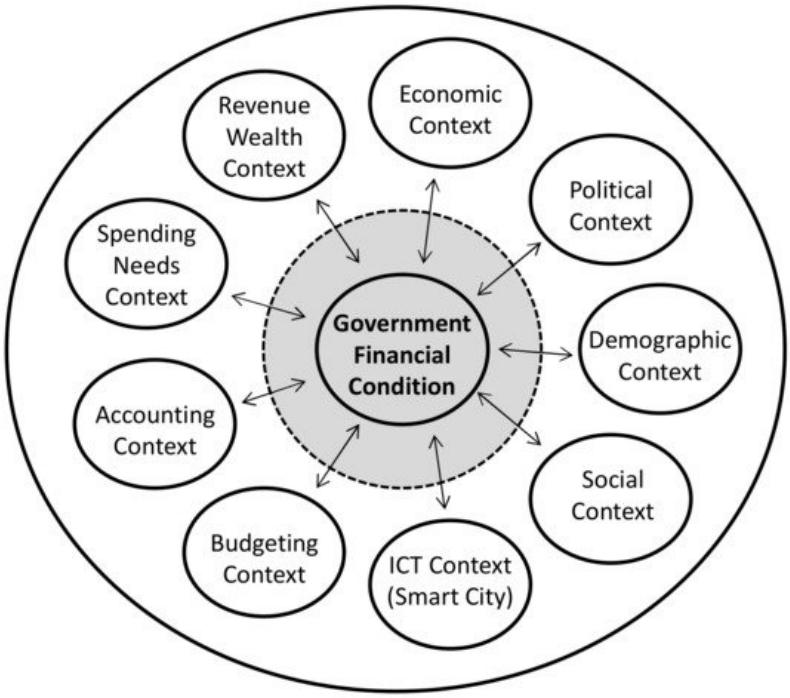

Figure 2. A systematic perspective of FS. Source: authors' own elaboration, based on Hendrick's dimensions of financial health (2004) [49].

The first sphere assesses the financial condition of a government by analyzing revenue, spending, fiscal slack, relativity levels, current operating conditions, and future financial obligations (The indicators used include the unreserved fund balance as a percentage of expenditures (capital expenditures excluded), capital expenditures as a percentage of total expenditures, enterprise income as a percentage of total income and own-source revenue, and debt service as a percentage of expenditures). The second sphere assesses the government's environment by examining the levels of revenue wealth using various indicators. These include the income per capita; the equalized assessed value per square mile; weighted sales receipts per capita; the level of service provisions (spending needs), using indicators such as the weighted crime rate per 1000 inhabitants, reverse median age housing, reverse density (population/square mile), and the presence of a fire district); and other socio-economic, political, and demographic characteristics affecting public finances. The third sphere assesses the interactions between the previous two spheres as marginal effects, assessing indicators such as weighted own-source revenue per capita and the weighted total expenditures per capita (capital expenditure excluded).

Several studies have applied this framework at the national, state/regional, and local levels [6][50][52]. Several international organizations have developed frameworks for monitoring FS at the country level [54]: the UN [13], IMF [12], the World Bank, the Organization for Economic Cooperation and Development (OECD), and the International Federation of Accountants (IFAC) participated in and supported the endeavor together, through the International Public Sector Accounting Standards Board (IPSASB) [11], to establish an international standard of FS, as well as the European System of National and Regional Accounts of the European Commission (EC), for an FS standard based on the European System of Accounts (ESA) [10].

Since the 1970s, several frameworks have been developed and are used to assess the FS of state and municipal governments. For example, the International City/County Management Association (ICMA) developed a handbook for evaluating the financial condition of local governments, based on Hendrick's model in the US [55]. The Lincoln Institute of Land Policy (LILP) and the Government Finance Officers Association (GFOA) developed a financial sustainability index for local governments in California that considers three features of the inner sphere of the FS framework: (1) cash solvency (current assets divided by current liabilities, and the general fund balance as a percentage of total expenditures),

(2) revenue structure (total revenues per capita, with property tax as a percentage of own-source revenues), and (3) debt (total debt as a percentage of revenues, with total debt service as a percentage of revenues) [56]. The Auditor-General of the State of Florida developed a financial condition assessment tool based on 18 financial indicators for counties, municipalities, and special districts. Norcross and Gonzalez (2017) [52] and Wang, Dennis, and Tu (2007) [53] evaluated the IFAC's model at the state level, while McDonald (2017) [57], reviewing at the municipal level in the US, identified four groups of solvency: (1) the ability of the municipality to meet its immediate or short-term financial obligations (cash solvency), (2) the ability of the municipality to meet its financial balance over a fiscal year (budget solvency), (3) the ability of the municipality to meet its long-term financial obligations (long-run solvency), and (4) the ability of the municipality to finance mandatory programs and services (service-level solvency). The four dimensions used in these frameworks correspond to the sphere of the government financial condition of Hendrick's model.

In contrast to other regions in the world, in Latin America, a few tools exist to assess the financial performance of state and municipal governments, but very few frameworks exist for assessing FS, fiscal stress, or financial condition in the region. In Mexico, the Ministry of Finance of the federal government devised a warning system for monitoring the financial discipline of state and municipal governments since 2016 but made no reference to any FS framework. In Brazil, there are several studies about financial resilience across municipalities [58][59][60]. As a result, the current research attempts to contribute to filling this gap by adopting the FS framework to analyze local governments in Mexico that have implemented smart city projects.

In general, the literature related to public finance and accounting has identified the impact of digitalization on several aspects of public finance. Some examples are [61]: ICT tools for taxation and revenue administration, computing techniques for analyzing fiscal data, blockchain and cognitive computing for government spending, and digital technologies for improving public service provisions and financial and treasury management. The main focus of this body of research has been the benefits of digital transformation for government, citizens, and businesses, through reduced administrative burdens, costs, and spending, as well as improved service provision. Ndou (2004) [62] (p. 13) points out that the development of a basic ICT infrastructure is essential for implementing digital government tools, such as websites, mobile technologies, and kiosks, among others, that have implications for financial abilities. However, there is no specific mention of the impact of the ICT infrastructure on the financial condition of governments.

In the published smart city research, few studies have raised the importance of the financial assessment of smart city initiatives. Neirotti and colleagues (2014) [4] created a taxonomy of smart city applications to identify possible strategies and planning actions. They found that there are a few best practices for funding smart city investments through public–private partnerships [4] (p. 31). Alawadhi and colleagues (2012) [63] identify several challenges for smart city initiatives; among them, governance encompasses programmatic directions, budgetary and resource allocations, and other interactions and partnerships with internal and external actors. In this sense, these authors suggest that budgetary pressures and financial constraints are some of the main challenges faced by smart city initiatives [63] (p. 51). Timeus, Vinaixa, and Pardo-Bosch (2020) [4] identified the need for smart city business models including the financial aspects of these types of projects. The example of Barcelona was examined by Leon (2008) [64] (p. 145), who also identified several challenges in terms of insufficient venture-capital funding to attract public–private partnerships for smart cities. In addition, both Komninos (2013) [42] and Shen et al. (2011) [43] suggested incorporating a set of sustainability indicators, including measurements for the financial condition of smart city projects. The European Commission's "European Innovation Partnership on Smart Cities and Communities" (EIP-SCC) initiative raised concerns about the FS aspect of smart cities. This initiative attempted to offer a joint investment platform for European smart city projects by involving investors, city governments, industry, small- and medium-sized enterprises, and other actors in discussing and finding financial and business models solutions for the FS of smart cities, such as crowdfunding, community investment, and digital social markets. Assessing the FS of any municipality, in general [5][6], and those operating smart city initiatives, in particular [63], has become one of the most urgent issues in the context of recurrent severe economic crises such as the financial crisis in 2010 in Europe, caused by the sovereign debt and banking systems of several countries, or the financial crisis in 2009 in the US, provoked by a collapse of the housing bubble in the financial market [7][8].

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