Four European Smart City Strategies

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Abstract

This paper provides evidence-based policy recommendations about the development of smart cities. The core characteristics of smart cities, including the use of advanced technology, human and social capital development, the development of pro-business environments and networking, are 'translated' into individual domains that characterize smart city strategies. Four major European cities (Amsterdam, Barcelona, London and Stockholm) are examined in terms of how they have so far incorporated those domains in their ongoing smart city strategies. The data are analyzed comparatively, highlighting trends and contrasting differences among strategies. The paper closes with conclusions about those characteristics and their role in smart city policy making.

Keywords: urban development; strategy; policy; sustainability; society; technology

1. Introduction

The technological advancements of recent decades have had not only a powerful, but also a transformative impact on urban life. The wide availability of Information and Communication Technologies (ICTs) in urban settings and their broad adoption throughout society have created a state of technological ubiquity in developed countries. As technology advances and becomes more affordable, the functionality and sustainability of urban systems undergoes significant advancements as well. At the same time, increased access to information enforces the role of knowledge as a powerful engine of economic growth. This enables the development of knowledge-based societies. Under these continuously evolving conditions, many concepts about the organization and management of the new technological capabilities have become popular, including the one of 'smart cities'.

Inspired by the above situation and the recent literature, this paper aims to illustrate the state-of-play of applied smart city strategies in large European cities and then reach conclusions about the current idea of what it means to be 'smart' in a city context. This is achieved by exploring how the core characteristics of the smart city idea have been incorporated so far in four ongoing European smart city strategies (Amsterdam Smart City, Barcelona Smart City, Smart London Plan and Stockholm Smart City).

The paper is structured accordingly. The following section (2) starts by presenting the smart city idea and pointing out the defining characteristics of smart cities, as they have been documented in the recent literature. These characteristics include (i) the central role of technology as an enabler of effective infrastructure and recourse management, (ii) the role of human and social capital as sources of knowledge dissemination and new knowledge creation, (iii) the development of pro-business environments pro-business environments attracting investment and spawning new businesses and (iv) the increasing importance of collaboration and networking of city authorities in pooling recourses, exchanging knowledge and attracting citizens and businesses. The third section of the paper (3) describes how the presented research was conducted, including the data, cases and analysis methods that were used. The fourth section (4) presents the empirical findings about each case of a smart city strategy and explores each of the previous characteristics through a critical lens, reaching conclusions about each of them individually. The last section of the paper (5) discusses the conclusions that emerge from the previous review about the smart city movement as a whole.

2. The 'Smart city' movement and its characteristics

2.1 The smart city idea

There are fundamental disagreements about the meaning and the dimensions of the smart city, while many cities claim to be 'smart' without evidence-based justification (Komninos, 2011a; Chourabi et al., 2012; Nam and Pardo, 2011a;

Papa et al., 2013; Allwinkle and Cruickshank, 2011; Wolfram, 2012; Lombardi et al., 2012; Hollands, 2008). The discussion is ongoing, fueled by a multitude of definitions and solutions in the smart cities' arena, without a prevalent or universally acknowledged set as of yet. In this context, no city can actually claim that it has conquered smartness fully; rather, as technologies and societies are changing dynamically, the smart city is called to redefine itself and experiment with new ways of thinking about technology, and how this technology can be used to enhance common good.

Smart cities represent a conceptual development model that aspires to use ICTs for the development of a city's human, collective, and technological capital, with the ultimate scope of increasing urban sustainability. They constitute an idea for the ideal future of an urban settlement that harnesses technology. They also imply integrated processes to realize this idea. In the best case scenario, a city that aspires to become 'smart' has an integrated, forward-looking strategic plan that defines a vision and a methodology based on capitalizing digital technologies to improve urban functions and develop knowledge ecosystems. As any strategy, it is important that strategic plans for smart cities are adapted to the needs, priorities and constraints of their circumstances.

Recent estimations speak of 143 (Lee and Gong Hancock, 2012), 300-400 (Nikkei BP Cleantech Institute, 2010) and 102 smart city projects worldwide (ABI Research, 2011). It is difficult to estimate the exact number of smart city projects undergoing implementation in the different parts of the world because of abundant disagreements. Beyond doubt, however, they are popular and, for that matter, 'fashionable' in the policy arena (Lombardi et al., 2012; Kourtit and Nijkamp, 2012; Kourtit and Nijkamp, 2013). This situation complicates efforts to define the real meaning of 'smartness' in a city context and clearly distinguish a smart city's characteristics.

2.2 Characteristics of smart cities

As mentioned previously, the concept of the smart city emerged recently and is constantly being transformed by contemporary technological and economic trends and ongoing discussions. Nevertheless, in order to be able to study a number of applied smart city strategies comparatively, it is first essential to point out the general characteristics that define what it means to be 'smart' in an urban context . Based on these characteristics, we will proceed in the later sections of this paper to investigate how four actual smart city strategies have been designed and implemented so far.

The first distinctive characteristic of smart cities is the central role of technology as a means for accumulating, organizing and making vast amounts of information accessible to an increasing number of people, subsequently using this information to improve urban functions and save recourses. As technologies become more affordable and the urban environment gets extensively instrumented with sensors, real-time data streams and the Internet of Things (IoT) emerge. If we add to this the rising interest of people and communities to log their own data about their lives and activities, the volume of collected data becomes vast. Not only can a city's functions be monitored constantly, but also, with the help of advanced analytics, they can be audited to identify prevailing patterns and trends, predict incidents before they even occur and adjust the provision of services and goods depending on the circumstances. Public authorities can make better-informed and documented decisions and solve problems successfully, while the city's populace can access efficient and high-end services in the domains of economic activity, governance, quality of life and utility management (Komninos, 2011a; Komninos, 2011b; Schaffers et al., 2011). This technologically-enabled ecosystem yields improvements of a city's functions, enhancing environmental sustainability and rendering the city 'smart' (Allwinkle and Cruickshank, 2011; Caragliu et al., 2009; Tranos and Gertner, 2012; Angelidou, 2014).

The second quality of smart cities is the advancement of human and social capital through knowledge creation and dissemination, advanced participation and digital inclusion, and the establishment of new forms of innovation (open, social). In smart cities, a large fraction of the available knowledge is produced collectively; knowledge is an asset that stems from everybody's contribution. Smart cities attract highly qualified people and a skilled labor force because of their openness and their eagerness to use technology in effective and innovative ways. They attract creative people who build creative cultures and industries, which in turn foster the development of knowledge ecosystems that bring prosperity to the city. In addition, it is now well documented that creative, intelligent and highly skilled people are the most powerful engines of urban development (Edvinsson, 2006; Glaeser and Berry, 2006; Shapiro, 2006; Florida, 2002; 2005; Landry, 2000); they produce new ideas, products and strategies, either individually, or in collaboration within social networks (Komninos, 2009). The 'crowd' can be smart; collective intelligence is more powerful than any machine or individual intelligence (Ratti and Townsend, 2011). In parallel, smart city programs provide platforms for engaging citizens and stakeholders and assessing the viability of smart city solutions and services in real-life contexts (Carter et al., 2011; Bria, 2012; González and Rossi, 2012). Overall, the city benefits widely from localized knowledge spillovers, collective intelligence functions and the development of inclusive communities that confront the challenges and grasp the opportunities of the rising digital economy (Allwinkle and Cruickshank, 2011; Caragliu et al., 2009; Tranos and Gertner, 2012; Hollands, 2008; Angelidou et al., 2012; Angelidou, 2014).

The smart city movement is also geared towards the advancement of the business sector, to be realized through a high

record of entrepreneurial agility, investment attraction and new business creation. Smart cities, as documented in the recent bibliography, are characterised by a distinctive emphasis on business-led urban development and attraction of capital. They aim to forge business-friendly environments offering advanced services to businesses and entrepreneurs. They also claim to nurture the development of highly professional entrepreneurial environments, providing the ideal preconditions for businesses to prosper, innovate and network (Caragliu et al., 2009; Hollands, 2008; Tranos and Gertner, 2012). Furthermore, in the EU's current policy framework, RIS3 strategies for smart specialization call, among others, entrepreneurial actors to explore opportunities in existing or new sectors and experiment with new activities, to pin-point the most promising areas for future regional development (Foray et al., 2012). On the whole, both European policies and the smart city movement place a distinct priority in advancing and diversifying the entrepreneurial environments of cities.

Finally, critical thinking about smart cities emphasizes networking within and among cities and regions, for purposes of image making, best practice dissemination, production base diversification and the establishment of economies of scale. In today's knowledge economy and culture, city authorities find themselves increasingly under pressure to offer more innovative and high quality services, while increasing public endorsement. Cities are geared towards creating alliances and collaboration networks to exchange knowledge and coordinate recourses, while bringing out the diversity and unique character of their locus; most cities already have such alliances in place. Marketing and communication techniques have penetrated strategies for future urban development, including smart cities. Authorities attempt to communicate their smart city plans to the public by sharing concepts (promotional identity and brand), visions, goals, priorities, and even strategic plans (Nam and Pardo, 2011b) and by publishing annual reports, including performance data and statistics (Bélissent, 2011). Networking is today realized primarily thought online digital media (websites, social media, wikis etc.) and in a European context, through trans-regional and trans-national collaboration, especially in the field of smart cities.

3. Research Design

This section describes how the research presented in this paper was designed, including the data, cases and analysis method that were used and why they were chosen.

3.1 Data Selection and Accumulation

First was decided the information that would be collected about smart city strategies. Taking into account the framework of the available literature, the characteristics of smart cities (section 2.2.) were 'translated' into domains to be surveyed in each case. The followings show these characteristics and their breakdown:

Characteristic 1: Central role of technology

- Domain 1: Smart technologies and infrastructure: how each smart city strategy approaches technology and infrastructure

- Domain 2: Digital services and applications: the types of services and applications offered in the context of a smart city strategy. These can be categorized in the domains of: (i) Economic activity: manufacturing, commerce, businesses and finance, education, research, health, tourism, primary sector, (ii) City Infrastructure & Utilities: transport, energy, water, waste, (iii) Quality of Life: social inclusion, social care, safety and security, environmental alert and (iv) City Governance: city hall services, citizen participation, informed top-level decision-making, monitoring and benchmarking (Komninos, 2011a).

Characteristic 2: Human and social capital advancement

- Domain 1: Education and training: smart city strategies that promote infrastructures, institutions, and programs for high quality and innovative undergraduate/ postgraduate/ vocational education.

- Domain 2: Social & Digital Inclusion: the main drive behind the smart city strategy: Social inclusion, addressing the digital divide, accessibility, closing of skills gap, etc.

- Domain 3: Bottom-up approach: in the context of the smart city, a bottom-up approach refers to the involvement of the city's people, interest groups and organizations (i.e. 'stakeholders') in all or some stages of the smart city development. With engagement, users with different knowledge domains and levels, skills, experiences, roles, points of view and needs contribute to the success of the smart city.

- Domain 4: Experimentation and testing of new products and solutions: pilot programs and test beds are platforms that are used to assess the viability of specific solutions and services or to engage citizens and stakeholders. They are useful in delivering proof of concept, testing specific tools and techniques and validating and perfecting the proposed strategic framework.

- Domain 5: Culture shift: smart city strategies driving a culture shift throughout society, for example, towards

environmental awareness, a technology savvy society, a participatory society, creative and innovative thinking, etc.

Characteristic 3: Business sector advancement

- Domain 1: Measures for Business sector development: these include measures for attracting and developing innovative businesses and knowledge workers: (i) financial incentives (tax exemptions, bank loans with privileged interest rates, business angels, seed funding, venture capital etc.) (ii) business incubation services (growth assistance for startup and early-stage companies) and (iii) technology transfer and commercialization services (intellectual property protection, industrial support of ongoing Research and Development (R&D), collaboration platforms with academia, industry and government).

Characteristic 4: Networking

- Domain 1: Partnerships and alliances: Partnership with other cities for knowledge and experience exchange, in order to disseminate best practices, develop complementarities in weak and strong points, coordinate recourses and create economies of scale.

- Domain 2: Marketing: A dedicated strategy about how the smart city organization will create, deliver and communicate the value of the project to the wider audience, so as to gain broader support and acceptance. This may include promotional events to market the smart city project, participation in conferences/competitions/awards, a branding strategy, etc.

- Domain 3: Digital presence (website, social media): A website to make the smart city project known to a broader audience and provide information for stakeholders. Presence on common social media (city-operated blog, Facebook, Flickr, FourSquare, Google+, Instagram, LinkedIn, Pinterest, Tumblr, Twitter, YouTube, Vimeo).

3.2 Case selection

Four major European cities that are in the process of developing or implementing a smart city strategy were selected to be studied: Amsterdam, Barcelona, London and Stockholm. Their selection took place considering the following criteria:

- Conformation with the working definition of the 'smart city' (section 2.1)
- The existence of an integrated smart city strategy, to the extent possible
- The degree of data availability

The data was sourced through academic articles published in scientific journals and conferences, academic and corporate research reports, government documents, corporate documents and non-scientific articles published during the period January 2014- September 2014 on online sources (technology websites, online newspapers and blogs, etc.)

3.3 Case selection

The analysis method that was used is the Multiple case study analysis[1] (Miles et al., 2013; Yin, 2003; Eisenhardt, 1989), is a type of qualitative analysis that presents and compares the main findings of qualitative research in a detailed and systematic way. In order to perform the multiple case study analysis, cross-case matrices were developed (presented in the Appendix 1 of this paper). These matrices allow comparison of findings systematically across cases and analyze similarities, differences and patterns of behavior.

4. Results

4.1 Empirical Findings

The first smart city strategy that was studied is Amsterdam, the Netherlands. Amsterdam Smart City is being realized through a partnership among businesses, authorities, research institutions, and the people of Amsterdam (over 70 partners, including CISCO and IBM). The aim of this partnership is the transformation of the Amsterdam metropolitan area into a smart city with the ultimate goal of reducing CO_2 emissions. Amsterdam's smart city platform connects all of the city's stakeholders through 'smart' collaborations; it brings them together with the purpose of developing and implementing shared ideas and solutions for the city. Currently the program comprises 32 projects that present innovative ideas and new business models across Amsterdam's neighborhoods. These projects fall within seven 'areas of interest': Smart Mobility, Smart Living, Smart Society, Smart Areas, Smart Economy, Big & Open Data and Infrastructure (water, roads, energy, ICT). Initially, they are to be tested on a small scale and the ones that prove to be effective will be extended to larger areas. All projects are built around informing citizens, entrepreneurs and the public sector about their energy consumption and educating them about how to manage it more prudently. To achieve this,

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[1]also known as ' cross-case analysis'

smart devices and wireless meters transmit information over broadband networks helping the citizens and organizations of the city to behave more 'intelligently' by reducing their energy consumption. Two well-known projects of Amsterdam Smart City are the 'Climate Street' and the 'West Orange' project. They are a commercial and a residential area respectively, where smart and energy-saving technologies were introduced along with smart meters and energy displays with the purpose of encouraging users to save energy and reduce their carbon footprint (Amsterdam Smart City official website, 2014; Baron, 2012; Šťáhlavský, 2011; Sauer, 2012).

The next strategy was the one for the Smart City of Barcelona, Spain. The City of Barcelona has been using ICTs to improve urban functions for more than a decade now, with dispersed projects running in various departments. Barcelona also has a long experience in Living Lab initiatives and is in the process of developing a formal smart city strategy. The Urban Habitat Department (the so called 'Smart City' department) was created after a major organizational reform. It is a new umbrella structure to coordinate services previously provisioned by individual City Departments regarding infrastructure, ICTs, urban services, urban planning, environment, housing, architecture, energy and water, etc. Under this new organizational scheme, previously isolated government departments are called to coordinate their strategy in order to achieve common goals. In addition, the formal strategy has a global outlook, seeking to forge an open environment for the collaboration among government, industry, academia and citizens. It comprises three individual axes: 'international promotion', 'international collaboration' and 'local projects'. The number of local projects is over 100 –some examples include the New Municipal Network, Energy Efficiency in Buildings, Smart Lighting, Smart Water, Smart Transportation, Smart Citizens, O-Government & Efficiency and Optimized Waste Collection (Barcelona Smart City official website, 2014; Ajuntament de Barcelona, 2013; Ajuntament de Barcelona, 2012; Bakici et al., 2012).

The next smart city strategy studied is London's 'Smart London Plan'. In London, the first concerted effort to use smart city applications took place in 2012, with the purpose of managing public transport under the demanding circumstances of that year's Olympic Games. Eventually, in 2013, the Smart London Board was created, comprising academics, businesses and entrepreneurs, commissioned to advise the Greater London Authority on smart city matters. The Board produced the Smart London Plan, organized around seven key themes: (1) placing Londoners at the core of innovation, (2) providing access to open data, (3) leveraging London's research technology and creative talent, (4) facilitating networking among and with other smart city stakeholders (5) enabling 'smarter' infrastructure development and management (6) providing more effective and integrated City Hall services and (7) offering a 'smarter' London experience for all. The plan includes a series of actions and measures of success for each key theme. London's smart city strategy is mostly focused around the institutional and digital space, rather than the physical. However, it also includes some improvements and new developments in infrastructure, as well as urban regeneration projects. The most important one is 'Here East', a 1,200,000 sq. ft. digital quarter to be developed at Queen Elizabeth Olympic Park, leveraging the buildings of the former Press and Broadcast Centers of the 2012 Olympics. It will be a campus that supports growth of London's technology sector, combining business, technology, media, education and data to create a local system of innovation. As such, it will provide space for start-ups, education and post-graduate research (Greater London Authority official website, 2013; Fletcher-Smith, 2014; Malthouse, 2014).

In the case of Stockholm Smart City, Sweden, the data collection process has already been completed. Stockholm has a long tradition in research and innovation in environmental and information technology. It also has a well-established culture as a livable and sustainable city that offers high living standards and efficient government services. Stokab is the name of the city-owned company which has been developing and managing the city's open fiber-optic communications network and promoting optimal conditions for ICT development since 1994. Today Stokab offers 100% broadband coverage within the Stockholm region. In Stockholm's smart city strategy, environmental and information technologies are tested and used extensively throughout the city's infrastructure, with the purpose of creating a flourishing ecosystem that involves the city's inhabitants, the private industry and the public sector, while fostering a dynamic local economy. The strategy is citizen-centric, focusing on providing enhanced e-government services to citizens. Government services include online City Hall services and services for mobility and energy improvement based on real-time data collection about traffic and weather. The data are collected through Global Positioning Systems (GPS) placed on public vehicles, as well as traffic and weather sensors, pollution monitoring equipment, etc. Residents have real-time information about traffic flow, journey times, and best travel options, including a journey planner. The City is also using pilot projects to test technology solutions but in a different light than most of its counterpart smart cities: it uses large scale, real environment test beds, called 'demonstrators'. One of those demonstrators, for example, is 'Kista Science City', Sweden's world-class ICT cluster, where Research and Development (R&D) and technology transfer take place between businesses and the academia, demonstrating an exemplary concentration of expertise, innovation and business opportunities in the ICT field. Another demonstrator is the 'Royal Seaport' area, which is being redeveloped into a 'smart' area with a capacity of 20,000 residents and 50,000 workers, to be used for testing innovative technologies and services in health care, energy and transport (Stockholm smart city official website, 2014; Johnson, 2014; Stockholm

Royal Seaport Innovation official website, 2014; The Intelligent Community Forum, 2009).

4.2 Multiple case study analysis results

The previous smart city strategies were screened to acquire information about each smart city characteristic (section 2.2.) and its constituent Domains (section 3.1.). This information was studied comparatively regarding each characteristic across the four cases. The results are presented in the following paragraphs.

In terms of technology as a core component of smart city strategies, all four cities invest predominantly in broadband networking (mostly wireless and optical fiber) and on a second level on sensor networking (sensors on stationary and mobile devices). Wireless broadband networking is obviously a more convenient option for cities with complex physical structures already in place. However, Stockholm's case of 100% optical fiber coverage is an exemplar that is the result of proactive policy making and continuous efforts by the City. In terms of digital services and applications, the foremost frequency is observed in the domain of city infrastructure and utilities, namely energy, transport and waste management. Government services play an important role, too, encompassing city hall services and means for engaging citizens in the policy making process. Digital services for the improvement of economic activity and quality of life have a non-existent or secondary role in the studied smart city strategies, although one would expect the contrary regarding cities with a long history, culture and established social innovation dynamics. This phenomenon can be explained by the fact that the current experience, availability and technological maturity of digital services in the domains of city infrastructure and utilities and government services far outweigh the more 'sensitive', vaguely defined and largely untried services in the domains of economic activity and quality of life. The following cross case matrix (Table 1) summarizes the characteristics of each case:

Table 1. Cross case matrix displaying the status of each case with regard to Characteristic 1: Central role of technology (source: author's elaboration)

City	Domain	Data / Information
Amsterdam	Smart technologies and infrastructure	Broadband and sensor networking. Innovative technologies for energy consumption monitoring and renewable energy production.
Amsterdam	Digital services and applications	Services and applications for energy consumption monitoring and renewable energy production (distributed power generation, energy advice, energy displays, energy storage, smart meters, smart lighting, electric vehicles, EV charge points, electric waste collection, sustainable logistics and ultra-fast charging).
Barcelona	Smart technologies and infrastructure	Broadband and sensor networking. Emphasis on connectivity as a means for better urban services, public participation, mobility and sustainability.
Barcelona	Digital services and applications	Services and applications for (i) transport, energy efficiency in buildings and utilities, waste collection etc., (ii) government services and citizen participation, (iii) urban resilience.
London	Smart technologies and infrastructure	Broadband and sensor networking.
London	Digital services and applications	Services and applications for (i) infrastructure management (smart grid, smart waste collection, 3D visualizations of infrastructure and smart transport for people and freight), (ii) city governance (e.g. 'Talk London' platform), joint working across different policy and physical areas, city planning and city management.
Stockholm	Smart technologies and infrastructure	Mostly broadband networking (through Stockab, the city-owned company that manages the city's open fiber-optic communications network of a 100% broadband coverage).
Stockholm	Digital services and applications	Services and applications for (i) mobility and energy consumption improvement based on real-time data collection about traffic and weather and (ii) government services (online council meeting, permits, applications).

In terms of human and social capital advancement, and specifically education and training towards 'smart' people and economy, the situation appears to be fragmented. Most smart city programs include minimal education and training activities for individuals, mostly confined to the use of selected 'smart' devices rather than extending the population's digital skills over the broad spectrum of smart city capabilities and closing the skills gap. The exemplar here is London's smart city strategy, which targets education and training in multiple levels, including physical and digital educational infrastructure, institutions and targeted programs. Educational institutions have an active role within the smart city ecosystem, as they are expected to become hubs of innovation in education, collaborative research in edge sectors and multifaceted social interaction. However, a weak link is documented between academia and industry as well as government, meaning that new knowledge and innovative ideas face difficulties in circulating, becoming

commercialized and adopted throughout society.

Social and digital inclusion appears as the most problematic policy area. All strategies regard social and digital inclusion as related loosely or even completely disconnected with the smart city idea. No mention whatsoever to these aspects was found in two of the studied smart city strategies (Amsterdam, Stockholm), while one strategy includes it as priority but does not elaborate the idea further (Barcelona), and another one (London) regards the issue of social and digital inclusion as a parallel, standalone policy area.

Bottom up approaches, on the other hand, seem to be a smart city domain where experience is starting to bear fruits. The studied smart city strategies demonstrate an increased understanding of the significance of participatory procedures, as well as their underlying technological and cognitive processes, which are increasingly becoming common ground in public policy making. They foresee the collaboration among the cities' inhabitants, businesses and public sector as a source of new and effective knowledge production and as a precursor for the development of open knowledge and innovation ecosystems. However, there is still work to be done towards extending bottom-up engagement into the strategy development phase (besides the implementation phase). In the studied cases, the most important vehicles for bottom-up engagement are primarily Open Data initiatives and, secondarily, Living Labs. Nevertheless, there is still progress to be made, and as technological advancements enable new forms of collaboration and bottom-up organization, this domain will not cease to require special attention.

In addition, we observe that testing of smart city solutions is an integral part of smart city strategies. Pilot projects are useful in delivering proof of concept, testing specific tools and techniques and validating and perfecting solutions and strategic frameworks. However, the scale and the degree of dispersion behind the testing of those solutions vary. In Amsterdam and Barcelona most pilot programs test a specific technology on a neighborhood scale -for example, pilot energy management systems along commercial streets or residential neighborhoods. Other pilot programs in the same cities extend over multiple points throughout the city -for example electrical vehicle transport systems including dispersed electric vehicle and charging stations. London's strategy includes reasonably fewer and locally concentrated piloting activities, focusing on so-called 'lighthouse' projects that demonstrate new approaches. Finally, in Stockholm, a completely different approach is adopted, prioritizing integrated, large scale test beds, called 'demonstrators'. These demonstrators forge new, real environments where many smart city services and solutions are tested at the same time; for example, the Royal Seaport area, with a capacity of 20.000 residents and 50.000 workers, is conceived as one of these demonstrators; Kista Science City is also classified as a demonstrator. In Stockholm, the thought is that this type of large-scale demonstrator allows a better understanding of the potential impact of smart city projects.

Inducing a culture shift throughout society is the domain that summarizes the long term effect of all the above domains and their procedures. The foremost objective in this direction is the establishment of a climate of 'openness', dialogue and collaboration among the city's inhabitants. Other objectives include the development of tech-savvy and environmentally aware people and communities. The following cross case matrix (Table 2) summarizes the characteristics of each case:

Table 2. Cross case matrix displaying the status of each case with regard to Characteristic 2: Human and social capital advancement (source: author's elaboration)

City	Domain	Data / Information
Amsterdam	Education and training	No large scale or integrated education and training activities. Some training to facilitate the implementation of the initiatives, for ex. how to monitor energy consumption devices and how to use open data.
	Social & Digital Inclusion	No information.
	Bottom-up approach	Collaboration among the city's stakeholders, including its people and knowledge institutions to develop knowledge and innovation ecosystems. Both in strategy development and strategy implementation. Open data and Living Lab initiatives.
	Experimentation	City seen as platform for testing innovative ideas and solutions. Projects, ideas and business models are initially tested on a small scale and the ones that prove to be effective will be extended to include other areas.
	Culture shift	Towards sensible energy consumption and sustainable ways of living. Towards a climate of openness and exchange of innovative ideas.
Barcelona	Education and training	Universities are invited to collaborate with research centers and businesses to formulate 'smart ' clusters.
	Social & Digital Inclusion	Social cohesion and accessibility are stated as primary goals. It is not obvious, however, how this will be achieved through the foreseen smart city programs.

	Bottom-up approach	The city's ingenuity, innovation and talent (entrepreneurs, businesses, universities, institutions etc.) are expected to contribute to making Barcelona more innovative. Mostly in strategy implementation and less in strategy development. Open data and Living Lab initiatives.
	Experimentation	Aim to establish the City as an international benchmark platform for innovative solutions. The 22@Urban Lab encompasses 14 pilot programs and aims to use the city as a laboratory of new solutions for marketing municipal services, and also for companies to use as a space for testing, facilitating market access and promoting competitiveness.
	Culture shift	Towards a climate of cooperation, openness and flexibility.
London	Education and training	Education for developing digital technology (not just consuming it). Increase of computer science uptake in London's schools. Program for training of young people with tech city firms. 'Tech City Institute' will provide a space for the discussion of the role that technology can play in the city's development.
	Social & Digital Inclusion	Pan-London digital inclusion strategy about how to address digital exclusion.
	Bottom-up approach	Bottom-up engagement is a focal point of the strategy. The city's people, businesses and other stakeholders are seen as indispensable sources of innovation. Open data initiative.
	Experimentation	Small number of project-based pilots. 'Lighthouse' projects to demonstrate new approaches at scale.
	Culture shift	Towards a climate of cooperation among the city's stakeholders.
Stockholm	Education and training	The City offers e-learning packages on issues such as environmental-friendly practices and Green IT to the City's employees, students and companies. The city's universities and research centers have an active role in the smart city strategy providing educational programs and engaging in R&D in related fields.
	Social & Digital Inclusion	No information.
	Bottom-up approach	The city's inhabitants, private industry and public sector are called to collaborate to produce knowledge collectively. Open data initiative.
	Experimentation	City open to using pilots to test technology solutions, through large scale, real environment test beds, called "demonstrators" (e.g. 'Kista Science City' and 'Royal Seaport' area).
	Culture shift	Towards a climate of tech-savvy people and communities. Locals are well trained and early adopters of new technology.

Proceeding to the third characteristic, all of the four strategies include measures to help their business sector to develop, but each prioritizes different aspects. The most prominent measure regards technology transfer and commercialization, focusing on facilitating business networking and collaboration with academia and citizens. Financial support for business growth follows, involving mostly venture and seed capital funding. Incubation services for early-stage businesses are also frequent, although somewhat less commonly adopted. The above observations could be explained by the fact that technology transfer and commercialization stand for capabilities of high added value in innovative businesses; at the same time, this domain is advancing rapidly thanks to recent technological developments, with the number of related platforms increasing. On the other hand, nowadays, there is a lot of experience available in business incubation, while to a large extent it is an affair of the private sector, i.e. it is exercised by private business incubators which are not formally included in smart city strategies. Overall, one can discern a neoliberal approach towards business sector development, with businesses expected to determine their own position within the broadband economy, leverage offered infrastructures to their best interest, and grasp opportunities in a laissez-faire atmosphere for economic development. The following cross case matrix (Table 3) summarizes the characteristics of each case:

Table 3. Cross case matrix displaying the status of each case with regard to Characteristic 3: Business sector advancement (source: author's elaboration)

City	Domain	Data / Information
Amsterdam	Measures for Business sector development	Seed funding programs / collaborations with banks. Incubation services. Support in international networking of local technology companies and startups.

Barcelona	Measures for Business sector development	Capital attractiveness is a secondary priority, compared to technology and human and social capital. Physical areas for the development of smart city clusters (22@ District and others), equipped with high-technology infrastructure and collaborative spaces.
London	Measures for Business sector development	Support for SMEs to gain access to affordable ultrafast broadband and embrace digital tools. Support of commercialization of innovation, especially in the technology sector.
Stockholm	Business sector development	Measures for Business sector development

Finally, although smart cities harness digital technology for human and social capital advancement, the overall situation in terms of networking has not met its target. It is encouraging that all of the cities participate in networks to exchange knowledge and software, find out about best practices, promote their brand and attract investors and other collaborators in the venture towards 'smartness'. When it comes to marketing, though, none of them has developed an integrated marketing strategy. Marketing efforts are limited to occasional participation in international and promotional events. Barcelona's smart city strategy is the only case with an explicit mission to promote the project internationally, although it is not clearly described how this will be achieved besides the occasional participation/hosting of international events. The scarce digital presence of the studied smart city strategies is even more alarming; the only one with an integrated and long-standing website is Amsterdam, while Barcelona's website about the smart city project was inaugurated only recently. The smart city of London and Stockholm, on the other hand, are being promoted through sections in government websites which, unfortunately, provide limited information about the projects. In terms of social media presence, the only well-performing one is Amsterdam, demonstrating a frequent activity on multiple social media channels. The following cross case matrix (Table 4) summarizes the characteristics of each case:

Table 4. Cross case matrix displaying the status of each case with regard to Characteristic 1: Central role of technology (source: author's elaboration)

City	Domain	Data / Information
Amsterdam	Partnerships and alliances	Alliances with other cities for knowledge exchange.
	Marketing	Organized efforts started in summer 2014. Amsterdam Connects' program, to promote the developed solutions to the international market. Brand name.
	Digital presence	Website: standalone. Social media: Facebook, Google+, LinkedIn, Twitter, YouTube.
Barcelona	Partnerships and alliances	Participation in the City Protocol Society, collaboration with other cities and research centers.
	Marketing	No integrated marketing strategy. Priority to international promotion: participation in international events, multinational corporate events and international lobbies. Brand name.
	Digital presence	Website: standalone. Social media: no. Info about smart city project is communicated via the City's social media channels.
London	Partnerships and alliances	Collaboration with other cities with other cities for knowledge exchange. Some dedicated events.
	Marketing	No integrated marketing strategy. No brand name.
	Digital presence	Website: section on the website of the Greater London Authority. Social media: no. Info about smart city project is communicated via the City's social media channels.
Stockholm	Partnerships and alliances	Rather limited collaboration and networking activities. Some dedicated events that have to do with specific initiatives, such as Open Data. Awards: 'Green Capital of Europe' (2009), 'Intelligent Community of the Year' (2009).
	Marketing	No integrated marketing strategy. No brand name.
	Digital presence	Website: section of City's website. Social media: no. Info about smart city project is communicated via the City's social media channels.

5. Conclusion

Apparently, many cities fail to see smart city programs as part of their long-term, comprehensive development plan and, consequently, they do not engage in methodical strategic planning. However, smart city strategies represent very important urban development policies that include large investments and long-lasting physical infrastructures. They yield serious consequences in the delivery of services and the relationship among the public sector, citizens and businesses, shaping the future of society and governance in the years to come. It is thus essential to study them methodically and strategically, including all stages of strategy development and capitalizing broadly on of the city's resources.

Undeniably, the defining characteristic of a smart city strategy is the promotion of technological infrastructure development. Technology and artificial intelligence are indispensable dimensions of a smart city. It seems that cities opt for tried-out and quick result yielding technological solutions in a variety of domains, with a preference on transport, energy and waste management. Nevertheless, technology is not an end in itself. Smart city strategies should combine tested and leading edge technology, rather than focusing on either; the first one secures efficient function and broad adoption, while the second one promotes new and innovative solutions. Experimenting with new technologies and solutions is an integral element of smart city strategies, and it can take place to various extents ranging from a city block to whole neighborhoods or the entire city.

Technology would be useless if it didn't promote the development of human and social capital. Strategic planning for the development of smart cities needs to capitalize on both technological advancement (i.e. digital intelligence) and on the development of knowledge and innovation networks (i.e. human intelligence); technology underpins the development of knowledge and vice-versa, improving knowledge dissemination, social innovation and digital inclusion. Most smart city strategies seek to improve human and social capital by (a) developing their 'soft' infrastructure, namely social and education programs to improve accessibility, inclusion, and awareness of the public and/or (b) developing their 'hard' infrastructure in form of educational and social facilities. There is also a trend to establish dedicated areas within smart cites, where academia and industry collaborate and engage in innovative activities that overall contribute positively to the development of human and social capital.

Smart city strategies seek to enhance the attraction capital predominantly by offering financial and operational incentives (government services for businesses, business incubation services, and incentives such as tax exemptions and favorable financing schemes) and collaboration opportunities with other businesses, the government and academia. Some smart city strategies also offer showcase opportunities (businesses have the opportunity to demonstrate their products and services in real-life settings) and business promotion services (platforms to market the city's businesses). Nonetheless, attracting capital and investments are important elements of smart city strategies.

Collaboration and networking, referring to partnerships with other cities for knowledge and experience exchange and examining complementarities in strengths and weaknesses, is a basic horizontal characteristic of smart cities, too. Large and established cities, such as the ones studied in this paper, are in privileged position, as they are already experienced in international networking and are members of various networks and city alliances that they can leverage. Special attention should be paid to promote the digital presence of the city (website, social media). Such promotion will underpin efforts towards becoming smart and engaging stakeholders in this process.

Overall, it seems that we are finally heading towards a true integration of the digital with physical and institutional dimensions of the smart city. Physical planning and social policy, then, can and should underpin the digital or 'smart' dimension of the city and promote its integration upon them.

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