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Current trends in Smart City initiatives: Some stylised facts

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ABSTRACT

The concept of Smart City (SC) as a means to enhance the life quality of citizen has been gaining increasing importance in the agendas of policy makers. However, a shared definition of SC is not available and it is hard to identify common global trends. This paper provides with a comprehensive understanding of the notion of SC through the elaboration of a taxonomy of pertinent application domains, namely: natural resources and energy, transport and mobility, buildings, living, government, and economy and people. It also explores the diffusion of smart initiatives via an empirical study aimed at investigating the ratio of domains covered by a city's best practices to the total of potential domains of smart initiatives and at understanding the role that various economic, urban, demographic, and geographical variables might have in influencing the planning approach to create a smarter city. Results reveal that the evolution patterns of a SC highly depend on its local context factors. In particular, economic development and structural urban variables are likely to influence a city's digital path, the geographical location to affect the SC strategy, and density of population, with its associated congestion problems, might an important component to determine the routes for the SC implementation. This work provides policy makers and city managers with useful guidelines to define and drive their SC strategy and planning actions towards the most appropriate domains of implementation.

Introduction

Current cities are complex systems that are characterised by massive numbers of interconnected citizens, businesses, different modes of transport, communication networks, services and utilities. Population growth and increased urbanisation raise a variety of technical, social, economic and organisational problems that tend to jeopardize the economic and environmental sustainability of cities. The rapid growth faced by several cities has generated traffic congestion, pollution and increasing social inequality (Kim & Han, 2012). In this context, a debate has emerged on the way new technology-based solutions, as well as new approaches to urban planning and living, can assure future viability and prosperity in metropolitan areas (Alawadhi et al., 2012; Dirks, Keeling, & Dencik J., 2009; Nam & Pardo, 2011; Nijaki & Worrel, 2012). In this discussion, the concept of Smart Cities (SCs) (Hollands, 2008) has been the subject of increasing attention and it now appears as a new paradigm of intelligent urban development and sustainable socio-economic growth, whose origin can be traced back to the Smart Growth Movement of the late 1990s (Harrison & Donnelly, 2011). However, despite the rise in SCs in the urban planners' debate on the future of cities, the diffusion of SC initiatives in countries with different needs and contextual conditions (e.g. in either developed or developing nations) makes it difficult to identify shared definitions and common current trends at a global scale. There is still in fact no general consensus on the meaning of the term SC or on what its describing attributes are. However, there is wide agreement about the fact that SCs are characterised by a pervasive use of Information and Communication Technologies (ICT), which, in various urban domains, help cities make better use of their resources. However, ICT-based solutions can be considered as just one of the various input resources for projects and approaches to urban planning and living that have the aim of improving the economic, social and environmental sustainability of a city. This implies that those cities that are more equipped with ICT systems are not necessarily better cities, and that the number of "smart" initiatives launched by a municipality is not an indicator of city performance, but could instead result in an intermediate output that reflects the efforts made to improve the quality of life of the citizens.

As a consequence of the lack of a common view, investigating the diffusion patterns of SC initiatives around the world may help to generate a better understanding of the characteristics and future trends of SCs and contribute to the current debate. The importance of this analysis lies in the awareness that various obstacles tend to slow down the diffusion process of SC initiatives. According to recent evidence (The Economist, 2013), most of the companies

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on the market for ICT solutions for cities have not met their revenue targets from 2010 to 2013.

Because of the obstacles that slow down ICT diffusion, and the central role of political, economic and cultural contexts in shaping the way cities try to become smarter, it can be expected that there is not just one unique paradigm of SC evolution throughout the world. As a result, the aim of this research activity was to investigate whether, and how, the emerging models of SCs differ from the concept of SC developed by city planners, technology visionaries and academicians.

This work is an attempt to fill the research gap in the diffusion of SCs through an empirical study on the role that SC initiatives play on the functional domains of urban living. The role of economic, urban, demographic, and geographical factors on the planning approach to the building of a smarter city is investigated by analysing the coverage ratio that SC initiatives have in relation to the extent of their application domains. The paper may thus be considered as a support for local policy-makers and city managers as it articulates the value proposition of SCs in a basket of appropriate initiatives and applications.

The remainder of this paper is structured as follows. The key elements that characterise the notion of SC in the literature are examined and integrated in an extended taxonomy of SC application domains. On the basis of this taxonomy, a sample of 70 international cities has been analysed through the lens of a Coverage Index (CI), which takes into account the number of application domains wherein cities have launched their projects. The relationship between the CI and the economic, social, geographic, demographic and environmental characteristics of a city allows one to find common points and differences in the way the SC paradigm is applied throughout the world. The implications of these analyses are discussed in the final part of the paper with the aim of providing policy-makers with recommendations on the levers that are likely to foster SC initiatives. Finally, possible future research directions are discussed.

Literature review on the Smart City notion

This section is aimed at clarifying the meaning of SC by discussing its characterising features and their application domains. To this end, a categorisation of the possible domains of an SC has been proposed to represent the patterns of SC initiatives in the empirical work presented in this paper.

The characterising attributes of SC

One part of the SC literature stresses the need for citywide planning and control, and the central function of ICT systems as the city digital nervous systems that obtains data from heterogeneous sources (e.g. sewers, parking spaces, security cameras, school thermostats, traffic lights, etc.). Many SCs are thus sophisticated systems that "sense and act" (REF, (Hall, 2000; Marsa-Maestre, Lopez-Carmona, Velasco, & Navarro, 2008), and in which a great volume of real-time information is processed and integrated across multiple processes, systems, organisations and value chains to optimise operations and inform authorities on incipient problems. The role that ICT plays in cities is the same one that these technologies have in organizations and that has been largely described in Information Systems literature and organization studies: improving productivity (i.e. output divided input) through automatic routine processes and by powering managers' decision-making, planning and control activities. In cities, ICT is likely to contribute substantially to solve the emerging problems of urban living. For example, a mixture of the right data and of the right policies and interventions can make morning traffic run more smoothly, or spread out the evening peak energy use.

According to this view of SCs, the deployment of ICT should not be identified with the concept of SC, since smart initiatives do not only entail technology changes, but also investments in human capital and changes in urban living practices and conditions. In other words, ICT is a General Purpose Technology (Bresnahan and Traitenberg, 1995), which is complementary to human and organizational capital and whose usage is shaped by political choices and by the urban ecosystem of the citizens, technology vendors and local authorities, depending on the city's needs and habits. As such, the same ICT system can exhibit different patterns of usage across cities to reflect different needs and conditions in their local contexts. This directs interest towards studying the various diffusion patterns of SC initiatives around the world.

Since ICT is unable to transform cities without human capital, another body of studies has focused on the role of human capital in improving city liveability. As such, SC initiatives can also include human capital investments that are aimed at fostering a city's capacity for learning and innovation, by supporting and motivating the local population in education and by improving their own life and attracting and retaining other valuable inputs from outside, i.e.: talented and highly educated figures, investments from innovative enterprises, investors and entrepreneurs with the financial and human capital to start-up new enterprises (Caragliu, Del Bo, & Nijkamp, 2009; Correia & Wünstel, 2011; Giffinger et al., 2007; Hollands, 2008; Rios, 2008; Toppeta, 2010).

Finally, in previous studies, the adjective "smart" also referred to the government of a city and its capacity to generate innovation in the way services and communication are delivered to the local population (González & Rossi, 2011).

Application domains of the SC

Basically, the various positions in the debate agree on the fact that an SC should be able to optimise the use and exploitation of both tangible (e.g. transport infrastructures, energy distribution networks, natural resources) and intangible assets (e.g. human capital, intellectual capital of companies, and organisational capital in public administration bodies). The various approaches to the definition of SC are mainly related to two different factors, namely the way cities can steer themselves to achieve this goal of optimisation, and the domains that are more critical for a cleverer usage of urban resources. Some planners, who have echoed Le Corbusier's dictum that a "house is a machine for living in", see cities as factories for life, on the basis of a broad use of ICT that enables central planning and an integrated view of the processes that characterise urban operations. Consequently, the emphasis of this approach is on production and the distribution of energy, transportation and logistics, waste management and pollution control, and it looks at the way ICT can harness information processing in these fields.

The other positions instead view the ways of building SCs as being based more on bottom-up approaches in which cities provide access to data and allow citizens to make their own decisions. Consequently, they stress the importance of investments in "soft" urban living domains wherein ICT plays a more limited role in enabling sustainability and handling "transactions", which is thus related to welfare and social inclusion policies (e.g. the assistance of disabled citizens), culture and education.

This variety of visions and facets about the SC concept is an expression of the multitude of urban living domains to which technology and policy interventions can be applied. Table 1 provides an overview of the domains that are illustrated in various streams of literature, relevant to the topic of urban development. As can be seen in this table, the domains in which urban development policies are applicable can be classified as "hard" or "soft", in relation