ICT and sustainability in smart cities management

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Abstract

Purpose – Contemporary debate is increasingly focused on ICT and sustainability, especially in relation to the modern configuration of urban and metropolitan areas in the so-called smartization process. The purpose of this paper is to observe the connections between smart city features as conceptualized in the framework proposed by Giffinger *et al.* (2007) and new technologies as tools, and sustainability as the goal.

Design/methodology/approach – The connections are identified through a content analysis performed using NVivo on official reports issued by organizations, known as industry players within smart city projects, listed in the Navigant Research Report 2013.

Findings – The results frame ICT and sustainability as "across-the-board elements" because they connect with all of the services provided to communities in a smart city and play a key role in smart city planning. Specifically, sustainability and ICT can be seen as tools to enable the smartization process.

Research limitations/implications – An all-in-one perspective emerges by embedding sustainability and ICT in smart interventions; further research could be conduct through direct interviews to city managers and industry players in order to understand their attitude towards the development of smart city projects.

Practical implications – Potential approaches emerging from this research are useful to city managers or large corporations partnering with local agencies in order to increase the opportunities for the long-term success of smart projects.

Originality/value – The results of this paper delineate a new research path looking at the development of new models that integrate drivers, ICT, and sustainability in an all-in-one perspective and new indicators for the evaluation of the interventions.

Keywords ICT, Sustainability, Community services, Smart city management, Smartization

Paper type Research paper

1. Introduction

Many cities, due to rapid population growth, face two conflicting issues. On the one hand, problems include the overexploitation of resources, an inadequate number of services, and an increase in pollution. On the other hand, sustainable goals must be achieved to overcome these criticalities.

The integration of new aspects brought to take into account different and innovative factors in governance and management of the urban areas, and this process turned the focus on more complex conceptualizations such as the "smart city" (Schaffers *et al.*, 2011) in which human and social capital and traditional and modern communication infrastructures are combined to carry on the sustainable economic growth and a higher quality of life through a proper management of available resources (Caragliu *et al.*, 2011).

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The challenges in smart cities have fuelled the search for better quality services and have led cities to begin the process of smartization, a path towards the integration of technology in every aspect of the urban environment to offer a better quality of life to its stakeholders.

Since the twenty-first century, an increasing number of smart city projects have emerged using a variety of methods, dimensions, and typologies to address cities' specific policies, objectives, funding, and scopes for their planned projects (Amitrano *et al.*, 2014).

In recent years, the conceptualization of a smart city has generated a large number of studies from scholars, central or local institutions, and industry players involved in smart projects (Nam and Pardo, 2011). The connected streams of research aimed at creating models for smart city projects has led to the identification of pivotal elements, usually known as "characteristics" (Giffinger *et al.*, 2007) or "drivers" (Meijer and Rodríguez-Bolívar, 2015). The latter term indicates the propelling role of the above-cited elements in the development and improvement of urban and metropolitan areas.

The value of these features is strictly related to the decisions of local governments and city managers because they can guide the urban context through the smartization process (Previtali and Bof, 2009). However, the related framework remains complex and diversified, as like as differences emerge when comparing features of local contexts influencing smart projects (Neirotti *et al.*, 2014). More recently, attention has focused on both sustainability as the goal for smartization and on ICT (information and communications technology – or technologies) as a relevant tool or as the key to addressing smart processes (Meijer and Rodríguez-Bolívar, 2015), especially given the findings contained in official reports released by organizations and local agencies.

To identify the results that have already been achieved through smart projects and, in particular, to investigate how to attain a smart city, this paper analyses two connections: the first between ICT and individual smart city drivers and the second between sustainability and individual smart city drivers. The results lead the authors to consider ICT and sustainability as across-the-board elements for smart city projects due to the central role they play in performing smart activities.

2. Literature review

2.1 The conceptualization of smart cities

Currently, urban and metropolitan contexts are increasingly influenced by globalization processes (Berry, 2008) and new technologies (Demirkan, *et al.*, 2011). ICTs are now heavily involved in the governance and management of cities, where they are used as tools and as resources to improve quality of life, achieve sustainable development, and create a more open and innovative urban context through the participation of several actors (Anthopoulos and Tougountzoglou, 2012).

Accordingly, a popular topic in this field is the smart city, which is a new configuration of the urban and metropolitan contexts based on a set of linked features to improve citizens' quality of life, as the urban development policies are often addressed by urban managers dealing with the smart city discourse (Vanolo, 2014).

The smart city began its evolution in the 1970s, when urban contexts adopted a digital configuration (Ishida and Isbister, 2000) that focused on technologies and non-material structures embedded in the physical space of the city. More recently, the integration of new aspects of everyday life turned the focus to more complex innovations, supported by broadband networks and collective intelligence determining the development of the city (Elmquist *et al.*, 2009; Schaffers *et al.*, 2011).

Indeed, over time, scholars, central and local institutions, and large corporations driven by globalization have offered numerous contributions and have proposed several definitions (i.e. digital, intelligent, ubiquitous, wired, hybrid, information, creative, learning, humane, knowledge, and smart) aimed at describing the renewed configurations adopted within the local contexts (Nam and Pardo, 2011). As introduced above, the most commonly used labels are "digital city" and "smart city", and while scholars do not agree on the definitions of these two labels (Shen *et al.*, 2011; Tregua *et al.*, 2015), projects led by supranational institutions share the perspective that a sustainable city represents the evolution of the smart city concept. Anyway, smart interventions in cities have even been criticized, due to issues like poor or fragmented inclusiveness (Walravens, 2011) and splintering urbanism (Vanolo, 2014), and more generally the usage of "smart" just as a label (Hollands, 2008).

Newly developed technology for city (Feldman and Audretsch, 1999) retains an important role in both conceptualizations; indeed, when reviewing the literature, it is clear that in the digital city, ICT represents the infrastructures that shape the city, and in the smart city, ICT is regarded as a set of tools for the governance and management of urban and metropolitan areas to improve services through innovative technologies (Anttiroiko *et al.*, 2013; Lee *et al.*, 2013).

The various aspects characterizing the smart city conceptualization can be summarized through two of the most relevant definitions:

(1) "we believe a city to be smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructures fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance" (Caragliu *et al.*, 2011, p. 50); and

(2) "the more recent interest in smart cities can be attributed to the strong concern for sustainability, and to the rise of new Internet technologies, such as mobile devices (e.g. smart phones), the semantic web, cloud computing, and the Internet of Things (IoT) promoting real world user interfaces" (Schaffers *et al.*, 2011, p. 434).

The inclusion of these different elements in smart cities is based on a model known as the "triple helix" (Etzkowitz, 2003), which involves different and complementary features such as knowledge, entrepreneurship, and institutions. The evolutionary offspring of the "triple helix", namely, the "quadruple helix" and the "quintuple helix" (Carayannis and Campbell, 2010), are based on the inclusion of civil society and natural environment. For this purpose, civil society is defined as the community of users who have an essential role in governance and management – not including the local administrator – and who become operators and users or, better, cre-actors (Tregua *et al.*, 2015), while the natural environment is seen as the context framing these interventions and even as something to be safeguarded when performing smart interventions.

2.2 The development and primary features of smart city models

The approach towards smart cities has evolved through a focus on one or more elements favouring the smartization process. However, only the integration of all of the domains of intervention based on the contribution of ICT can help cities to achieve long-lasting and sustainable economic growth and a better quality of life for urban stakeholders (Anthopoulos and Tougountzoglou, 2012).

This process of integrating different smart initiatives in urban and metropolitan contexts has been achieved through the efforts of different stakeholders (Tregua *et al.*, 2015) playing a role in the analysis of the prerequisites for creating cities with an improved quality of life (Giffinger *et al.*, 2007). These stakeholders include industry players, central or national agencies (i.e. the European Union), and scholars. Their efforts to study smart cities have led to the creation of models which collect the dimensions of urban life to be enhanced and developed through the implementation of smart city projects.

These features have been grouped into clusters and are called drivers because of their propelling role in the development of smart cities. These sets of smart elements have undergone various changes over recent years, and this path can be seen in a selection of studies ordered from the oldest to the most recent (Table I), showing a greater number of studies performed in the last five years.

This table shows an early attempt by the Centre of Regional Science at the Vienna University of Technology, to create a smart city model, which, as of today, remains the most cited and most frequently used (Schaffers *et al.*, 2011). The approach at the foundation of the model considers a smart city to be "a city well performing in a forward looking way in these six characteristics" (Giffinger *et al.*, 2007), namely: Smart Economy, Smart People, Smart Governance, Smart Mobility, Smart Environment, and Smart Living.

The Smart Economy groups all features related to economic competitiveness, such as entrepreneurship, innovation, productivity, and flexibility of the labour market, as well as the international expansion of the local economy. The development of a smart city is closely linked to the creation of an urban context that stimulates new industrial activities (Bronstein, 2009).

Another driver is Smart People, which has been defined through the quality of social interactions in cities, openness towards different cultures, the development of human capital, the education of people, and the role of ICT in the improvement of participation and the reduction of the digital divide (Giffinger *et al.*, 2007). Smart Governance concerns citizens' participation in urban decision-making processes (Kolsaker and Lee-Kelley, 2008), the co-creation of new services for an improved quality of life (Bélissent, 2010), and the implementation of different instruments for collaboration, service integration, and data exchange (Maltby, 2013).

Smart Mobility focuses both on sustainable and intermodal transport systems offering safe and secure conditions through the use of ICT (Bifulco *et al.*, 2014), and on local, national, and international accessibility.

The Smart Environment has been studied in connection with pollution reduction, natural resource management, and the protection and conservation of natural habitats through the efficient use of resources as well as the re-use or substitution of natural resources to reach sustainability goals (Tanguay *et al.*, 2010).

Study developer (year)	Drivers
Centre of Regional Science, Vienna UT (Giffinger *et al.*, 2007)	Economy, people, governance, mobility, environment, living
Bélissent (2010)	Transportation, healthcare, education, public safety and security, building management, city administration, waste management
Smart Cities Council (2013)	Buildings, energy, telecommunication, payments, transport, human services, water, public safety
EU-European Parliament (2014)	Governance, economy, mobility, environment, people, living

Table I.
Smart cities drivers

Finally, Smart Living has been identified with quality of life, namely, housing, culture, health, tourism, and a specific interest in the search for high levels of social cohesion.

This smart city model was updated by the European Parliament in "Mapping Smart Cities in the EU" and the comparison between the two studies shows that the EU highlights ICT as a feature within all of the six previous identified characteristics rather than as a particular element acting as a Smart Mobility driver. ICT is considered to be a fundamental feature with specific qualities: it is an across-the-board driver, specifically, "a key enabler for cities to address these challenges in a 'smart' manner".

2.3 The role of ICT and sustainability in smart cities

The increasing number of smart city initiatives can be linked to the diffusion and integration of new technologies, in particular, ICTs and data management functionalities, expanded from elementary data acquisition to data processing and interpretation. These advances have been widely exploited due to the diffusion of mobile devices, which allow people to participate in (Kirwan, 2015) and contribute to their urban and metropolitan environments.

The important role played by people, the so-called human component (Nam and Pardo, 2011), within the smartization process has led to a different conceptualization of technologies as intelligent instruments aimed at the creation of cities with an improved quality of life (Bulu, 2014) and at the improvement of human participation through services co-creation (Kirwan, 2015). The participation should be further enabled to avoid social marginality (Vanolo, 2014; Huston *et al.*, 2015).

The technological elements required to deploy smart initiatives include the implementation of the necessary hardware (sensors, wireless equipment, etc.) and software (artificial intelligence, expert systems, etc.) to create a "physical-digital environment of smart cities" (Schaffers *et al.*, 2011, p. 435; Li *et al.*, 2015). Scholars have focused their attention on the relationship between technology and urban life, and some recent studies (Lombardi *et al.*, 2012) analyse the requirements of a new holistic system for integrated data acquisition, querying, and mining that can be realized through the development of common open platforms and ubiquitous ICT infrastructures. Specifically, a smart city must deploy smart computing technologies, combining the use of software systems, server infrastructures, network infrastructures, and client devices to connect different urban services and stakeholders (Åkesson *et al.*, 2008). Some of the most developed ICT applications in smart cities are GPS technologies to enhance transportation and traffic flow; database technologies for health, energy efficiency, and education; pattern recognition software to improve security systems; and mobile technologies to engage people in services co-creation or social activities (Bulu, 2014). The role of ICT is related to the development of smart initiatives within all smart city drivers, but it has also a clear relationship with the challenge of sustainable development in urban environments (Lombardi *et al.*, 2012; Meijer and Rodríguez-Bolívar, 2015) for all citizens, looking for a participation as wide as possible (Vanolo, 2014; Luque-Ayala and Marvin, 2015). Strictly related to ICT, sustainability has been widely analysed among international agencies, scholars, and associations, and its application in the smart context (Lombardi and Vanolo, 2015) has led to different definitions in relation to the focus on a specific dimension (economic, social, and environmental) in the deployment of smart projects.

In fact, the concept of sustainability is widely recognized as "development that meets the needs of the present without compromising the ability of future generations

to meet their own needs" (World Commission on Environment and Development (WCED), 1987). This first attempt to define the context of sustainable development has been expanded to take into account the economic and social dynamics of modern economies, leading to a broader meaning with the so-called "triple bottom line" (Rogers and Ryan, 2001). The prevalent definition of sustainability has been used to underline the relevance of the preservation of natural resources, social equity, and economic development in search of a systemic vision with elements that contribute to achieving common goals.

The application of sustainability within territories has been proposed by different scholars such as Beatley (2000), who considered the concept of smart growth in urban neighbourhood, Schilling and Logan (2008) who emphasized sustainable strategies in cities to create new urban scenarios, especially regarding local communities, and Talen (2011), who argued the replace of unsustainable contexts with sustainable ones.

Other operative implications of sustainability in urban contexts have been proposed by Yigitcanlar and Lönnqvist (2013), who focused on the role played by knowledge in city design and on strategies concerning all three different dimensions of sustainability for a sustainable urban development; Hollands (2015) highlighted the role of sustainability in smart cities and the opportunity offered by new technologies to achieve sustainable goals.

Furthermore, another field of study has focused on more complex issues, namely, sustainability models, first conceived by scholars such as Hartwick (1977) and Solow (1986), who considered sustainability to be an investment with clearly observable direct impacts in relation to the achievement of a goal. Consequently, scholars have focused on sustainability within the domain of economics and finance to analyse the existing evaluation tools and to create new ones. Increasing attention has been paid to identifying financing opportunities for smart initiatives and to selecting the most suitable initiatives to create smart city projects that are sustainable in the long term. One of the main contributions to the analysis of financial solutions was provided by Komninos (2013), who delineated the instruments used to support the implementation of an enabling platform for the development of innovative city services for urban stakeholders. Specifically, the identified solutions are public development funding, reselling, data monetization, free core services and payments for additional features, advertising, sponsorship, leasing, and crowdfunding (Komninos, 2013).

Finally, there has been increasing interest in sustainability in smart cities from a quantitative perspective; namely, attention has focused on the development of measures and indicators. One important attempt was made by Tanguay *et al.* (2010), who first provided an overview of sustainability and the definition of the "triple bottom line", after which they explored a wide range of indicators aimed at examining the risks related to data accessibility, and the absence of standards before analyzing and presenting suitable indicators to apply in smart cities. The approach to sustainability was even considered as a limit when referred just "to classic dimensions" (Tanguay *et al.*, 2010, p. 410), since a city requires a perspective as wider as possible to the multiple challenges arising (Hollands, 2015).

3. Purpose and methodology

3.1 Purpose

An investigation of the literature shows the relevance of smart city characteristics, also known as drivers. Specifically, our research will focus on the role of ICT and sustainability in smart cities, particularly in relation to these drivers; the expected

results will contribute to enhance the recent research streams on smart cities and to follow the investigations on ICT firms supporting smartization (Hollands, 2015).

Indeed, ICT and sustainability cannot be considered using the characteristics detailed above because these characteristics have across-the-board aims. New technological development is pivotal in cities' growth, primarily because ICTs connect different stakeholders and offer better services (through informatization and digitalization). New technologies are connected to each driver with the aim of generating urban growth through sustainable development.

Therefore, the goal of this paper is to investigate how ICT and sustainability interact with smart city drivers when considering the following question:

RQ1. What are the links between ICT and smart city drivers?

There are different approaches to sustainability in smart cities both in the literature and in projects launched around Europe. Sustainability can be seen as strictly related to non-compromising development, as a set of different tools (or different perspectives) or as a goal in smart city projects. The second RQ is as follows:

RQ2. What are the links between sustainability and smart city drivers? Is sustainability primarily considered in economic, social or environmental terms?

3.2 Methodology and data analysis

The characteristics of our research questions lead us to apply a qualitative methodology, due to the novelty of the topics (Lee, 1999), leading to an exploratory nature of our approach. We chose to perform a content analysis using NVivo (Krippendorff, 2012) on official reports released by industry players supporting smart city projects, namely, highly detailed dossiers, from 10 to 30 pages long, on how innovative activities are carried out in cities that aim to become smart, in order to examine how the features under investigation are considered in projects launched around Europe.

The choice of NVivo was based on methodological suggestions by scholars (Krippendorff, 2012) in a inductive approach (Bazeley and Jackson, 2013) because it provides the chance to explore connections among elements (Tesch, 1990); moreover the software gives the opportunity to perform different levels of analysis and to present them in statistical indices and graphs, which are useful when considering the relevance of the results. Specifically, this software allows one to observe, analyse, and classify the information contained in the selected documents and to state linkages among pieces of information and among the issues shaping them. This perspective is useful in management studies (Patton, 2005) and it leads to some advantages when investigating the strategic approach to interconnected issues (Morris, 1994).

The collection of documents includes a selection from 15 industry players based on a list of organizations performing smart city projects by Navigant Research (2013), a firm that offers market research and consulting services through in-depth analyses on global technology markets and especially on smart cities. The reliability of the analysis is safeguarded thanks to the parallel contributions of each author, as suggested by Krippendorff (2012).

Specifically, official reports were selected by performing a Google search (Oh *et al.*, 2005; Morris *et al.*, 2005) and collecting the first three documents reported by each player. This process resulted in a data set comprising 45 documents. The relevance of the documents was based on the information they contained about ideas, strategies,

and the performance of smartization processes; their content had been validated by both industry players and local agencies involved in the projects.

To answer to the first research question, a content analysis was performed on the industry players' official reports using the NVivo word frequency query based on ICT. As regards the second research question, the investigation aimed to deepen the meanings assigned to sustainability as it relates to smart city drivers, in line with the findings of the literature review.

To achieve this goal, a second level of similarity among words, namely, "stemmed words", was chosen. This analysis uses the primary word – known as the stem or root – and its corresponding similar words (i.e. plurals, pronouns, etc.) in a process comparable to lemmatization.

The results were found in the so-called "near content", namely, in a fixed range of closeness (five words) around the focal term of the semantic area used in the first query.

To answer *RQ1* and *RQ2*, the most frequent words, as identified in the word frequency query, were employed to create semantic areas to be implemented in a cluster analysis. This approach combined evidence from the empirical analysis with that emerging from theory based on the analysis performed on official reports from large corporations involved in smart city projects.

Each semantic area was considered to be a "node" for the cluster analysis: in NVivo, a "node" is a unit of analysis that groups data. All authors took part to the analysis of "nodes" to give more reliability to the research process. Through cluster analysis, it is possible to infer relationships among nodes, even when using different indices to measure the similarity, dissimilarity and distance of the data sets. Finally, Jaccard's proximity index was selected – as the most suitable among the three indices proposed – to measure the probability and verify links when performing a content analysis through NVivo (Gök and Hacioglu, 2010; D'Enza and Palumbo, 2013) and when comparing the proximity of the data (Bazeley and Jackson, 2013) without the use of redundancy.

4. Results and discussion

NVivo performed different types of analysis, as stated in the above paragraph on the methodology. The sources from all organizations related to smart city development were first used to focus on the word frequency and to there by understand the most relevant topics. These results were then used to create the nodes and to analyse the relationships among them, as represented in the following figure (Figure 1); each node

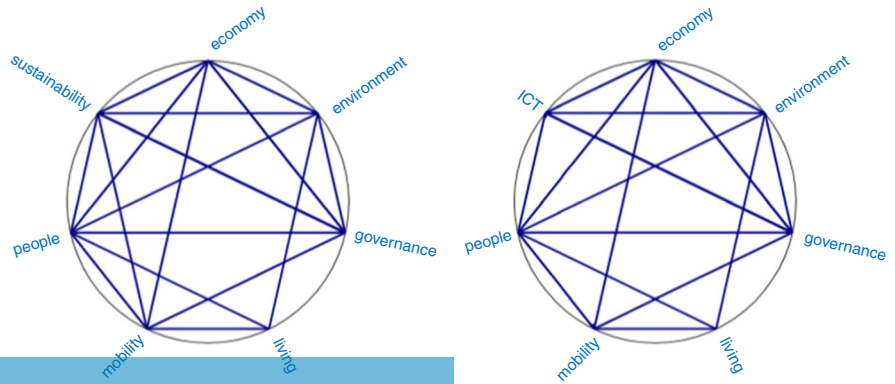

Figure 1.
Nodes clustered by word similarity

from the analysis is useful to represent one of the six drivers, the ICT, or the sustainability. The focus of the two research questions led us to perform a cluster analysis to depict the relationships emerging between the semantic areas based on the concept of sustainability and the semantic areas describing the drivers of the smartization process.

The results relate to the role of sustainability and ICT in terms of the drivers arising from the literature; the links that emerge from these are used to express the relationships among the created nodes if their likelihood is equal to or higher than 0.75 based on Jaccard's index. The results show a strong level of cohesion in how organizations approach smart cities, so the focus was on those relationships with a result of 0.75 and above. These results are represented in the following figure (Figure 2), which depicts the relationships between the six smart city drivers and ICT and sustainability.

The links indicated by a continuous line are of a likelihood equal to or higher than 0.75 on Jaccard's proximity index (ranging from 0 to 1), while those depicted by a dotted line have a likelihood level lower than 0.75.

Regarding the links between ICT and the six drivers (Table II), the software analysis offered the highest levels of likelihood for relationships between ICT and people, ICT and living, and ICT and the environment, which are all over 0.75 on Jaccard's index.

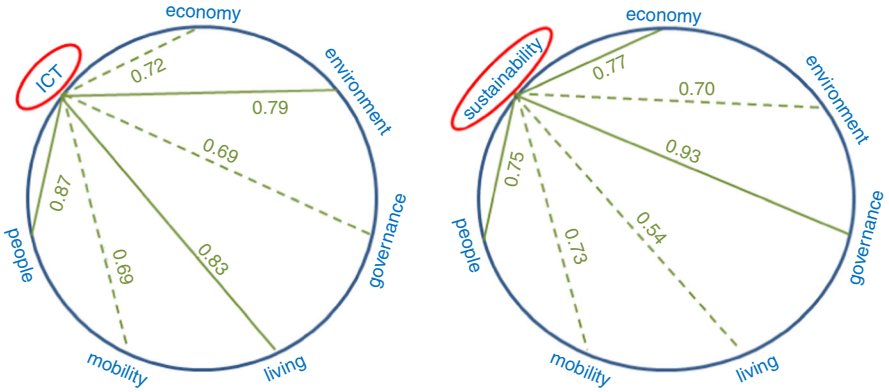

Figure 2.
Relationships between drivers and ICT and sustainability classified using Jaccard's proximity index

Main node	Node (drivers)	Jaccard's coefficient
(a) ICT	People	0.871686
	Living	0.831807
	Environment	0.797004
	Economy	0.720386
	Mobility	0.692934
	Governance	0.692509
(b) Sustainability	Governance	0.926875
	Economy	0.773381
	People	0.750686
	Mobility	0.734021
	Environment	0.704062
	Living	0.54164

Table II.
Relationships between the six drivers and ICT (a), and between the six drivers and sustainability (b)

The relationship emerging between ICT and people can be better understood by focusing on the creation, spread, and usage of mobile and smart phone apps. These apps are tools provided to citizens and other stakeholders aimed at encouraging their participation, improving the availability of information, and, in general, enhancing their sense of community (Lee and Lee, 2014). ICT is a method to enable resource integration and service provision in a context with numerous stakeholders who are both the carriers of resources to be integrated and actors expressing needs to be satisfied.

The link between ICT and Living is relationship is directly connected to ICT and people, as ICT is seen as a method of improving service provision to communities. "Living" groups a wide range of facilities – cultural services, health, education, housing, and safety, among others – that are provided to improve the quality of life in urban contexts, particularly for citizens. The primary challenge for a city is to become "smarter". The switch in smart services (Lee and Lee, 2014) started with digitalization and is ongoing, especially in terms of encouraging service integration. This link mirrors the step enabling the leveraging of data to achieve better services (Ishida and Isbister, 2000) using ICT methods to collect information emerging from feedback.

The third relationship among those with a likelihood higher than 0.75 is represented by ICT and the environment. This link is based on the testing and the usage of sensor networks in the processes planned and deployed to perform waste and water management. These types of processes also provide electricity in cities and in residential areas (Bulu, 2014) in a more sustainable way and favour the exchange of data through ICT. The sensors linked in networks are the outcome of the "convergence of micro-electro-mechanical systems technology, wireless communications and digital electronics" (Akyildiz *et al.*, 2002).

Other links are observed, although their likelihood level is lower than 0.75. ICT in relation to the economy increases income through the sale of apps, leading to a higher propensity to buy services, especially those related to culture and tourism, and offering increased economic efficiency for some services (Kramers *et al.*, 2014). ICT is a tool for mobility because it can facilitate the use of public transport by providing logistical information, and it can even encourage a switch between different methods of transportation (Lee *et al.*, 2013). Moreover, apps can be used to link transport services to transport-related facilities such as parking and rental facilities. Finally, ICT and governance can be examined together by taking into account the increasing spread of projects based on leveraging open data from public administration activities (Maltby, 2013). Open data "is data that can be freely used, re-used and redistributed by anyone – subject only, at most, to the requirement to attribute and share-alike" (Open Knowledge Foundation, 2012); with the use of technological infrastructures and specific software, open data can be easily achieved.

The results of the second research question are related to the topic of sustainability and an overall presentation is contained in the following table (Table II).

The first piece of evidence from the analysis is represented by the linkage between sustainability and governance, which has the highest level of likelihood (0.93 with a highest possible value of 1.00). Thus, the topic of sustainability can be taken into account as a type of guideline directing governing bodies (Neirotti *et al.*, 2014) and as a series of interventions to be deployed over a given period of time. This conception is based on the definition of a vision and a strategy oriented towards the smartization process. Acting sustainably means considering the needs of citizens and other stakeholders, leading to the creation of value when they use the services and resources provided (Lee *et al.*, 2013). Hence, the overall goal of smart interventions is to enable a

sustainable approach when acting to satisfy stakeholders' needs and to achieve the expected outcomes in the long term.

A second result is the link between sustainability and the economy; Jaccard's proximity index for this relationship is equal to 0.78, which is greater than the benchmark of 0.75. This connection led us to consider the relevance of sustainability to smart city projects and how it can lead to both economic feasibility and financial sustainability (Shen *et al.*, 2011).

In line with this consideration, financial and economic issues are the most relevant aims (Neirotti *et al.*, 2014) among those affecting smart project plans; however, this choice has disadvantages when considering other features of sustainability. Moreover the expected revenues or the decreases in costs are advantages representing a potential aim for both public actors and private organizations (Kramers *et al.*, 2014).

The third result that emerged from the cluster analysis is the link between sustainability and people, which has a 0.75 likelihood level on Jaccard's proximity index. This relationship led us to focus on the significance of the social dimension of sustainability in terms of the potential output for some of the city's stakeholders, especially citizens, as seen when debating the relationship between sustainability and governance. The social perspective on sustainability is relevant because "community" and "citizens" are some of the most important elements shaping the semantic area built around "people", and this perspective can complement the previous approach to economic issues. Specifically, the smart community is an emerging topic in the smart cities management literature, and projects present the smart community as an evolution of the smart city concept. Finally, smart interventions need to be oriented towards sustainability because their deployment should create benefits for some actors without decreasing the wellness of others as is clearly stated in the most common definition of sustainability (Carroll and Buchholtz, 2014).

The results shaping this last section of findings for *RQ2* consists of the links with a likelihood level of lower than 0.75, for example, sustainability and mobility (0.73), sustainability and the environment (0.70), and sustainability and living (0.54).

The tie between sustainability and mobility has a 0.73 likelihood level on Jaccard's proximity index, and the approach to mobility in smart projects is related to transportations facilities. Sustainability is considered to be one of the most relevant goals when transport networks are improved to decrease congestion and facilitate transit connections, particularly for commuters. Sustainability linked to transport has a positive impact on the environment because the increased usage of public transportation can result in a lower quantity of CO_2 and other toxic emissions. This latter point is critical in the debate on environmental sustainability, since cities pinpoint environmental sustainability as one of their primary goals on their agenda.

Conversely, the link between sustainability and living has a lower level of likelihood because of the heterogeneous way in which the semantic area built around "living" is shaped by services related to culture, tourism, education, security, and health. Apart from tourism, the link with sustainability is rarely considered. The role of all facilities is considered to be an issue that must be taken into account but not necessarily approached in a sustainable way.

5. Conclusions

This paper contributes to literature on smart cities, namely, on contributions on urban management, by highlighting a perspective that goes beyond a mere "technology-centric vision" (Vanolo, 2014), specifically a multifaceted issue, as it has been recently

defined by Hollands (2015); the results and considerations presented above are useful to frame ICT and sustainability as "across-the-board elements" because they connect with all of the drivers of a smart city (Giffinger *et al.*, 2007) and play a key role in smart city planning. Specifically, sustainability and ICT can be seen as tools to enable the smartization process, as partially highlighted by Li *et al.* (2015) as it concerns ICT, and by Hollands (2015) when investigating the role of sustainability. The results achieved in this research give the opportunity to enlarge the existing perspectives as they just focus on the drivers (Giffinger *et al.*, 2007; Nam and Pardo, 2011; Schaffers *et al.*, 2011). Moreover, a focus on ICT was missing when scholars investigated sustainability in smart cities (Huston *et al.*, 2015); a similar consideration arose when scholars focused on ICT without taking into account the relevance of sustainability (Kolsaker and Lee-Kelley, 2008; Bulu, 2014). By adopting a perspective based both on ICT and sustainability we joined the research avenue proposed by Vanolo (2014) when stating "urban visioning is increasingly reduced to a single technology-centric vision of the city of the future" (p. 897). A focus on communalities emerging from the analysis of different approaches to smartization is interesting, since in previous studies (Neirotti *et al.*, 2014; Hollands, 2015) scholars just paid attention to dissimilarities depending on local actors and factors.

From a practical perspective, city managers can choose to lever on ICT to improve services and thus quality of life, leading to sustainability goals. The evidence presented in this paper comes from official reports in connection with different geographical areas; completed projects such as these are useful for city managers planning smart interventions or for large corporations partnering with local agencies in cities aimed at becoming smarter. Anyway, local issues have to be taken into account when planning interventions, due to the features arising from each specific local context. Furthermore, as the documents we collected represent ideas, strategies, and the performance of smartization processes, new insights can be attained in future through investigations on new performances and further deployment of smart interventions.

Finally, the links emerged in the analysis can be further investigated, as sustainability management is a common topic in the recent literature about city managers. To follow this research path, new models that integrate drivers, ICT, and sustainability in an all-in-one perspective can be proposed and, in line with these models, new indicators for the evaluation of the interventions can be developed.

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