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The many faces of the smart city: Differing value propositions in the activity portfolios of nine cities

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ABSTRACT

There are still misunderstandings and differing opinions about what a smart city (SC) is, and there are only of few publications available on what beneficial outcomes cities are anticipating from SC developments. This paper identifies nine anticipated benefits/value proposition components of smart city activities, based on a literature review. It then uses a comparative multiple case study analysis to investigate how value proposition components are present in the SC activities of six cities with demonstrated excellence: Amsterdam, Barcelona, London, Helsinki, New York, Vienna; and three with emerging excellence: Berlin, Budapest, Moscow. The study reveals the distribution of the components in each city for different years, then these annual activity portfolios are clustered. Four different types of smart cities emerge from the analysis: (1) The Green City – in which years of activities, cities are focusing on environmentally related objectives; (2) The App City – in which years of activities, cities are focusing on developing and rolling out platforms and ICT applications to provide Quality of Life improvements directly for citizens; (3) The Socially Sensitive City - in which years of activities socially sensitive activities are prominent; (4) The Participatory City – in which years of activities citizen engagement is in focus. The findings provide a more comprehensive explanation to the mono-dimensional and holistic strategic approach of smart cities.

1. Introduction

Ever since fundamental controversies were reported by Hollands (2008) in the smart city (SC) research, covering the period between 1990 and 2007, studies aiming for untangling the contradictory nature of the literature have been gaining ground in the scientific community. Mora et al. (2017); Mora et al. (2018) and Komninos and Mora (2018) unveiled the significant differences of SC research streams, by capturing four distinct dichotomies, present in scientific publications. Mora, Deakin, and Reid (2019) introduced a rigorous case-study based methodology to analyze SC developments. With their proposed research methodology framework, they tested and validated the four dichotomies as the divergent strategic principle of SC development, and tested their hypothesis in leading examples of cities (Mora, Deakin, Reid, & Angelidou, 2019).

The purpose of this paper was to establish a better connection between the theory of SC and practical implementation. There are still misunderstandings and differing opinions about what a SC is (Kitchin, 2015; Komninos, 2011). Additionally, the implementation of smart city developments ought to be realized with strategic methods (Angelidou, 2015; Komninos, 2014; Mora & Bolici, 2016, 2017). The particularities of how these strategic principles should be considered are relatively well researched; however, there are only of few publications available on what beneficial outcomes cities are anticipating from SC developments, and how are they represented in their implemented activities. Moreover, the theory lacks empirical research.

To address this knowledge gap, we investigate (1) what benefits are anticipated from SC developments; (2) how these benefits are present and distributed among SC activity portfolio of cities; (3) how SC activity portfolios and cities are categorized based on their anticipated benefits. To answer these questions, in this paper, we deconstruct the principle value proposition components - or in other words, anticipated benefits - of SC development activities, identifiable in the SC literature. Then, we analyze their presence in the activity portfolio of eight European and one North American examples of smart city development. To achieve this, we adopt a deductive-based multiple case study analysis, following the methodological research principles, introduced by Mora, Deakin, Reid, and Angelidou (2019). In the sampling procedure, we included six

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cases, reported by researchers as best practices, the excellence of SC practices. Other three samples are covered to a lesser extent in the literature, labelled as emerging excellence cases of SC development.

The paper is structured accordingly. After this Introduction section, a comprehensive literature review follows, where the anticipated benefits of SC development activities are collected. Papers range from 1999 to 2020. The identified value proposition components are eventually used as a conceptual framework for the analysis. The next section explains the particularities of the case study methodology and reasoning for the sampling of the cities and their SC development activities. The Results section provides descriptive statistical data on the distribution of value proposition components, and other factors, that were considered in the analysis. Based on the identified anticipated benefits and temporal data, SC activities are categorized with cluster analysis, and the sampled cities are studied with comparative analysis, considering different periods of the reported activities. The results are followed by the Discussion section, which outlines the conclusions resulting from the study. The last section explains limitations, validity of the results and future research directions.

This paper may be useful to policymakers and urban managers, SC specialists involved in strategic planning processes, and mainly when designing portfolios of SC solutions for a city, benchmarking, and peer learning activities. Practitioners can gain insights to create development pathways for their SC strategies that fit their cultural context.

2. Literature review and research framework

This part of the paper reviews the literature on the anticipated benefits of SC activities, which will be the foundation of our empirical research. The emerging concepts serve as a structure for building the database to analyze in the next section. The adoption of a SC model promises advantages for decision-makers, including various benefits across the different urban sub-systems. However, there are still differing opinions on what constitutes a smart city. We argue that SC, as a concept, can be better understood by deconstructing its value proposition components. This part of the study collects and classifies the most critical anticipated benefits of SC activities. Reffering authors and definitions for each value proposition component are summarized in Table 1.

2.1. Efficiency

Ever since the SC concept emerged in global discussion, improved efficiency in cities has played a pivotal role in the discourse, assumed to be one of the most referred benefits. As Bibri & Krogstie (2017:191) point out, “a smart city represents essentially efficiency”. However, this is often considered as an exclusive trait, a compromise of an achievable outcome, promised by technology and its dealers (Söderström et al., 2014), which on the other hand is a key disadvantage (Angelidou, 2014).

One of the earliest, and influential publication,[1] the “Vision of a Smart City” (Hall et al., 2000:1) stresses the importance of efficiency, as one of three main factors of future cities, which are supposed to be “made safe, secure environmentally green, and efficient” and they shall be “models for efficiency” ultimately. Subsequently, it remains as a defining factor in further publications (Dodgson & Gann, 2011; Nam & Pardo, 2011a; Barrionuevo et al., 2012; Batty et al., 2012; Chourabi et al., 2012; Vanolo, 2014). Another early study argues that the inherent economic excellence of competitiveness implicitly “cause benefits to the public. In terms of time, effort and cost, there are numerous instances of efficiency” (Mahizhnan, 1999:17).

Based on our review, that majority of researchers have considered the efficiency gain potential of technology and particularly ICT on hard infrastructure (Caragliu et al., 2011; Desdemoustier et al., 2019; Lombardi et al., 2012). In parallel, studies also highlighted “soft” factors, referred to the political and social efficiencies, covering the topic of the efficient government and its services to the public.

Regarding hard infrastructure or physical capital, researchers draw our attention to an idealized efficiency gain (also referred as optimization), caused by the increased interconnectedness and interactions of city systems (“system of systems”), which is claimed to be superior, in contrast to alleged existing inefficiencies (Dirks & Keeling, 2009; Dirks et al., 2010; Washburn et al., 2010; Nam & Pardo, 2011b). From this perspective, smartness can also be interpreted as a new level of efficiency by the integration of public and private systems into the aforementioned ‘system-of-systems’ (Naphade et al., 2011). In their analysis of SC performance, Giffinger et al. (2007) primarily associate the term with environmental sustainability and resource management.[2] A great deal of previous research on SC models has focused mainly on energy efficiency (Deakin & Reid, 2018; Lazaroiu & Roscia, 2012). This research stream is labelled as “European Path: Smart City for a Low-Carbon Economy” by Mora et al. (2018)., which organizes studies around this subject.

Parallelly, from a knowledge communication and social capital perspective, Komninos (2006) suggests that cities may be able to carry out “knowledge work”, utilizing effective education and training for the local workforce, and effective marketing that attracts new, desirable employers. Hollands (2008) claims that besides economic, there is political efficiency that is also a key outcome of “networked infrastructure”. Therefore Hollands extended the understanding of efficiency to far-reaching terms, directly connecting it with social and cultural development. In a narrower sense, highly efficient city governance and local policymaking (Kourtit & Nijkamp, 2012) became another critical issue, in the field of overall city management (Angelidou, 2015; Belanche et al., 2016; Hao et al., 2012) and public services (Almirall et al., 2016; Bakici et al., 2013). This extends to private services, affecting various stakeholders (Dameri & Rosenthal-Sabroux, 2014).

Collectively, these studies outline a critical role for efficiency; however, the term is used in various instances that makes no clear interpretation. Readers might have the impression; it is merely an expletive to transcribe something that is superior. The specific cases are energy efficiency, environmental efficiency, transport efficiency (Debnath et al., 2014; Neirotti et al., 2014) resource efficiency (Fernandez-Anez et al., 2018), economic efficiency (Hollands, 2008), operational efficiency, infrastructure efficiency, data management efficiency, technology efficiency (Vanolo, 2014), information management efficiency, decision-making efficiency, service efficiency, political efficiency (Albino et al., 2015), institutional efficiency, design efficiency, mobility efficiency, and (urban) management efficiency (Bibri & Krogstie, 2017).

2.2. Citizen (stakeholder) engagement

The literature on community growth management has already highlighted the critical role of active citizen engagement (Porter, 1997). Despite the economic growth focus, stakeholder engagement soon became a topic of discussion, an alleged necessity for the successful transformation of smart cities. The reason for this is the need for developing social capital and smart communities, where stakeholders can meaningfully utilize ICT technologies in the smart city (Hollands, 2008). To achieve this, a growing construct of social relations, stakeholder partnerships and empowerment of communities are required, (e.g., citizen engagement (Dezi et al., 2018)), which create the ‘city intelligence’ (Komninos, 2011). Community engagement is also a key

[1] Most cited among pieces published around 2000, before the significant uptake of the topic in academia (568 and 321 citation as per Google Scholar and Semantic Scholar, respectively (as per 2020.05.05); no data available in other reputable indices i.e. Scopus).

[2] Efficient use of water and electricity, as Smart Environment indicators.

anticipated benefit, where a SC constitutes meaningful collaboration between various stakeholders – i.e. "public institutions, private sector, voluntary organizations, schools and citizens" (Nam & Pardo, 2011a:286) – through diverse channels in order to jointly tackle urban challenges (Batty et al., 2012). Co-creation or co-production of these solutions and services are also a key topic. With advancements in ICT, researchers and practitioners have argued that cities will be able to facilitate improved participation of communities and citizens, coupled with a shift in paradigm from the centralized silos of bureaucracy, to a decentralized participative model, including platforms (Anttiroiko, 2016; Rajakallio et al., 2018). Almirall et al. (2016) describe this new form as platform-based governance, where the city takes a role like technology platform owners, an orchestrator of different ecosystems – i.e. civic, digital, innovation.

Giffinger et al. (2007) incorporates these traits to the 'Smart People' and 'Smart Governance' in their SC characteristics, while proposing the fundamental role of "independent and aware citizens" or "informed, educated, and participatory" as phrased by Chourabi et al. (2012). Besides social capital, others consider civic engagement as a domain of institutional capital, contributing to 'city intelligence' (Barrionuevo et al., 2012). Caragliu et al. (2011) measure e-government by downloadable forms, as an indicator for citizens to interact with public administration, while Lombardi et al. (2012) use internet usage for interaction with public authorities. Aside citizen-government interactions, general, proactive stakeholder engagement (Bakici et al., 2013), particularly public-private interactions are crucial for the SC (Washburn et al., 2010; Gil-Garcia et al., 2015; Meijer & Bolívar, 2016), specifically for their strategies (Angelidou, 2014). The difficulties, cities face in engaging wide-ranging stakeholders, are recognized as potential pitfalls in developing SCs (Lam & Ma, 2019).

Some have suggested that cities can only achieve 'real' smartness by integrating official city management with the democratic participation of its diverse stakeholders (Fernandez-Anez et al., 2018). The spheres of decision making and public or social services both required for the idealized Smart governance (Albino et al., 2015). Citizens may be able to address particular urban challenges if they systematically orchestrate their actions (van der Graaf & Ballon, 2019). Through digital solutions such as urban platforms, people can collaborate, co-create, and solve specific problems on their own. They can also act as sensors (crowd-sensing) for corporate or public bodies by, for example, reporting events or creating content. There are multiple channels for citizen engagement, including political decision-making (participatory governance), innovation, urban planning and design, or "problem-solving".

Trencher (2019) argued that second-generation smart city paradigms define the role of citizens as active contributors to problem-solving and planning, in contrast to the passive role of 'users' provided by the first generation, describing a higher level of engagement of citizens. Mora et al. (2018) found the most significant role of stakeholder engagement in the "Holistic Path: Digital, Intelligent, Smart" approach.

2.3. Quality of life

Improving the quality of life of citizens is a central concept, and we assume it to be an ultimate goal of SC developments. Singapore's first agency for exploiting IT stated that both economic excellence and Quality of Life (QoL) are their objective, the latter, particularly for the ordinary citizen. In their interpretation, QoL means a higher level of comfort, in the forms of lower costs, effort or time, which mainly comes from efficiency gains (Mahizhnan, 1999), showing a direct cause of QoL, by specific efficiency type of gains. The term is included in several definitions for the SC, as the desired outcome in cities (Giffinger et al., 2007; Chen, 2010; Caragliu et al., 2011; Thuzar (2011); Bakici et al., 2013; Anttiroiko, 2016).

Previous studies have explored the relationships between social capital and QoL. Eger (2003) states that the higher QoL attracts employees in knowledge-intensive sectors. Shapiro (2006) analysis the relationship of "more educated population" and growth in QoL, and showing a high level of influence, besides productivity. Others also claim that QoL attracts knowledge-based population (Caragliu et al., 2011; Dirks et al., 2010).

The services available for citizens largely determine QoL (Komninos, 2011). Giffinger et al. (2007) associate QoL with the Smart Living factor of the SC, which comprise – e.g. culture, health, housing, social cohesion. Similarly, Dirks and Keeling (2009) categorize QoL to one of the six core systems of a city - People - which is defined as "human and social networks", and it comprises health, education and safety. They conclude that the performance of the core systems improves QoL, and consequently, social capital. One interpretation about this claim explains that better services presumably cause less stress, which improves QoL. Further research often considers it as a factor of "People" and "Living" in other SC frameworks (Belanche et al., 2016; Chourabi et al., 2012; Fietkiewicz & Stock, 2015; Neirotti et al., 2014).

QoL studies show a renewed interest, with the emerge of "Science of Happiness"; however, this is a new field for urban research. There is a growing discussion on how to measure happiness, considering both subjective and objective approaches (Ballas, 2013). Robinson (2014) deconstructs QoL in cities through the Maslow's (1954) hierarchy of needs framework but admits that various contextual factors influence citizen's perception of QoL.

The range of technological solutions available has often been questioned and criticized by researchers because these solutions fail to address this fundamental factor (Hollands, 2015; Thomas et al., 2016). A sole focus on efficiency could cause a less pronounced focus on societal aspects (Angelidou, 2014). The techno-led or holistic dichotomy identifies QoL, as a critical factor of tension between a market-oriented, and a human-centric vision of SCs (Mora, Deakin, & Reid, 2019).

2.4. Inclusion and equality

Social Inclusion or (in)equality are becoming a vital element in the discourse. SC labelled initiatives were criticized for being only a variation of urban entrepreneurship, which begun to spread various attempts to characterize a more inclusive SC, by introducing a social justice component to the debate (Harvey, 2000). As discourse moved the concept to a more sustainable agenda, inclusiveness in urban environments became the desired outcome (Batty et al., 2012; Komninos, 2011; World Bank, 2016). Caragliu et al. (2011) highlight the aim of achieving social Inclusion, as a critical characteristic of SCs, in a sense, how equally different social classes benefit from urban technology. Neirotti et al. (2014:27) classifies this benefit as "Social inclusion and welfare", within the "Soft domain" of their framework, focusing on reducing the barrier of social groups in social learning and participation processes.

Growing social distance affects the number of interactions, the potential for knowledge-sharing and creation, and trust in communities. The digital or technology divide is a specific issue that smart actions address by - e.g., providing access to technology or specific knowledge for all citizens. It is acknowledged, that technology per se opens up various divides, while the SC carries the promise of ending them. The SC should be anticipating and planning for both cases: "Efficiency must be balanced with equity." (Batty et al., 2012:485). The target groups of these solutions are usually marginal, disadvantaged groups. These solutions are intended to reduce barriers for such groups, i.e. digital initiatives may provide better access to government for underprivileged citizens with a less powerful network of relationships with political figures (Nam & Pardo, 2014).

Many SC frameworks define an inclusive society in the 'smart people' domain (Manville et al., 2014). Effectuating social Inclusion in European cities became an objective, declared by the Mission Board for Climate-neutral and Smart Cities of the European Union (European Commission, 2020). Social Inclusion appears to be a key expected benefit (Anttiroiko et al., 2014). However, others often criticize this for being fundamentally paradoxical and suggest that inequality is always present

across various dimensions (Hollands, 2008). While some SC actions are expected to contribute to social Inclusion, it is not excluded, that others amplify that divide. It is also shown that SC initiatives with potential inclusiveness might produce other inequalities (Beretta, 2018).

Social Inclusion is understood in this study as an anticipated benefit of social equality, equitable urban growth, reduction of the divide between groups of the local population in terms of – e.g. education, wealth, and providing support for disadvantaged groups – e.g. assistance for disabled citizens. Actions that recognize inequalities and strive for greater social justice in the local population.

2.5. Connectivity

Cities are viewed as systems of networks, with an unprecedented scale of interdependencies (Batty et al., 2012). They shall be instrumented, interconnected and intelligent (Harrison & Donelly, 2010). Connectivity is, therefore, an exceptionally essential element of SC theory (Lazaroiu & Roscia, 2012). Researchers have interpreted connectivity from both a technological perspective, where ubiquitous technologies are gaining higher space, and a social perspective, or increasing social interconnectedness of local inhabitants, businesses, communities, and policymakers. Members of smart communities are connected (Komninos, 2011), and both public and private actors hold a capacity to successfully achieve this (Dezi et al., 2018). Besides these two distinct categories, the interconnectedness of people and urban systems represent another area of interest (Allam & Dhunny, 2019). However, it is claimed that SCs must be more than just broadband networks, connected is no guarantee for being smart; it would only resemble a 'wired city' (Hollands, 2008).

Singapore's strategy centered around an excellent IT infrastructure, connecting its households and business spaces to the national optical fiber network, with a user-centric design (Mahizhnan, 1999). Others interpret connectivity with the interconnectedness of core city systems ('connected infrastructure'), which brings smartness (Dirks & Keeling, 2009), or devices (IoT components) and city-wide networks (Lam & Ma, 2019).

The term appears to have various definitions in the literature. It may refer to the connectedness of different infrastructures (e.g., physical, IT, business, and social) (Harrison & Donelly, 2010); physical and virtual (Zygiaris, 2013); stakeholders (e.g., companies, citizens, institutes, and sectors) (Schuurman et al., 2012); people; technologies (e.g., sensors and mobile devices); networks (e.g., broadband); systems (e.g., communication and city domains); data; linking local actors with the necessary resources and competencies or other actors (e.g., entrepreneurs with tools, investors, and mentors, or labor with employers) (Adler et al., 2019), local and global interconnectedness in the smart economy (Giffinger et al., 2007); and services (Lee et al., 2014).

Based on these findings, we define connectivity as a feature, creating links among data, systems and people.

2.6. Knowledge creation and sharing

Knowledge and innovation are key drivers of the SC discourse (Angelidou, 2015), considered to be critical enabling factors for creating smart cities (Heaton & Parlikad, 2019; Sepasgozar et al., 2019; Yigitcanlar & Velibeyoglu, 2008). It is knowledge and innovation that influenced technological advancements to have such a substantial impact on cities (Komninos, 2011). Creating a knowledge-intensive economy and becoming a knowledge society is stimulated and influenced by the use of ICT, i.e., superior approaches (faster, safer, cheaper) to advancing, sharing and storing knowledge, that is otherwise distributed throughout the society (Caragliu et al., 2011; Kummitha & Crutzen, 2017). Creativity, learning, and education are incorporated into smart communities, which supports the creation of a knowledge economy, described as a "bridging initiative" (Marsal-Llacuna et al., 2015). Knowledge creation and knowledge management are essential. The transfer of knowledge, including knowledge sharing, is a crucial facilitator in this transition (European Commission, 2020; Ruhlandt, 2018). The role of knowledge is usually classified into the "soft infrastructure" category of SC developments (Ahvenniemi et al., 2017). Desdemoustier et al. (2019) classify this anticipated benefit to the 'Human & creative' category, and they claim, SCs aim to improve the knowledge economy.

2.7. Cost reduction

'Cost reduction' is not a frequently used phrase in SC definitions. However, it is an attractive value proposition of smart solutions. Many types of transactions can be conducted in the cyberspace with virtually no costs, making considerable investments beneficial (Mahizhnan, 1999). Virtual spaces reduce costs in various forms of transactions – e.g., logistics, marketing, policy information (Komninos, 2006). One of the many reasons for initiating smart investments is that city systems are operating with growing costs (Nam & Pardo, 2011b), imposing burdens on infrastructure, administration (i.e. e-government), businesses and citizens (Dirks & Keeling, 2009). The factor is argued to restrain competitiveness and attractiveness for the desired employers and creative population (Ballas, 2013), in the form of – i.e., energy consumption, education, real estate, transportation (costs associated with congestion) (Washburn et al., 2010). Smarter city-systems create cost-saving and additionally, increased efficiency (Dirks et al., 2010). Komninos (2011) claims that besides better procedures and problem-solving capabilities, lower operation costs are also criteria for intelligence.

In an environment of constraints on public budgets, decreased investment and increasing operational expenses of city services and infrastructure, it is likely to be one of the most significant expected impacts for city management. The value propositions of key SC market actors and implemented projects also suggest this, because they promise that their technology will provide cost reductions (Hunter et al., 2018; McNeill, 2015; van den Buuse & Kolk, 2019). Barcelona expects to become the leading place for sustainable urban development by 2020 while reducing capital costs and save in its operations (Bakici et al., 2013). The pressure to optimize the efficiency of public spending also suggests that cost reduction is a significant expected benefit of SC initiatives (Lee et al., 2013).

2.8. Scalability and transferability

Scalability is an essential attribute of SC solutions. There is a gap between small-scale demonstrations or pilot projects and large-scale implementation. This phenomenon is a significant challenge in achieving sustainable urban development (Winden & Buuse, 2017). Many cities want to capitalize on small-scale deployments, and technologies, products, and services that are difficult to scale, create a barrier. As Taylor Buck & While (2017:504) reminds us: "smart city innovation is most evident through well-funded niche experiments in a limited range of urban contexts". Many projects and solutions do not scale up, and the desired impacts are lacking, after an often-subsidized initial phase. They do not operate on a larger scale (Deloitte, 2015). SC solutions are expected to have the ability to scale up. Less developed cities are particularly interested in learning from successful implementation elsewhere, which makes transferability a critical enabling factor in accelerating the diffusion of proven technologies or methods. Policymakers want to expand small scale deployments and 'copy' them to new areas with different boundary conditions, to contribute to higher-level (national or supranational) goals (Ferrer et al., 2017).

There are three non-exclusive categories for scaling up in case of SC initiatives: Replication, Expansion and Roll-out (Winden et al., 2016).

2.9. Environmental impact

The vision of SCs suggests, the urban centers of the future are environmentally green (Hall et al., 2000). As Giffinger et al. (2007:12)

describe the environment sub-system of their SC concept: "attractive natural conditions (climate, green space etc.), pollution, resource management and also by efforts towards environmental protection". Besides social, environmental sustainability became an important outcome for smart cities (Albino et al., 2015; Caragliu et al., 2011; Hunter et al., 2018; Neirotti et al., 2014), as one of the determinants for urban living quality. Some authors (e.g., Dodgson & Gann, 2011; Pham, 2014) have attempted to draw subtle distinctions between environmental preservation and economic growth, stating that SC initiatives are promoted to serve a double purpose of these goals. Others question the fundamental compatibility of these outcomes (Hollands, 2008). Concerning 'Efficiency', it is claimed to be an essential distinguishing feature between the related terms of sustainable and smart cities (Bibri & Krogstie, 2017). Naphade et al. (2011) emphasize water, energy, food supplies, waste management, and reducing GHG emissions, as critical targets of environmental sustainability. Chourabi et al. (2012) find that the natural environment is one critical factor of SC initiatives, particularly the protection of natural resources and their related infrastructure. Dameri and Rosenthal-Sabroux (2014) highlights environmental considerations, to prevent further environmental degradation, as one of the three main aspects of a SC. Other classifications consider the 'Environment' domain, as utilizing technology for superior environmental resource management, to increase sustainability (Neirotti et al., 2014).

Using ICT to transform the economy to an energy-efficient and low carbon one, became an important goal for Members States of the European Union, greatly influencing the European interpretation of the SC (Mora et al., 2018; Mora, Deakin, & Reid, 2019). The European Commission is promoting investment in low and zero-carbon solutions to support the transition of 100 climate-neutral cities by 2030 (European Commission, 2020), which also demonstrates a significant emphasis on the "Smart Environment" factor of European SCs, showed by Manville et al. (2014).

Much of the available literature on SC performance deals with the components of environmental factors (Ahvenniemi et al., 2017; Lazaroiu & Roscia, 2012; Lombardi et al., 2012), as well in SC strategies (Angelidou, 2017; Ben Letaifa, 2015).

3. Methodology

We use a deductive-based multiple case study analysis that helps to investigate our research questions. The manifestation of each identified anticipated benefit in research subjects explain how theoretical benefits of SCs are present in SC developments, and tested in eight European and one American city. This task is accomplished by comparing nine cities, of which six are considered to be leading examples of smart cities, while three are considered to be examples of emerging excellence.

The selection of the appropriate cases was key to adopt a successful multiple-case study analysis. The selection process relied on a theoretical sampling approach and not a random selection. Theoretical sampling is a process of data collection for generating theory whereby the researcher takes the double role of a data collector data analyst and decides what data to collect next and where to find them, in order to develop a theory as it emerges (Glaser, 1978). This also means that the case studies are "chosen for the likelihood that they will offer theoretical insight" (Eisenhardt & Graebner, 2007: 27). The basic requirement for selecting the cities was the existence of well documented and demonstrated SC development activities, with a SC strategy as an essential requirement. As a next step, our attention was drawn to intensive cases, where outstanding success or failure was observed. The selection of cases depends on the selection logic, which means either a literal replication with similar settings and similar results or theoretical replication cases have different settings and anticipated different results. There can be cities where SC development and ICT-driven approach to urban sustainability was admittedly successful, and cities where the transition process is less prominent, meaning that it is not widely recognized as an example of excellence. In order to find efficient and normative approaches for the SC, we needed to cover both successful and less outstanding cities with our sampling. Therefore we adopted a theoretical replication logic. In order to differentiate, we label these two groups as follows: (1) Demonstrated SC Excellence, and (2) Emerging SC Excellence. Criteria for meeting the demonstrated excellence condition is the acknowledgement by top-tier publications, influential organizations, and outstanding placement in significant SC rankings. Based on these criteria, we selected the following cities, as subjects of our investigation (Table 2) (Fig. 1).

The adoption of the replication logic made it possible that all subject cases were processed with the same analytic procedure, starting with the data collection phase. To study how the identified value proposition components are present in the SC activity portfolio of cities, we built and analyzed the database, which classifies all the activities that each city has implemented or currently implementing to enable SC development. The classification was conducted by considering the nine components presented in Table 1. This framework allowed the activities to be grouped according to the anticipated benefit, towards which efforts have been directed. The activities with multiple value proposition components were included in more than one group. The analysis of the percentage share related to each group made it possible to investigate the research questions, to determine how these value proposition components are distributed across cities, and what differences appear between cities and their performance.

The activities grouped in the database were mapped and analyzed by cross-referencing the qualitative data extracted from multiple sources. Digital contents, reporting on the SC developments under investigation and produced by the nine city governments were considered as primary sources. The collected digital records may include press releases; newsletters; conference presentations; videos of conference speeches; reports; brochures; government documents; official project repositories; policy documents, and webpages. Additional data originates from private companies, implementing SC activities in the cities, with declared cooperation of the local government, or academic institutions, participating in activities in cooperation with the city. These sources were considered secondary sources, reports, news and articles published online, academic literature, and research or innovation project deliverables. A large part of the already acknowledged activities was taken over from the literature. This data collection process strengthened the valid of the multiple case study analysis, because multiple data sources were used, considering both external and internal observers. Overall, 2856 digital records were collected, in either written or audio-visual formats. Data were collected by conducting a series of online searches with different search engines, and multiple search strings were deployed. No restrictions for languages were set during the searches. In case of links that were no longer working, the Internet Archive's Wayback search engine was used to collect digital records.

Digital records were extracted from the original sources, to enable the coding of the value proposition components from the research framework. During the coding process, a dichotomous variable was assigned for each of the nine categories, with a value of either 0 or 1. Each of the 637 activities was given a code for each of the nine variables to show whether a component of that type was anticipated from the activity. Further attributes of the activities that were collected: (1) year when the activity has begun, (2) status of the activity (0: research or pilot action; 1: rolling out technology or currently implementing a solution, initiative; 2: concluded initiative, or technology deployment, that was finalized), (3) outcome of the activity (0: activity's outcome not available anymore; 1: activity's outcome available).

We utilized a two-stage validation process in order to avoid subjective judgments. In the first stage, the authors performed the coding independently, and any differences were discussed with three other experts on the topic. Once the codes had been agreed, a 50-sample dataset was extracted and checked independently by the authors. When there were no differences in opinion, the variables were considered finalized.

Fig. 1. Case study cities sampled in the analysis.

4. Results

4.1. Descriptive statistics of the anticipated benefits of SC activities in the case study cities

The anticipated benefits in the sample help us to identify different trends. The Connectivity component has the highest rate of distribution across the cases, ranging from 39% (Budapest) to 88.46% (Moscow). The average share of the component is 60.44% of all cases. The second most significant benefit is Efficiency Gains, ranging from 19.61% (Budapest) to 45.12% (Barcelona). Both components show a consistent share in the top-performing cities, with an average of 37.46%. The third most important trait is Quality of Life, averaging 35.79%, with a moderately higher scatter, compared to the two other benefits. Knowledge Sharing is observed to have also a prominent presence, averaging 29.51%. The other components of Citizen Engagement, Easy Replication and Environmental Impact have a share equating between 24 and 25%. However, while citizen engagement shows a somewhat even distribution, environmental impact is more scattered across the cases. Based on the results of the descriptive statistics, Cost saving has the lowest share, ranging from 3.39% to 22.03% (Table 3).

There is a significant difference between the two categories in the knowledge sharing component, cities with demonstrated excellence have a higher share (31.95%), in contrast to emerging ones (21.88%). Top-performing cities also have a relatively higher share in 'Efficiency gains' (40.09% to 32.26%), 'Easy replication' (27.77% to 18.10%) and 'Environmental impact' (26.06% to 16.97%). On the other hand, they have a moderately higher share in 'Citizen engagement' and 'Cost savings'. In 'QoL' and 'Inclusion and equality' components, emerging cities have relatively higher shares, while the connectivity component is very similar (both around 61%).

Despite the differences, it is important to note that these figures do not reveal the degree of commitment related to each component. A higher value does not necessarily correspond to a more significant investment or a greater level of importance. These figures should rather be considered as an initial proof of the alignment between the approach to SC development of the studied cities and the presence of the nine identified value proposition components and assembling process.

Considering the status of the observed activities, in most of the cases, we found fully implemented solutions. The share of the pilot is research activities are also significant in several cities: 55.9% in Helsinki, and 40.70% in Vienna (Table 4).

The spatial level of the analyzed activities is also reported in the analysis (Table 5. Most of the expected impacts are focusing on the whole city level, while districts are also key targets for the SC activities. There is also a high scatter between the various cases. Some cities are showing a more distinct based approach, while others were solely focusing on city-wide approaches (e.g. Moscow).

4.2. Clusters analysis of the anticipated benefits of SC activities in the case study cities

Based on the built-up database, we were able to group the observed activities, according to their similarities in the nine value proposition components. The purpose of this analysis is to reduce the high dimensionality of SC activities to lower-dimensional data while preserving much of the data variation. Eventually, we selected k-means clustering, as it is one of the most popular methods, and it properly minimizes variance within clusters. Using this technique, we categorized the activities into four clusters: (1) Environmental efficiency, (2) QoL Applications, (3) Social Sensitivity, and (4) Intelligent Inclusion. The influence of each component on the four clusters are presented below Figure 2. In the next subsection, we describe these clusters.

4.2.1. Environmental efficiency

Cluster 1 represents the SC activities, with a high share of 'Environmental impact', 'Efficiency', and 'Cost Savings', while the share of 'Citizen Engagement', 'Inclusion and Equality', and 'Connectivity' is the lowest, compared to other clusters. Activities in this group are primarily concerned with environmental goals coupled with cost reductions and efficiency gains. These solutions generally have low scalability and were generally based on the use of novel technologies, focused on mostly city-specific energy efficiency solutions, where direct QoL effects are not present, emphasis on developing city-systems. Many of the SC activities in this group are research energy-related research projects, pilot applications of technologies, or environmental programs of the city. As an

Table 1
Breakdown of value proposition components of SC solutions, with references.

Components	References
Efficiency	Mahizhnan (1999), Hall et al. (2000), Komninos (2006), Giffinger et al. (2007), Hollands (2008), Dirks and Keeling (2009), Dirks et al. (2010), Washburn et al., 2010, Caragliu et al. (2011), Dodgson and Gann (2011), Nam and Pardo (2011a), Naphade et al. (2011), Barrionuevo et al. (2012), Batty et al. (2012), Chourabi et al. (2012), Hao et al. (2012), Kourtit and Nijkamp (2012), Lazaroiu and Roscia (2012), Lombardi et al. (2012), Bakici et al. (2013), Angelidou (2014), Dameri and Rosenthal-Sabroux (2014), Debnath et al. (2014), Neirotti et al. (2014), Söderström et al. (2014), Vanolo (2014), Albino et al. (2015), Angelidou (2015), Almirall et al. (2016), Belanche et al. (2016), Bibri and Krogstie (2017), Deakin and Reid (2018), Desdemoustier et al. (2019), Fernandez-Anez et al. (2018), Mora et al. (2018)
The superior performance of city systems, expressed in products, technologies and processes and measurable with quantified parameters.	
Citizen (stakeholder) Engagement	Porter (1997), Giffinger et al. (2007), Hollands (2008), Washburn et al. (2010), Komninos (2011), Caragliu et al. (2011), Nam and Pardo (2014), Batty et al. (2012), Chourabi et al. (2012), Barrionuevo et al. (2012), Lombardi et al. (2012), Bakici et al. (2013), Angelidou (2014), Gil-Garcia et al. (2015), Albino et al. (2015), Anttiroiko (2016), Almirall et al. (2016), Bolívar & Meijer, 2016, Dezi et al. (2018), Rajakallio et al. (2018), Lam & Ma (2019), Fernandez-Anez et al. (2018), Mora et al. (2018), van der Graaf and Ballon (2019), Trencher (2019)
Activities that are intended to involve non-elected citizens directly and their groups to the operation of city systems.	
Quality of Life	Mahizhnan (1999), Eger (2003), Shapiro (2006), Giffinger et al. (2007), Dirks and Keeling (2009), Chen (2010), Dirks et al. (2010), Caragliu et al. (2011), Thuzar (2011), Caragliu et al. (2011), Komninos (2011), Bakici et al. (2013), Chourabi et al. (2012), Ballas (2013), Robinson (2014), Neirotti et al. (2014), Angelidou (2014), Fietkiewicz and Stock (2015), Hollands (2015), Anttiroiko (2016), Belanche et al. (2016), Thomas et al. (2016), Mora, Deakin, and Reid (2019)
Activities, directly providing better conditions for the citizens to pursue happiness in their daily life, considering their needs and experience in mind, resulting in well-being.	
Social Inclusion and Equality	Harvey (2000), Hollands (2008), Komninos (2011), Caragliu et al. (2011), Nam and Pardo (2011a), Batty et al. (2012), Neirotti et al. (2014), Manville et al. (2014), Anttiroiko et al. (2014), World Bank (2016), Beretta (2018), European Commission (2020)
Activities, to realize social equality, providing better urban living conditions for all segments of the society, without discrimination.	
Connectivity	Mahizhnan (1999), Giffinger et al. (2007), Hollands (2008), Dirks and Keeling (2009), Harrison and Donelly (2010), Batty et al. (2012), Lazaroiu and Roscia (2012), Schuurman et al. (2012), Zygiaris (2013), Komninos (2014), Lee et al. (2014), Ahvenniemi et al. (2017), Dezi et al. (2018), Lam & Ma (2019), Allam and Dhunny (2019)
Activities to create information channels in-between humans and non-humans in order to interact with each other.	
Knowledge creation and sharing	Yigitcanlar and Velibeyoglu (2008), Komninos (2011), Caragliu et al. (2011), Angelidou (2015), Marsal-Llacuna et al. (2015), Kummitha and Crutzen (2017), Ahvenniemi et al. (2017), Ruhlandt (2018), Desdemoustier et al. (2019), Heaton and Parlikad (2019), Sepasgozar et al. (2019), European Commission (2020)
Activities that are supporting the accumulation and flow of local urban knowledge in-between urban stakeholders, contributing to city intelligence.	
Cost reduction	Mahizhnan (1999), Komninos (2006), Dirks and Keeling (2009), Washburn et al. (2010), Nam and Pardo (2011b), Komninos (2011), Ballas (2013), Bakici et al. (2013), Lee et al. (2013), McNeill (2015), Hunter et al. (2018), van den Buuse and Kolk (2019)
Activities that are specifically intended to replace or substitute an existing solution, to be operated in a less resource-intensive way.	
Scalability and transferability	Deloitte (2015), Winden et al., 2016, SCIS (2018), Winden & Buuse, 2017, Ferrer et al. (2017), Taylor Buck and While (2017), Borsboom-van Beurden et al. (2019)
Activities that incorporate features, which makes them easy to extend, replicate and adapt in different contexts.	
Environmental impact	Hall et al. (2000), Giffinger et al. (2007), Caragliu et al. (2011), Dodgson and Gann (2011), Naphade et al. (2011), Chourabi et al. (2012), Lazaroiu and Roscia (2012), Lombardi et al. (2012), Neirotti et al. (2014), Pham (2014), Dameri and Rosenthal-Sabroux (2014), Manville et al. (2014), Albino et al. (2015), Ben Letaifa (2015), Bibri and Krogstie (2017), Ahvenniemi et al. (2017), Angelidou (2017), Hunter et al. (2018), Mora et al. (2018), Mora, Deakin, and Reid (2019)
Activities, with objectives related to contributing to environmental sustainability.	

Table 2
Demonstrated and emerging excellence of case study cities.

City cases	Evidence for demonstrated or emerging
Amsterdam	Amsterdam is selected as "Benchmark of Excellence" by the European Commission, who describes the Amsterdam's smart city development strategy as a best practice to be replicated in other urban contexts (Reported by Velthausz, as cited in Mora and Bolici (2017)).
Barcelona	Reported as number three for Europe and ninth in the world in the smart city ranking of the Eden Strategy Institute and Ong&Ong (OXD).
London	London is ranked in top 10 of most SC rankings, being first in the world according to Eden Strategy Institute in 2019 (Eden Strategy Institute, and ONG&ONG Pte Ltd., 2018).
Helsinki	2014: Helsinki is recognized by the European Parliament as one of six most successful smart cities in Europe and one of the most suitable cases for further in-depth analysis and benchmarking activities (Manville et al., 2014).
New York	New York City is named best smart city at the 2016 edition of the World Smart City Awards. The award recognizes the success of the city government in leveraging smart technologies to support urban sustainability
Vienna	2014: Vienna is recognized by the European Parliament as one of six most successful smart cities in Europe and one of the most suitable cases for further in-depth analysis and benchmarking activities (Manville et al., 2014)
Berlin	Berlin has a smart city strategy since April 2015. It is a small metropolis, member of the European lighthouse cities community. Berlin is sometimes reported as top SC in Europe; however, different rankings show mixed results.
Budapest	Budapest has a smart city strategy since 2019, which makes it a late adopter of the concept, its ranking classifies the city to However, SC developments were already undergoing in the last decade. The city ranked lower, than it's regions average (Csécsei, 2020).
Moscow	Moscow jumped 16 ranks up in IMD's global ranking of smart cities to be 56th globally. The government would like Moscow to be known as one of the smartest cities in which to live.

example, in this cluster, the 'Power to Protein' initiative in Amsterdam is piloting a modern technology solution, which produces protein for animal feeding, from sewage sludge. The Accelerated Conservation and Efficiency ("ACE") Program in New York City provides funding for city agencies to implement energy efficiency developments. Another important type of activities here, which are not environmentally focused, are mainly concerned with community building and strategic implications and creating intelligence for the city management.

4.2.2. QoL applications

Cluster 2 members have the highest share of 'Efficiency gains', 'Life Quality' and 'Easy replication'. This cluster was named 'QoL Applications' because activities here are mostly application-based activities. These activities directly targeted citizens. The goal of these solutions is to provide new services to citizens, directly improving their quality of

Table 3
Descriptive statistics of value proposition components in case study cities.

	Demonstrated SC excellence						Emerging SC excellence			Average
	Amsterdam	Barcelona	Helsinki	New York	Vienna	London	Berlin	Budapest	Moscow	
Efficiency gains	**41/116**	**37/82**	**24/59**	**32/101**	**26/59**	**24/55**	**24/62**	**10/51**	**20/52**	
	35.34%	*45.12%*	*40.68%*	*31.68%*	*44.07%*	*43.64%*	*38.71%*	*19.61%*	*38.46%*	*37.36%*
Citizen engagement	**32/116**	**24/82**	**24/59**	**22/101**	**14/59**	**12/55**	**17/62**	**13/51**	**7/52**	
	27.59%	*29.27%*	*40.68%*	*21.78%*	*23.73%*	*21.82%*	*27.42%*	*25.49%*	*13.46%*	*25.90%*
Quality of life	**26/116**	**25/82**	**20/59**	**33/101**	**26/59**	**19/55**	**28/62**	**24/51**	**27/52**	
	22.41%	*30.49%*	*33.90%*	*32.67%*	*44.07%*	*34.55%*	*45.16%*	*47.06%*	*51.92%*	*35.79%*
Inclusion and equality	**15/116**	**28/82**	**5/59**	**23/101**	**16/59**	**5/55**	**17/62**	**12/51**	**11/52**	
	12.93%	*34.15%*	*8.47%*	*22.77%*	*27.12%*	*9.09%*	*27.42%*	*23.53%*	*21.15%*	*20.72%*
Connectivity	**65/116**	**54/82**	**47/59**	**49/101**	**32/59**	**36/55**	**36/62**	**20/51**	**46/52**	
	56.03%	*65.85%*	*79.66%*	*48.51%*	*54.24%*	*65.45%*	*58.06%*	*39.22%*	*88.46%*	*60.44%*
Knowledge sharing	**36/116**	**30/82**	**20/59**	**33/101**	**20/59**	**13/55**	**13/62**	**12/51**	**11/52**	
	31.03%	*36.59%*	*33.90%*	*32.67%*	*33.90%*	*23.64%*	*20.97%*	*23.53%*	*21.15%*	*29.51%*
Cost savings	**20/116**	**6/82**	**2/59**	**18/101**	**13/59**	**11/55**	**5/62**	**6/51**	**3/52**	
	17.24%	*7.32%*	*3.39%*	*17.82%*	*22.03%*	*20.00%*	*8.06%*	*11.76%*	*5.77%*	*13.19%*
Easy replication	**27/116**	**21/82**	**20/59**	**28/101**	**17/59**	**15/55**	**12/62**	**9/51**	**9/52**	
	23.28%	*25.61%*	*33.90%*	*27.72%*	*28.81%*	*27.27%*	*19.35%*	*17.65%*	*17.31%*	*24.80%*
Environmental impact	**43/116**	**8/82**	**10/59**	**30/101**	**21/59**	**15/55**	**17/62**	**11/51**	**1/52**	
	37.07%	*9.76%*	*16.95%*	*29.70%*	*35.59%*	*27.27%*	*27.42%*	*21.57%*	*1.92%*	*24.49%*

Table 4
Status of the reported SC activities in the case study cities.

	Amsterdam	Barcelona	Berlin	Budapest	Helsinki	London	Moscow	New York	Vienna
Pilot or research	36.20%	15.90%	16.10%	21.60%	55.90%	30.90%	7.70%	7.90%	40.70%
Full scale implementation ongoing	10.30%	8.50%	11.30%	2.00%	5.10%	0.00%	3.80%	18.80%	1.70%
Fully implemented and applied to intended target	53.40%	75.60%	72.60%	76.50%	39.00%	69.10%	88.50%	73.30%	57.60%

Table 5
Spatial level of the reported SC activities in the case study cities.

	Amsterdam	Barcelona	Berlin	Budapest	Helsinki	London	Moscow	New York	Vienna
City	42.20%	81.70%	56.50%	39.20%	61.00%	43.60%	94.20%	69.30%	59.30%
District	39.70%	13.40%	29.00%	49.00%	22.00%	21.80%	1.90%	37.60%	20.30%
Building	10.30%	4.90%	9.70%	15.70%	10.20%	25.50%	3.80%	8.90%	13.60%
Home	2.60%	0.00%	1.60%	0.00%	0.00%	0.00%	0.00%	0.00%	5.10%

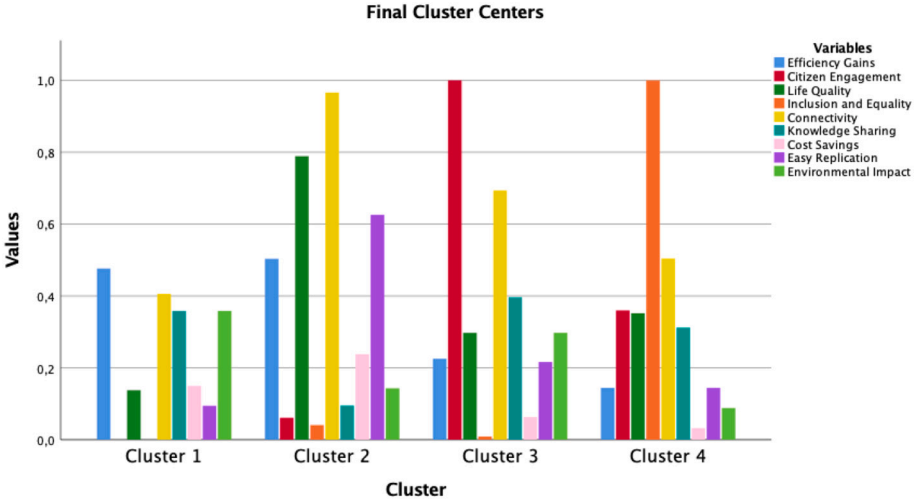

Fig. 2. Influence of value proposition components on the clusters (created and exported from IBM SPSS Statistics 25) .

life. These solutions had an exceptionally high scalability load, so were straightforward to scale up and transfer to other locations, often regarded as platforms. Typical services included mobility (parking services for municipalities, or vehicle sharing), intelligence (citizen behaviors, activities, etc.) and digital infrastructure services (Wi-Fi network). As an example, the 'Regent Street App' in London is an innovative mobile application, providing an exclusive shopping experience. The SMILE mobility platform in Vienna comes with a mobile application, to provide excellent mobility service for all type of passengers.

4.2.3. Citizen engagement

Cluster 3 has the highest share of 'Citizen engagement' and 'Knowledge Sharing' while low values for 'Efficiency Gains', 'Inclusion and Equality', and 'Cost savings'. The most important factor for these activities is to create channels between governments and the public, and thereby involve them in making the decisions, or incorporate their needs and requirements to shaping the future of the city.

4.2.4. Social inclusion

Activities in Cluster 4 primarily aim to improve the everyday life of citizens, with particular emphasis on disadvantaged groups. These activities include socially sensitive areas, like elderly care, better working conditions for disabled people, or helping immigrants to settle. These solutions involved the intensive use of technology. Four main attributes were identified here are e-health, digital Inclusion, access to information, and convenience. There were a large number of healthcare-related services and programs. The healthcare-related solutions mainly focused on delivering high-quality patient services with the use of the latest technologies, e.g., implementing connected care, and better rehabilitation procedures. Digital Inclusion means public or private support of access to different technologies (city-wide Wi-Fi network, high-performance broadband) for citizens, especially in rural or less developed areas. Governments and companies typically aimed to provide these facilities to low-income citizens. Access to information was also important in this cluster. This uses open datasets, applications or platforms to provide access for citizens to a wide range of government information such as public transport real-time data, parking information, and patient data.

Fig. 3. illustrates the distribution of the four clusters in the dataset across years, between 2008 and 2019.

Observing the distribution of the four identified clusters across different years in all cities, we can observe that the activities are changing over the years, some are becoming more important, other less significant. Fig. 4. shows how these clusters are represented in eachcase study city. Even among the best performing cities, we observe differences. For example, Barcelona has a high emphasis on Social Inclusion, while Amsterdam is the most concerned with particularities of the first cluster, on the other hand, Moscow has an outstanding share of cluster two.

Fig. 5. provides an added depth to the relationship of the studied case study cities, and the clusters of the SC activities. The graph was constructed using another dimension reduction technique, Principal Component Analysis, and it shows which cities are more similar to which cluster. It provides another visualization for comparing the cities. The proximity of data points represents the degree of their similarity.

4.3. Temporal analysis of anticipated benefits of SC activities in the case study cities

Based on the temporal data in the database, we analyzed the SC activities of the case study cities across years. Four types of cities are identified with analysis: (1) The Green City – in which years of activities, cities are focusing on environmental sustainability related objectives Fig. 6; (2) The App City – in which years of activities, cities are focusing on developing and rolling out platforms and applications to provide QoL improvements directly for citizens Fig. 7; (3) The Socially Sensitive City - in which years of activities, social equality, and better urban living conditions for all segments of the society are prominent Fig. 8; (4) The Participatory City – in which years of activities citizen engagement is in focus Fig. 9.

5. Discussion

This research contributes to the better understanding of SC theory, and its practical realization, bridging a knowledge gap in research, by studying the different value proposition components defined in the SC literature. We revealed, what different scientific approaches expect from SC developments, and identified nine components which in turn enabled us to analyze which benefits are present and how they are distributed among SC activities. Besides, we compared SC development practices of cities. SC activities can be classified based on their value proposition components, which gave us novel methods to analyze and evaluate approaches to the concept. Our analytical framework also has a temporal dimension. We studied activities of cities across years and compared the activities of different cities to each other.

It is an important finding of the research that there could be significant deviations in performance of cities in SC development, despite carrying out activities with identical value proposition components. Excellent performance does not necessarily mean that it is an example to follow, per se. Due to the difference in periods, it shall also be considered, when was the focus of top-performing cities observed? Was it after a shift from another one?[3] Unconditionally following the strategic targets of developed (excellent) cases, by adopting similar target system, is not an enabler for success. However, there are various other factors (e.g., cultural context, governance structure and existing targets) that could be important. Longitudinal and local cultural aspects shall be considered when researching and benchmarking best practices. Few pieces of research are incorporating these contexts. Ruhlandt (2018) also highlights the lack of these parameters in research and practice. Cities embody their development vision into their SC activities, which is a possible reason for the differing understandings of the concept. Based on the distribution of value proposition components, Budapest shows quite a lot of similarities with Vienna. However, the two cities undoubtedly perform significantly different in SC developments.

Activities are not necessarily focusing on strong points. Amsterdam, for example, is well known for its high level of Quality of Life (QoL). Nonetheless, the QoL share in the studied activities shows a rather low QoL value. On the other hand, Budapest and Moscow have the highest scores, not being among top-performing cities regarding QoL. We assume that cities focus on deficit skills, and not those that they are already strong at. The overall anticipated benefits of their SC vision is dependent on the specific properties they own, which also explain differences in the divergent distribution across top-performing cities. If cities peer learn from each other and want to follow another city's path, they can check the other one's activity portfolio, with emphasis on their value proposition components.

We also revealed that cities with excellent performance are focusing on different activities across the years. They do not settle with a specific portfolio of activities and solutions but shift focus occasionally. Most of the cities' strategy focuses on similar activity portfolios for longer periods, while others change more often. Based on the observed activities that cities carried out, we also immersed in their perception to the SC, which seems to be a fluid one, changing from time to time. One of the years with the particular focuses were identified as 'The Green City' where the implemented activities have a higher emphasis on the Environmental Impact component.

Similarly, 'The App City' implies cities with years when the implementation of application-based solutions was significant. Considering these focuses, we argue that there is a great distance between a monodimensional and holistic strategic approach of cities to SC developments. The differences exist across periods within one city's holistic approach. Hence cities should concentrate resources and focus on certain activities with similar value propositions.

We assume that strategic principles cities adopt in the SC approach are very dependent on the local contextual parameters (e.g. perception

[3] Longitudinal and local cultural aspects shall be considered when researching. Little research is incorporating these contexts. Ruhlandt (2018) also highlights lack of these parameters in research and practice. Cities embody their development vision into their SC activities. This is a reason for differing understanding of the concept.

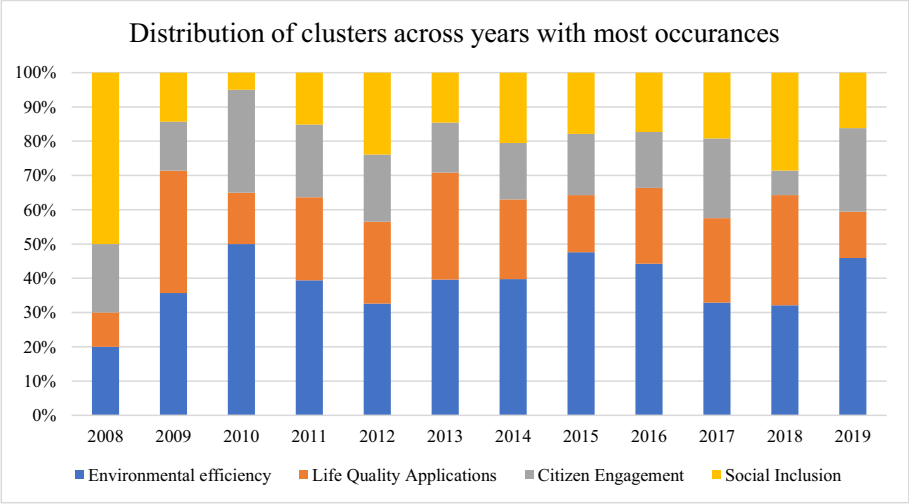

Fig. 3. Distribution of clusters across years with most occurrences.

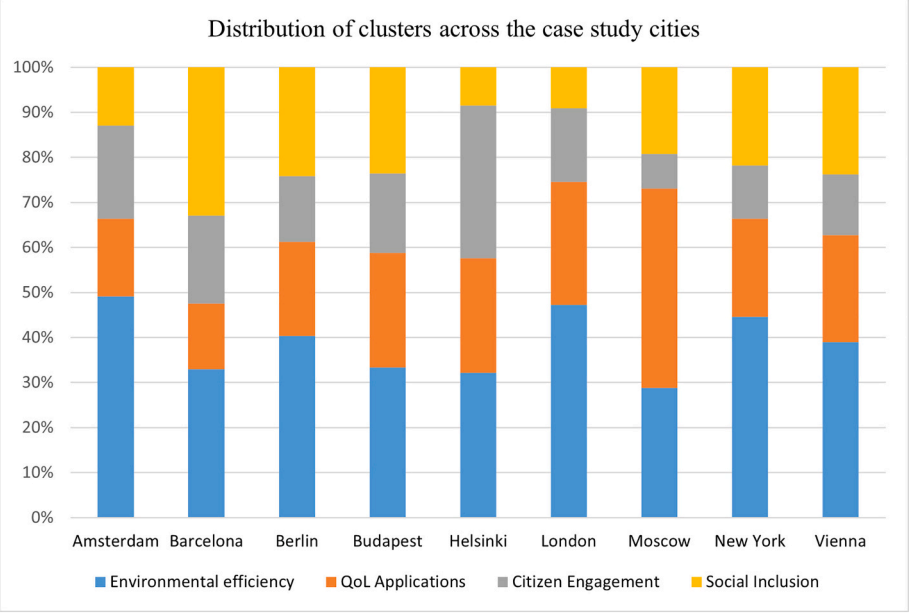

Fig. 4. Distribution of clusters across the case study cities in the dataset.

of new technologies, attitude towards privacy, cultural heuristics). In western European cities, citizen engagement has an overall high share; however, in Moscow, the research showed a lower one. The very same activities are not working in different contexts. Different solutions are creating different impacts: some are positive, but some may trigger other negative impacts. For example, electric vehicles improve air quality, but not able to solve the problem of congestion. A mass surveillance systems will bring efficiency, and even create QoL improvements, by decreasing crime, or easing government services. However, it also creates stress by diminishing privacy, which might outbalance the overall benefits the solution offers. Toronto's ambitious Sidewalk project incorporated all features, that new technology can offer. Yet, from the beginning, it was beset by controversy since its announcement, and eventually abandoned by Google's Alphabet on May 7, 2020. Looking at this activity through the research's framework, it would have created various benefits of efficiency, QoL, environmental impact and connectivity. At the same time, it also envisioned to create negative impacts for citizens – e.g. increased stress through surveillance and decreasing control over privacy. The acceptance and attitude towards these activities, the perception and subjectivity of citizens are different in other cities. For example, Moscow operates one of the world's biggest surveillance camera system. The attitude of people has also resembled in the distribution of components across cities investigated. Therefore, we propose, that cities shall focus on their specified local needs, on the path for development - i.e. citizen empowerment by investing in citizen engagement activities.

We also strongly recommend that the assessment of smart city performance should not only use output indicators that measure the efficiency of deployment of smart solutions but always include impact indicators that measure the contribution towards the ultimate goals such as environmental, economic or social sustainability. Indicator systems do not consider the local people's needs (specific parameters), because they probably have different utility curve. Rankings only show an output, which might be the result of various other factors.

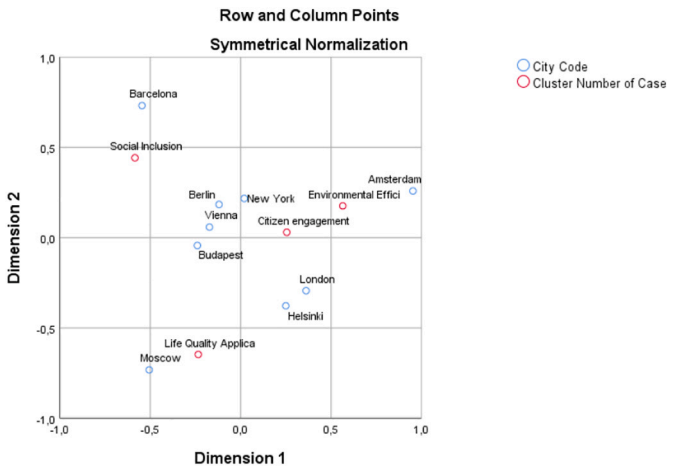

Fig. 5. Principle Component Analysis (PCA) of case study cities and clusters (created and exported from IBM SPSS Statistics 25).

6. Limitation, validity and future research

It is important to note that the multiple-case study selection process and the number of replications always determine the external validity of the study and the extent to which the results are generalizable. The extent of iteration is highly dependent on the confidence the researcher wants to achieve, and "the greater certainty lies with, the larger number of cases" (Yin, 2009: 58). (Eisenhardt, 1989) argues that the ideal number of cases ought to be between 4 and 10, which would provide adequate fundamentals for generalizing findings. The final number of nine selected city cases was based on this statement. On the other hand, the depth of the related activities collected was in line with researches, applying similar methods. However, the number of observations in each case could be further increased to ensure a higher level of confidence. Besides, analytical generalization is also affected by two contextual conditions: the geographical distribution of the selected cases and their size. A more heterogeneous sample determines a broader generalization of the results. This research framework enables to improve the common understanding of such effects in Europe and North America. However, additional research is required to test whether the findings are of wider significance because they also apply to other territorial contexts. As 50% of SC projects are claimed to be situated in China, we believe that the current sampling of cities does offer an acceptable level of certainty to generalize results for Asian examples of SC development. Nevertheless, we believe that replicating the research with Asian examples of SC development is a direction for future research. Data availability also has a limitation on the research. The annual distribution of observed activities is adequately balanced across years. Further extension of the dataset, by adding more records, or further restricting the years of observation, included in the analysis, by increasing the requirement of a minimum number of activities could be options for strengthening its validity.

The studied value proposition components in the observed activities are barely showing their presence in each activity, and do not consider

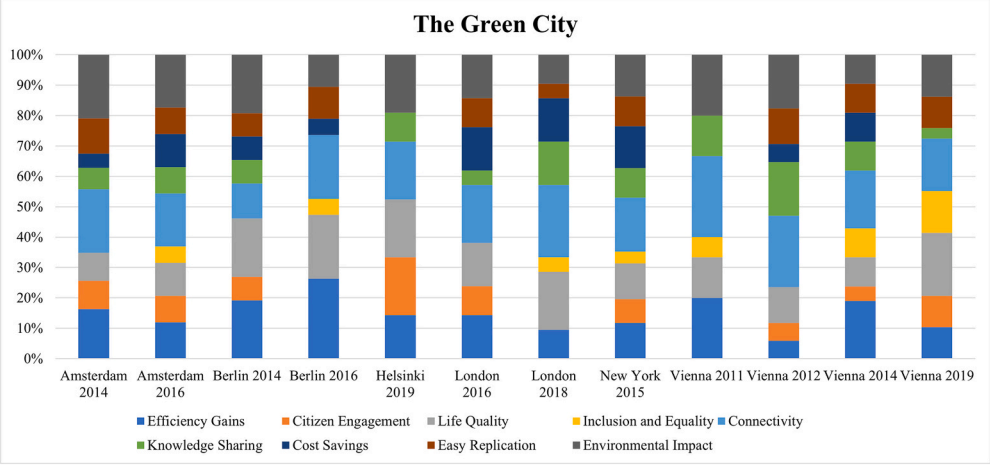

Fig. 6. Cities across years focusing on environmental sustainability goals.

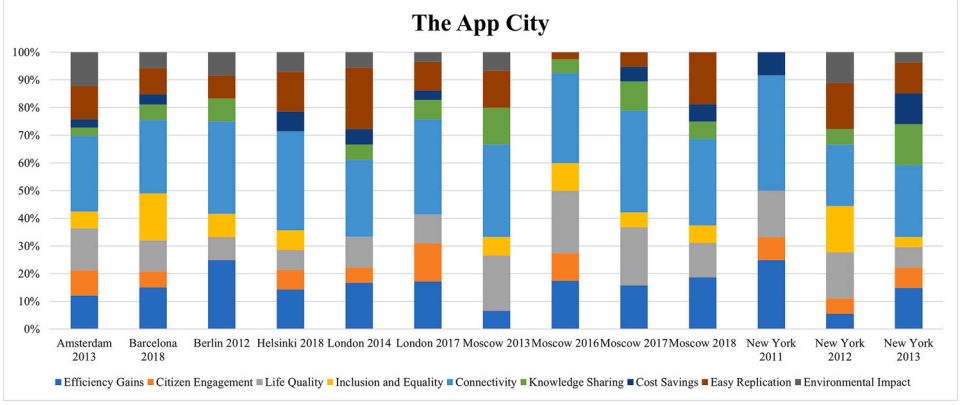

Fig. 7. Cities across years focusing on QoL applications.

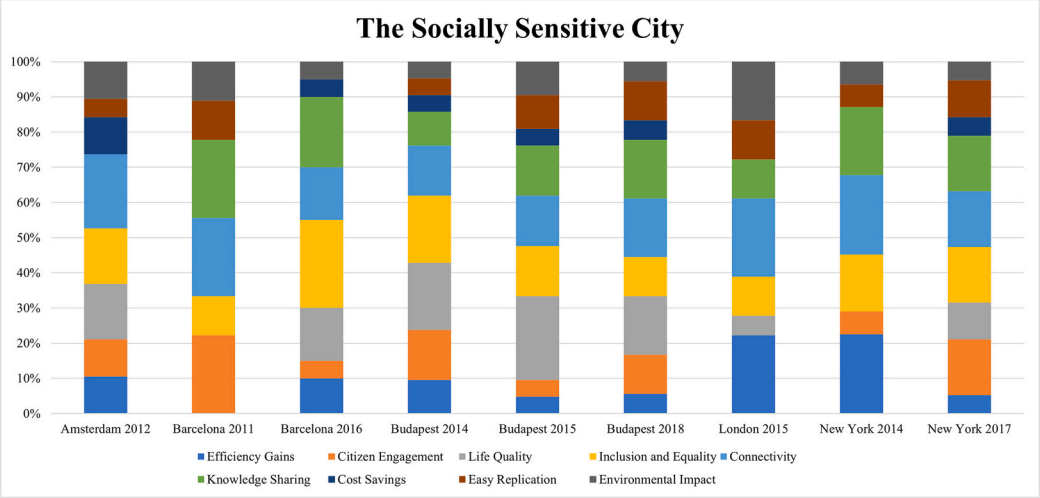

Fig. 8. Cities across years focusing on social impacts.

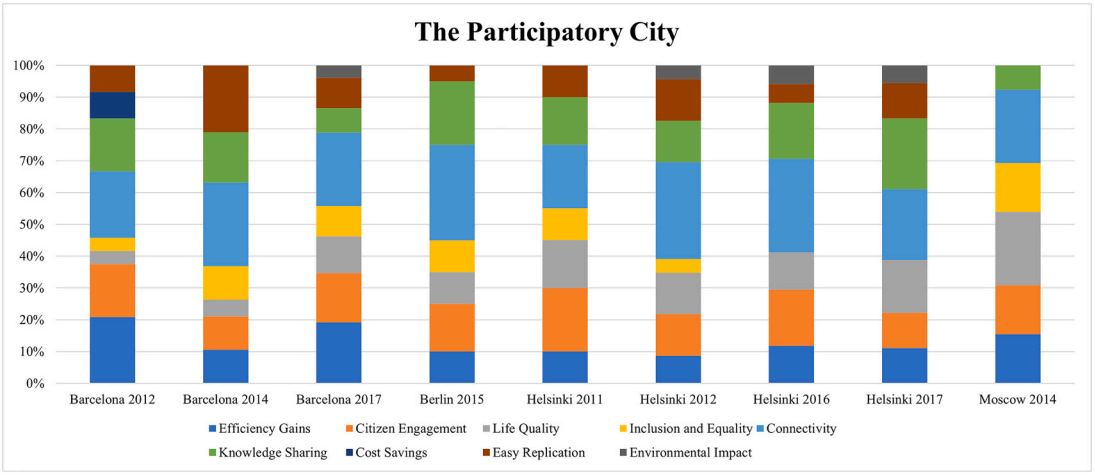

Fig. 9. Cities across years focusing on citizen engagement.

their weight. Furthermore, the weight of each activity is also not considered. These limitations could be managed by considering the main, as well as side effects of anticipated benefits, by introducing a weighting procedure, together with the investment size of each activity. However, these aspects were out of the scope of this research.

Although we examined the anticipated benefits of SC activities, our research did not consider the actual impacts, they realized. It is advisable to study, did cities achieve what they have planned? What was planned, and what was not achieved? What else did they achieve?

CRediT authorship contribution statement

Máté Szilárd Csukás: Conceptualization, Data curation, Writing - Original draft preparation, Visualization, Investigation, Software. **Roland Zsolt Szabó**: Methodology, Software, Validation, Writing - Reviewing and Editing, Supervision.

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Appendix A

Reference	B1	B2	B3	B4	B5	B6	B7	B8	B9
Ahvenniemi et al. (2017)						X			X
Albino et al. (2015)	X	X							X
Allam and Dhunny (2019)					X				
Almirall et al. (2016)	X	X							

(*continued on next page*)

(*continued*)

Reference	B1	B2	B3	B4	B5	B6	B7	B8	B9
Angelidou (2014)	X	X	X						
Angelidou (2015)	X					X			
Angelidou (2017)									X
Anttiroiko (2016)		X	X						
Anttiroiko, Valkama, & Bailey (2014)				X					
Bakici et al. (2013)	X	X	X				X		
Ballas (2013)			X				X		
Barrionuevo et al. (2012)	X	X							
Batty et al. (2012)	X	X		X	X				
Belanche et al. (2016)	X		X						
Ben Letaifa (2015)									X
Beretta (2018)				X					
Bibri and Krogstie (2017)	X								X
Bolívar (2016)		X							
Borsboom-van Beurden et al. (2019)								X	
Caragliu et al. (2011)	X	X	X	X		X			X
Chen (2010)			X						
Chourabi et al. (2012)	X	X	X						X
Dameri and Rosenthal-Sabroux (2014)	X								X
Deakin and Reid (2018)	X								
Debnath et al. (2014)	X								
Deloitte (2015)								X	
Desdemoustier et al. (2019)	X					X			
Dezi et al. (2018)		X			X				
Dirks and Keeling (2009)	X		X		X		X		
Dirks et al. (2010)	X		X						
Dodgson and Gann (2011)	X								X
Eger (2003)			X						
European Commission (2020)				X		X			
SCIS (2018)								X	
Fernandez-Anez et al. (2018)	X	X							
Ferrer et al. (2017)								X	
Fietkiewicz and Stock (2015)			X						
Giffinger et al. (2007)	X	X	X		X				X
Gil-Garcia et al. (2015)		X							
Hall et al. (2000)	X								X
Hao et al. (2012)	X								
Harrison and Donelly (2010)					X				
Harvey (2000)				X					
Heaton and Parlikad (2019)						X			
Hollands (2008)	X	X		X	X				
Hollands (2015)			X						
Hunter et al. (2018)							X		X
Komninos (2002)					X				
Komninos (2006)	X						X		
Komninos (2011)		X	X	X		X	X		
Kourtit and Nijkamp (2012)	X								
Kummitha and Crutzen (2017)						X			
Lam & Ma (2019)		X							
Lazaroiu and Roscia (2012)	X				X				X
Lee et al. (2013)					X		X		
Lombardi et al. (2012)	X	X							X
Mahizhnan (1999)	X		X		X		X		
Manville et al. (2014)				X					X
Marsal-Llacuna et al. (2015)						X			
McNeill (2015)							X		
Mora et al. (2018)	X	X							X
Mora, Deakin, and Reid (2019)			X						X
Nam and Pardo (2011a)	X	X		X			X		
Nam and Pardo (2011b)									
Naphade et al. (2011)	X								X
Neirotti et al. (2014)	X		X	X					X
Pam & Ma (2018)					X				
Pham (2014)									X
Porter (1997)		X							
Rajakallio et al. (2018)		X							
Robinson (2014)			X						
Ruhlandt (2018)						X			
Schuurman et al. (2012)					X				
Sepasgozar et al. (2019)						X			
Shapiro (2006)			X						
Söderström et al. (2014)	X								
Taylor Buck and While (2017)								X	
Thomas et al. (2016)			X						
Thuzar (2011)			X						
Trencher (2019)		X							

(*continued on next page*)

(*continued*)

Reference	B1	B2	B3	B4	B5	B6	B7	B8	B9
van den Buuse and Kolk (2019)							X		
van der Graaf and Ballon (2019)		X							
Winden & Buuse, 2017								X	
Winden et al. (2016)								X	
Vanolo (2014)	X								
Washburn et al. (2010)	X	X					X		
World Bank (2016)				X					
Yigitcanlar and Velibeyoglu (2008)						X			
Zygiaris (2013)					X				

B1: efficiency gains; B2: citizen engagement;B3: quality of life; B4: social inclusion and equality; B5: connectivity; B6: knowledge creation and sharing;B7: cost reduction; B8: scalability and transferability; B9: environmental impact.

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