Towards an effective framework for building smart cities: Lessons from Seoul and San Francisco

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Abstract

This study aims to shed light on the process of building an effective smart city by integrating various practical perspectives with a consideration of smart city characteristics taken from the literature. We developed a framework for conducting case studies examining how smart cities were being implemented in San Francisco and Seoul Metropolitan City. The study's empirical results suggest that effective, sustainable smart cities emerge as a result of dynamic processes in which public and private sector actors coordinate their activities and resources on an open innovation platform. The different yet complementary linkages formed by these actors must further be aligned with respect to their developmental stage and embedded cultural and social capabilities. Our findings point to eight 'stylized facts', based on both quantitative and qualitative empirical results that underlie the facilitation of an effective smart city. In elaborating these facts, the paper offers useful insights to managers seeking to improve the delivery of smart city developmental projects.

Keywords:
Smart city
Case study
Smart city services
Innovation
Sustainability

1. Introduction

Globalization, urbanization, and industrialization have been recognized as three important drivers leading human civilization into the 21st century. According to the [41], approximately 70% of the world's population will soon live in urban areas. Cities generate 80% of global GDP, a share that is continually (and sharply) increasing. In the context of addressing essential, urgent issues of climate change and sustainable environment, both central and local governments from around the world have devised plans for existing and emerging cities to become both smarter and greener.

Most leading cities in Europe, the U.S. and in Asia have adopted ICT (Information and Communication Technologies) and green technologies as ways to revitalize economic opportunities and to strengthen their global competitiveness. These initiatives range from small-scale applications of individual clean technologies to ambitious projects to transform entire urban areas through master planning and infrastructure development. Notwithstanding the vitality of these initiatives, smart city research remains at a preliminary stage. Discussions in academic literature of relevant theory or frameworks are few; analysis lags behind the actual practice of how different cities, sometimes aggressively, are moving toward transforming themselves into a smart and green city. The technologies necessary to do this span multiple fields and must be integrated in complex systems to be effective. Even though actual practice often remains fragmented, real world implementation still generally outstrips any discussion in academic literature capable of generalization.

Given the gaps in theory and practice for smart cities, this study aims centrally to lay out a taxonomy for analysing smart city development. This framework enables a more systematic exploration of smart development and implementation. What are the evolving best practices for developing innovative
products and service applications for smart cities? What lessons can be learned from particular smart city experiences? How can cities overcome challenges by building effective private–public partnerships, shaping business models that add value, and integrating disparate technologies in a productive ecosystem? What policies and governance structures have been effective in supporting the development and deployment of smart and green industries for cities? What are the driving forces behind these initiatives?

To contribute to meeting these research challenges, this study proposes a conceptual framework laying out a holistic taxonomy for smart city development and implementation practices. The study’s goal is to identify the opportunities offered and challenges posed to different stakeholders in the smart city, including central government officials, city representatives, and private sector players. Research objectives of this study thus include:

1. To develop a conceptual framework to better understand smart city practices and more effectively to identify and assess gaps where adaptation and improvement may be needed.
2. To examine and analyse two leading cases from the U.S. and Asia through the lens of this new framework to identify heterogeneous and heterogeneous characteristics in the process of planning and developing a smart city.

The study will bridge some theoretical and practical gaps for a holistic research approach to smart cities, especially in characterizing the implementation of services into a network infrastructure and structure of governance. The paper synthesizes its case study findings to present eight ‘stylized facts’ intended to offer guidelines to smart city developers. These facts highlight that the process of building an effective smart city is dynamic and relies on the interaction of a number of private and public sectors players, as this is facilitated by an innovation platform. The form of these interactions, that is, the nature of the networked linkages created by private–public interaction will reflect a smart city’s developmental stage and embedded cultural and social capabilities. In observing these characteristics, the study provides useful insights to managers on practical smart city development, especially since most existing studies take a piecemeal approach to the analysis of individual projects.

This paper is organized as follows. Section 2 discusses relevant literature on the smart city and its practices. Section 3 identifies the six driving forces that undergird our conceptual framework, while a consideration of the paper’s data, measures, and methods follows in Section 4. Empirical results applying the conceptual framework to smart cities are presented and analysed in Section 5. Section 6 concludes with a theoretically-grounded elaboration of these ‘stylized facts’ as they emerge from our empirical results and states the managerial implications of this study.

2. Theoretical background

2.1. Smart city definition

The smart city concept originated from various definitions including those of the ‘intelligent city’, ‘information city’, ‘knowledge city’, ‘digital city’ and (in a similar term to ‘smart city itself) ‘ubiquitous city’. These different ‘brands’ of the city concept have some characteristics in common, as well as individual elements, while the definitions have a different scope and place different emphases. The concept of the smart city itself is fuzzy and often inconsistent, as [19] points out.

The concepts of an ‘information city’ and ‘a digital city’ tend to be set out from within a technology perspective in which ICT is understood as the key driving force in delivering innovative online services [8]. The ‘information city’ collects information from localities and delivers it to the public via the internet. Yovanof and Hazapis [54] elaborate a comparable definition of the digital city as ‘a connected community that combines broadband communications infrastructure, a flexible, service-oriented computing infrastructure based on open industry standards; and innovative services to meet the needs of governments and their employees, citizens and businesses’. Other scholars also have emphasized the importance of a city connecting networked organizations comprising different participants including government, businesses and social groups. Discussion of the ‘digital’ city has mainly centered on the development of online services for various groups, who capture the ‘downstream’ side of service value chains.

The ‘ubiquitous city’ has been understood a further extension of the digital or information city in making data ubiquitously available through an embedded urban infrastructure (e.g. through equipment embedded in streets, bridges and buildings). The term originates from the South Korean government, who refer to ‘a city that is managed by the network and provides … citizens with services and contents via the network … with a BUCI (fixed u-City infrastructure) and MUCI (mobile u-City infrastructure), built on high-end technologies such as sensors’ [28,43]. The concept would fit all urban spaces with forms of embedded information infrastructure to provide various services including those for energy and environmental monitoring. Lee et al. [29] have further stressed an idea of the u-City as a convergence of IT services within urban space, accessible regardless of time and location. These services will enhance a city’s competitiveness and the quality of life of its citizens. However, the ubiquitous concept places less emphasis on the uses made of social infrastructure from (for instance) a human and social capital perspective.

The notion of an ‘intelligent city’ focuses on the out-performance of a smart city as this is achieved through innovation in three dimensions: 1) Intelligence, inventiveness and creativity; 2) Collective intelligence and 3) Artificial intelligence. Providers will use ICT to co-create and co-design services, typically through the systemic integration of embedded forms of technology such as sensors and interactive media. [25] understand intelligent cities as leading to a significant, fundamental change in the nature of life and work in a city, rather the space of merely incremental improvements. The theorization of intelligence cities is typically developed within the context of thinking about a ‘knowledge economy’ that views human and social capital as the most valuable assets [53]. Development (including social development) seeks to leverage these assets into the ability to support knowledge creation and procedures for learning. Technological innovation is central to the intelligent city [39], which positions the concept as analogous to the ‘knowledge city’, which encourage the nurturing of knowledge.

This discussion has shown that the smart city concept originates from various perspectives, including those of the ‘information city’. The concept, though, has incrementally evolved into an idea of an ICT-centered city or open city [39].
discuss some conceptual variants of the smart city and identify three core factors: technology (infrastructures of hardware and software), people (creativity, diversity, education) and institutions (governance and policy). Many scholars, including [16], have set out a concept of the smart city as having six main dimensions (a smart economy, smart mobility, a smart environment, smart people, smart living, and smart governance). These works generally define a smart city as being ‘smart when investments in human and social capital and traditional transport and modern (ICT) communication infrastructure fuel sustainable economic development and a high quality of life, with a wise management of natural resources, through participatory governance’ [6]. Besides scholars, some institutional agencies in the public sector have also set out their perspectives on the smart city. Barcelona City Hall defines a smart city as ‘a high-tech intensive and advanced city that connects people, information and city elements using new technologies in order to create a sustainable greener city, competitive and innovative commerce and an increased life quality’ [3]. They add that systems for maintaining and administering the city should be manageable. Amsterdam City Hall posits that the smart city specifically uses ‘innovative technology’ and is willing ‘to change behavior related to energy consumption in order to tackle climate goals. Amsterdam Smart City is a universal approach for design and development of a sustainable, economically viable program that will reduce the city’s carbon footprint’ [1]. Lastly, leading research analysis firms have proposed more specific smart city criteria. Forrester suggests that a smart city is one distinguished by ‘the use of Smart Computing technologies to make the critical infrastructure components and services of a city—which include city administration, education, healthcare, public safety, real estate, transportation, and utilities—more intelligent, interconnected, and efficient’ [51]. Gartner uses an information flow approach to posit that ‘a smart city is based on intelligent exchanges of information that flow between its many different subsystems. This flow of information is analysed and translated into citizen and commercial services. The city will act on this information flow to make its wider ecosystem more resource-efficient and sustainable. The information exchange is based on a smart governance operating framework designed for cities sustainable’ [31].

To sum up, a smart city aims to resolve various urban problems (public service unavailability or shortages, traffic, over-development, pressure on land, environmental or sanitation shortcomings and other forms of inequality) through ICT-based technology connected up as an urban infrastructure. The ultimate goal is to revitalize some of the city’s structural (environmental and social) imbalances through the efficient redirection of information. Smart cities are envisioned as creating a better, more sustainable city, in which people’s quality of life is higher, their environment more livable and their economic prospects stronger.

2.2. Smart city practices

As of 2012, there are approximately 143 ongoing or completed self-designated smart city projects [27]. Among these initiatives, cities in North America (35 projects) and Europe (47 projects) are currently leading efforts to implement smart technologies to address and resolve such urban problems such as energy shortages, traffic congestion, inadequate urban infrastructure, and some issues in health and education. In particular, the European Union (EU) is investing in smart city strategies for metropolitan city regions such as Barcelona, Amsterdam, Berlin, Manchester, Edinburgh and Bath. Further, Asian countries are active with more than 40 different projects, including in Singapore, Hong Kong, Seoul, Busan and Songdo; and smart city efforts extend, as well, to as other regions around the world, including South America (11 projects), the Middle East and Africa (10 projects).

While the scope and style of smart city initiatives vary widely, they all aim to be smarter and greener in order to improve citizens’ quality of life and economic opportunities. Smart green initiatives are generally delivered by a range of different ICT-based services (over a technological infrastructure) that connect to either a web device or smart phone apps. Further, these growing developments are also facilitated by open data platforms that allow the deployment of public service apps (e.g. in Barcelona, New York and Amsterdam, Helsinki and San Francisco). Different public and private bodies deliver services to citizens through smart city apps in the context of an information eco-system; this increases the social value of the city’s public infrastructure and services and private-sector ventures.

A recent GSMA report suggests that transportation (ticketing applications, intelligent transportation and traffic information systems) accounts for most smart city projects. The next sectors are environment/energy (smart metering, electric vehicles and charging infrastructure and renewable projects) and municipal infrastructure services, including water and waste management [18]. Lastly, some cities have set out service or application areas specifically to attract entrepreneurs and to stimulate the development of new economic clusters. For instance, the city of Busan in South Korea has established an app development center jointly partnered with CISCO and KT with the aim of creating new smart city services on a cloud-based smart city app development platform. Within the first year, this initiative has established 13 start-ups, developing 70 apps with a sales revenue of $42,000. The city’s goal is to employ 3500 app developers to drive economic growth and scale up to create business domains; they also hope to expand their business model into other cities [10].

A review of various smart city definitions and practices around the globe makes clear that most smart cities make extensive use of mobile network infrastructure and services. More than 100 cities have deployed smart city services, whether web service or apps based. Cities are also looking to deploy new smart services that intelligently connect not just to a wireless network but to a wider range of devices, machines and urban infrastructure. For instance, the smart city in Barcelona has configured 12 outdoor street lighting points, with eco-digital LED technology and multi-purpose sensors, to be used as a network by multiple vendors [3]. Amsterdam’s climate street app, meanwhile, has developed infrastructure in conjunction with the community to transform a district into a sustainable shopping area with a much reduced carbon footprint [1].

As these examples suggest, the availability of service-oriented business models, in which urban infrastructures can be integrated with intelligent devices and connected to a mobile wireless network, has become an important component in both the social and technological underpinning of a smart city. Lee et al. [28] propose the development of an
integrated smart city architecture taking the form of a multi-layered roadmap; they architected this service-device and technology roadmap based on input from experts and stakeholders involved in smart city R&D initiatives in Korea. The authors’ systematic classification of smart city services, devices and technologies enables research to project emerging smart technology trends and so better to support smart city implementation.

The different smart cities around the globe rely on widely different coordination and control mechanisms to govern their smart developments. A handful of cities take a holistic approach in formulating a long-term master plan (e.g. Seoul, Busan, Amsterdam and Barcelona), putting in place, for instance, test-bed smart city projects prior to the launch of actual commercial services. These pilot schemes may have city-wide coverage or be limited to certain specific zones (e.g. living-labs). Some city administrations coordinate smart city initiatives through a highly centralized office. The advantage of this arrangement is that it enables access to public funding for ICT related projects. In other administrations, individual departments (such transportation or environmental agencies) may enjoy a high level of autonomy in setting up and running their own smart services. These different governance structures tend to tap funding for developing and promoting smart services in different ways. GSMA [18] have categorized smart city governance structures into a typology, featuring four different classes in two dimensions: asset governance and availability of funding.

2.3. Summary

Despite the rapid growth of smart city development, few academic studies address smart cities from a holistic or typological viewpoint. Exceptions include the smart city definitions noted above, as well as several characterizations dedicated to conceptualizing smart cities. In this vein, Nam and Pardo [39] provide principles based on three different dimensions: technology, people and institutions. Their papers seek to establish conceptual relationships between the integration of infrastructure and technology-mediated services, citizens’ social learning through this infrastructure, and the forms of smart city governance needed to bring about institutional improvement. It is anticipated that this improvement will enhance citizen engagement with smart city initiatives beyond the simple delivery of services. In this paper, a proposed framework will focus on both technological (service-device-technology) and institutional elements (governance, partnerships) in putting in place a holistic representation of different approaches to smart city development and implementation. The tendency of existing studies have been to study the smart city only at a single point in time rather than over time, as the result of evolving interactions between consciously choosing users and responding service providers. A smart city’s ultimate goal is to create sustainable value for citizens, employees, shareholders and other stakeholders. With this understanding of the theoretical and practical challenges posed by smart city development, this study aims to explore the network relationships and drivers between human factors (stakeholders) and the smart city’s structural environment.

3. Conceptual framework

3.1. Framework development process

Building on the literature discussed above, this research study taxonomizes 6 key conceptual dimensions and 17 sub-dimensions of smart city practices, as shown in Table 1. Those dimensions form a theoretical foundation that classifies practices by category; taken together, the dimensions are taken to suggest a workable holistic view of the scope and style of smart city development. Each proposed dimension and its sub-dimensions are firstly conceptualized through an application of readings in innovation management literatures and followed by relevant citations in the smart city literature to date.

Since no single or body of literatures explained a definition of all 6 key aspects which the study integrates from various sources, the proposed dimensions are initially validated through a six-strong focus group. A conceptualization stage of the six dimensions, this focus group comprised three academics in technology management, IT and urban planning, two city officials (wish to remain anonymous) and two IT practitioners (LG CNS and CISCO). Conceptualization-stage work with the focus group involved introducing the purpose and objective of the proposed framework and seeking feedback from each group member on the dimensions, their distinctness and possible overlap or interrelationship. After this round of work, some proposed dimensions were rephrased or redefined for clarity, while others were excluded. For instance, an earlier version of the proposed framework featured a dimension that measured the degree of development of a smart city by counting the number of its start-ups or tech firms that serviced smart city industry. This dimension was removed in focus group discussion as some sub-dimensions were combined with others, owing to challenges with data collection facing the study at that time.

3.2. Urban openness

Networks have been recognized as an important part of open innovation cooperation in certain industries (e.g., [7,48]). The term ‘openness’ has shifted in meaning to a point where it may be now taken to apply to various forms of relationships between people, services, infrastructure and technology. From a social and human capital perspective, open public services facilitate the coordination of people’s participatory ‘living-playing-working’ activities, while open-service oriented business models work according to open industry standards (in terms of infrastructure and technology). These are standards which have emerged to meet the needs of communities and businesses [29,53]. Open innovation systems may be especially valuable in promoting a high quality of social interactions (e.g. within communities) [20]. These interactions may involve citizens in public life or collective decision-making or may strengthen a city’s participation level in civic engagement.

The current European Commission programs FP7-ICT and CIP ICT-PSP promote the smart city concept as piloting what is called ‘user-driven open innovation environment’ [44]. These initiatives all derive from a concept of “democratic” or “user” innovation [49], meaning that the city itself may serve as an open innovation platform on which citizens or
Table 1
Summary of proposed case framework for smart city analysis.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Definition</th>
<th>Sub-dimension</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Urban openness</strong></td>
<td>Systems’ degree of openness which enables user-driven innovation in existing and new services</td>
<td>• Participatory service design</td>
<td>Assessment of smart city services and infrastructure on whether service design is based on a platform people can interact with and participate in to foster civic engagement</td>
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<td></td>
<td></td>
<td>• Open data platform availability</td>
<td>Measurement of total data provided in open API format and distribution of data among various categories, which reflects a city’s willingness to open its data for outside service development</td>
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<tr>
<td><strong>Service innovation</strong></td>
<td>Development of innovative services through exploration of a variety of service areas as well as exploitation of higher interoperability</td>
<td>• Service diversity</td>
<td>Examination of service diversity or focus, driven by either the city itself or outside providers using open data</td>
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<td></td>
<td></td>
<td>• Service integration</td>
<td>The degree of interoperability or connectivity of different services from a business model perspective for innovating within same service domain or cross-functional service domains</td>
</tr>
<tr>
<td><strong>Partnerships formation</strong></td>
<td>Determination of types of partnerships formed to promote smart city development. Examination of funding types, whether top-down from government or bottom-up led by private sector</td>
<td>• Private–public partnerships types</td>
<td>Examination of city various types of private–public partnerships for service development</td>
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<td></td>
<td></td>
<td>• Funding resources</td>
<td>Evaluation of government or private funding sources of funding for service and infrastructure development</td>
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<tr>
<td><strong>Urban proactiveness</strong></td>
<td>Extent to which smart city services are moving toward sustainable energy use as well as IT-enabled services, through sensors, internet connectivity or intelligent controls</td>
<td>• Intelligent technology embedded in smart city services</td>
<td>Documentation of services with advanced intelligent technology including sensing and analytic technology</td>
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<td></td>
<td></td>
<td>• Smart green services related to environment and energy</td>
<td>Analysis of services or infrastructure monitoring energy consumption or saving as well as fostering civic engagement in environment. Examination of whether services are direct impact (e.g. Urban eco-map) or indirect impact (e.g. SF Park) on environment</td>
</tr>
<tr>
<td><strong>Smart city infrastructure integration</strong></td>
<td>ICT infrastructure for supporting smart city initiatives and creating higher network effects with complementary multiple devices</td>
<td>• Multiple-device/platform availability</td>
<td>Examination of network capacity by transmission speed and usage rates; Availability of free public wireless zones and sensor network</td>
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<td></td>
<td>• City’s own network infrastructure</td>
<td>Evaluation of number of data centers their level of interoperability for smart infrastructure; Consolidation plan for data center informs city’s efforts to utilize public services</td>
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<td></td>
<td></td>
<td>• Data center availability and integration</td>
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<tr>
<td><strong>Smart city governance</strong></td>
<td>Effective institutional governance structure impacts sources and uses of resources through dedicated organization support. Innovative institutional approach or governance model to bring together multiple stakeholders to drive growth and foster use of smart services.</td>
<td>• Smart city leadership</td>
<td>Strong smart city leadership by the mayor’s office plus different agency’s director within the city.</td>
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<td></td>
<td>• Smart city strategy</td>
<td>Formal, comprehensive smart city strategy reviewed and revised regularly to be aligned with city’s specific strategic initiatives</td>
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<td></td>
<td>• Dedicated organization for promoting smart city</td>
<td>Dedicated smart city team formed with diverse roles and skills to promote smart city development and also recognized by other city’s agencies</td>
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<td></td>
<td>• Smart city development and management processes</td>
<td>Standard planning and development processes defined with clear role and responsibility with stakeholder involvement. Post-implementation processes also defined and executed by the city’s agencies</td>
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<tr>
<td></td>
<td></td>
<td>• Smart city principles</td>
<td>Principles based on municipal ordinances related with smart city planning and development and used by other city agencies</td>
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<tr>
<td></td>
<td></td>
<td>• Performance measurement</td>
<td>Smart city performance criteria defined and used by the city agencies</td>
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communities engage with and empower one another, thus enhancing their ability to co-create. Efficient cooperation between network stakeholders (citizens and the city offices) is often facilitated through the use of IT [14]. These network-centered and technologically-enabled platforms facilitate information-sharing and, in advanced forms, can foster open and collaborative environments through advanced interoperability [9]. From this perspective, the drive towards open innovation networks and creation of new value may be reinforced by open-participatory services with well-defined interfaces or meeting other technical standards [22].

In another innovative and important movement at the city level, open government norms have given citizens the right to access different forms of public data in fields ranging from budgetary spending to local statistics, in the belief that local governmental transparency will bring about greater accountability [15]. Along with an interest in providing more access to public data, application developments, too, have recently started to offer users new commodities improving their quality of life, such as through increased access to information and improved ability to make specific, informed choices. These apps will increasingly sync with public (city) and real-time user-generated information, as cities make their public data available on open platforms. This can in turn stimulate people’s creativity (e.g. in transportation, health and education). Therefore, systems’ degree of openness in making the city’s data public represents an important characteristic of smart city.

3.3. Service innovation

Service innovation can evidently be put to various uses; no standard definitions of it, however, have been established. Since [34,35] put the term forward, several works in the literature have suggested that the concept itself is closely related to service design and new service development [21,40]. A more comprehensive definition has been proposed by van Ark et al. [2], in which service innovation not only includes new service concepts, channels or service delivery systems but combines these in a manner allowing the renewal or even creation of new services. Menor et al. [36] borrow March [33] notion of exploitation (meaning ‘persuading further leveraging and refinement’) and exploration (meaning the ‘identification of new areas or domains for development’) and apply this pair of terms to the growth of services. Similarly, Spoehr and Maglio [46] suggest that service innovation may create an impetus to change current service systems by co-creating value between clients and providers. When services specialize (focusing on what they do best), they create new value and increase productivity, boosting profits (serving supply diversity). These profits eventually lead to another new investment opportunity (serving demand diversity).

Smart city developments can also be characterized by the range of different (new or renewed) services they offer—that is, by the solutions they provide to various urban problems [43]. Drawing on advanced ICT infrastructure, leading smart cities have launched initiatives in domains including health, education and public services such as city transport [18]. In recent years, green services such as smart grids have emerged to promote a greener city (e.g. Amsterdam’s Smart Meter service and San Francisco’s Urban Eco-Map Service). Services’ diversity (i.e. in a range of different service domains) as they interlock may count as an important city characteristic in measuring cities’ service innovation. Various types of infrastructure in urban spaces (e.g. pervasive computing) can deliver smart services through features like roads and buildings. In general, the wider range of smart city services and devices in operation, the faster the diffusion of smart service innovation. This paper therefore investigates how different services are being explored in different domains as well as examining the degree of service exploitation within single domains borrowing from Menor’s notion.

Looking at services from the perspective of a business model, it may be plausible to assess innovation by examining how different services, whether in same-service domains or as cross-functional offerings across domains, exploit data that may be integrated or recombined i.e. in an innovative service model. Taking smart city services as different ‘resources’, resource integration is a basic function of service systems and also acts as a source of innovation [30]. The degree of interoperability or connectivity of different smart city services throws up both challenges and opportunities for service integration, allowing study to measure the service innovativeness of services at a city level.

3.4. Partnership formation

When ICT is embedded within a city’s advanced smart services and infrastructures, a complex eco-system is formed and evolves over time. One important challenge for smart cities (as it is, for instance, in an emerging industry like renewable energy) is to combine the innovativeness of different parties through the formation and management of partnerships and alliances (public and private partnerships) [10,18]. The resulting interactions as they take hold on a governed platform will combine to create a new, hopefully sustainable eco-system. The existence of an ecosystem opens up new innovative opportunities for large and small regional enterprises to offer new services on the back of their technological or other (human, organizational, informational etc.) capabilities. Entrepreneurship that comes out of social and human capital has the potential to foster emerging industries. Existing enterprises may move into new business sectors, while new entrepreneurial firms may emerge from both horizontal linkages (between firms) or vertical linkages (alliances between entities that operate at different levels in smart city) [37].

Schaffers et al. [44] conceptualize an ‘urban value creation system’ consisting of a smart city eco-system in which different stakeholders build sustainable partnerships in the context of a developing green ecology. Smart city services or infrastructure developments can be set up by different processes—sometimes by a central public authority, sometimes in partnership between city authorities and private technology providers, and sometimes in forms of private–public governance arrangements. It has been important for some cities to establish formal committees overseeing cooperation within their organization. Other cities have founded dedicated organizations to support smart technological developments in terms of planning, management and rollout. Some new cities have opted for SPCs (Special Purpose Companies) to attract private sector funds, expertise and other involvement in developing a smart city. This paper will investigate what types of partnerships have been formed to promote smart city development and will examine the funding
of smart city initiatives—whether by a top-down approach, with money coming from government, or a bottom-up, with direct contributions from the private sector.

3.5. Urban proactiveness

Another trend in smart city developments is towards supporting infrastructure and information sufficiently ‘intelligently’ way to allow services to be accessed by people and industry [24,32]. A city can no longer simply offer a wireless network and be labeled by that token ‘intelligent’. The term now means the provision of an infrastructure enabling users and user devices to sense, analyse and autonomously provide services to other relevant users (or consumers) [29,43]. Rather than sensing in passive way, these user devices act proactively in parsing and reformattting relevant data, and sending on selectively matched information to recipients. An intelligent urban landscape can make a significant difference in allowing devices to ‘talk to each other’. For instance, a given distance between cars can be managed through the coordination of each car’s driving and a centralized information system fed data from car sensors, which it processes through an Intelligent Transportation System.

Urban sustainability in the environment is a critical area for both new and old and smart and less-smart cities alike. Every city is finding its own ways to manage energy consumption more intelligently as resources dwindle and pressures to support environmental sustainability become more urgent [17,29,51]. Lee et al. [29] propose a ubiquitous eco city or U-Eco city designed to be sustainable and environment-friendly in encouraging the use of civic resources as a form of ‘urban nature’. The concept applies and expands issues of energy use, waste disposal and pollution. In another instance, smart city program aims to reduce the city’s carbon footprint by influencing citizens to change their energy consumption patterns and so protect the environment [1]. Similarly, the concept of the smart city has morphed into that of the smart city, in which people engage to create or maintain a green environment based on interactive ICT or services infrastructure.

Urban spaces have the potential to become greener as buildings, for instance, become more intelligent in providing new smart city services. An ICT application embedded within the city, whether a standalone service or combination of ICT infrastructures, may operate in a proactive manner to improve people’s quality of life which brings out more smarter and greener city. In sum, measures of both forms of pro-action—services and infrastructures—represent important evaluative criteria in understanding how far smart cities have progressed with ICT applications in this sphere.

3.6. Infrastructure integration

Most papers dealing with the ICT underpinning smart cities view technology as forming large, complex organic systems used by cities to deliver products and services [12]. Evidently smart city technologies may evolve as they continuously seek to integrate services, systems, infrastructures, and technologies and capabilities into a complex whole. The emergent properties of these features, in other words, may stimulate the emergence of new nodes or forms of interconnection in the city-wide information architecture that coordinates them [39]. Therefore, the degree of interoperability or connectivity of different services (from the ‘horizontal’ and ‘vertical’ perspectives, as described in the section dealing with service innovation) will also be a critical measure of smart city maturity.

The importance of network effects on technology adoption has been widely discussed in various literatures [5,46,50]. The role of city networks in supporting a variety of smart services becomes important in cases where service interoperability or integration can drive higher network effects. The consequence will be that the existence of complimentary multiple services (or services available on multiple devices) will speed up user adoption. In this way, the availability of free public wireless zones and optical and sensor network usages represent important criteria in understanding and evaluating the maturity of smart city IT infrastructure.

In addition, diversifying access to smart city services enables a diffusion effect to current and potential users [47]. Different smart city services will eventually be delivered over an integrated multiple-devices platform, accessible to different user devices such as smartphones, media boards, and other emerging tablet technologies. This is evidenced by the recent strategy of the cities that have begun to build IDCs (Integrated Data Centers) in an attempt to integrate a smart infrastructure joining services at a higher level of interoperability [13]. In IDCs, cities will be able to put data on platforms that are shared with private app developers, and/or interoperable with other smart city services. As city data becomes open and accessible over more devices, more citizens will be able to engage with large-scale programs on topics such as emissions reduction.

3.7. Smart city governance

Last, but not least, an important driving force in moving smart city forward is an effective governing mechanism in institutional terms [8,13,17]. Cities must develop governance models bringing together multiple stakeholders in driving growth and adaptability and fostering the broad take-up of smart services. To do this, services generally need a leader or a champion [26,38]. Citizen participation [17] and private–public partnerships [42] may further be an important element of smart city governance, although some researchers have considered the choice of governance model less important than efficiency at the operational level. Johnston and Hansen [23] describe smart city governance as the implementation of worked-out processes based on principles and standards in order to achieve goals and objectives.

Belissent [4] understands governance as leadership enabling the coordination of efforts across city departments, as integrated processes, tools, and technologies come together to set up platforms for service delivery. A high degree of integration, importantly, provides visibility enabling the inspection of activities at a departmental level. Without smart city leadership and a formalized strategy, cities may not be able to run smart developments effectively. A comprehensive strategic plan, meanwhile, can generate synergy effects among different city agencies. This requires a more holistic approach to smart city development and is usually supported by a dedicated team, who oversee the coordination of management processes and performance management. Such a team is likely to be in place whether cities have a centralized or decentralized governance setup. Based on the literatures summarized above, this paper proposes...
six different criteria for analysing smart city governance: 1) leadership, 2) strategy, 3) the presence of a dedicated organization, 4) processes, 5) principles and 6) performance measurements. Descriptions of each criterion are given in capsule form on Table 1.

4. Method, data, and analysis

4.1. Data collection

This study uses a multi-case study approach [52] as the most appropriate method for addressing a rapidly evolving field, where different cities have adopted smart services to a different degree and in the context of different strategies. Some cities, indeed, have planned or are implementing a comprehensive smart green architecture, while others are at an earlier stage or are proceeding with more piecemeal smart projects. Although a number of cities are initiating smart city development in the terms described in Section 2.2, this paper conducts case study analysis on two cities characterized by varying levels of smart city maturity and degree of data accessibility, Seoul Metropolitan City (SMC) in Korea and San Francisco City (SFC), in the United States. These two smart cities projects were initially recommended by the focus group involved in the process of conceptualizing a research framework; the study then took the suggestion up on the basis that many of the group participants were acquainted with smart city developments from around the world and would be able to point research in the direction of especially advanced, interesting or typical smart city instances. Further, it was possible to study the two case studies through both publicly accessible and secondary data. This study reviewed the available information detailing smart services and infrastructure in cities from around the world as this could be compiled from various academic and industrial reports. This process shortlisted a number of cities, before falling in with the focus group’s recommendation on the basis that smart city practitioners and managers from SFC and SMC were willing to participate in interviews and open up further documentary sources to the study. Both metropolitan areas under investigation are moving toward to implement smart city practices, but the cities are currently pursuing different initiatives determined by different strategies and resource availabilities. The study considers it highly likely that the two cities, Seoul and San Francisco, are marked by cultural differences of a kind that will influence possible institutional and organizational choices in the structuring of the cities’ smart developments. It is a feature of the paper’s comparative style of study that it is able to bring these cultural differences out and consider their consequences for the effectiveness of service delivery. A final advantage of the case study method, as it works through the proposed framework, is that its account of the dynamics of smart implementation in both cities provides useful insights into other cities.

To understand these contextual differences, we initially collected case data from secondary data-sources, including media reports, relevant smart city project reports (including planning documents) and smart city-related international conference presentations. In addition, we also specifically examined each city’s online public services by accessing their home pages, as well as applications (apps) stores for public services. Both cities host their own web pages giving access to the array of their smart services as these are available over a number of apps and a corresponding open data platform. Data about these sources counts as an empirical result in evaluating the maturity level of each city’s smart development according to the study framework.

Based on this empirical analysis, we then drew up lists of potential interviewees based in ‘City Hall’ (local governmental officers responsible for coordinating smart city development, e.g. specific smart city division or IT division), related government agencies and in the private sector (e.g. liaising with relevant city departments such as transportation, environment and public utilities). Semi-structured face-to-face interviews with different actors and were conducted to meet two main objectives: to confirm or improve upon empirical results, and to evaluate whether this data was suitable for an analysis seeking to understand the underlying processes by which the city concerned was implementing its smart services. In these semi-structured interviews based on the study’s conceptual framework, we were able to query the rationales behind smart city initiatives and to ask stakeholders about their city’s different service and infrastructure developments. The study moreover asked specific questions about smart city leadership, strategy and organizational support within City Hall or within more devolved or possibly even private-sector agencies. We collected information from respondents on any perceived challenges faced during smart city implementation and any future enhancements envisioned.

The research team conducted interviews between 2011 and 2012. The first sets of interviews took place in between October and December 2011 while second sets of interview carried out between April and July 2012. A summary Table of the profiles of the interviewees (27 interviews) with roles these interviewed experts hold, lasting approximately between 60 and 90 min as shown in Table 2.

By a ‘coordination team’, the study means a group that initiates smart city development within city hall. In SMC, we interviewed the director of the IT division, the director of urban planning and the smart city planning team leader (that is, the leader of the team dubbed ‘ubiquitous city’) and the strategic IT planning leader in the same team. Similarly, the study’s interviewees for SFC held posts at director or deputy director levels in departments of urban innovation and or the environment. We selected interviewees from agency teams by identifying those groups that were mostly developing or managing smart city projects (services/infrastructure) within the city. In SMC, we interviewed various agencies while our contacts from SFC came mainly from the IT division, public utilities, the environment and transportation. Our choice of
external experts came down on smart city scholars and authorities from industry. In the case of SMC, these experts were development team leaders and consultants from leading IT firms including KT, LG CNS, in addition to two professors who had been working as advisory board members for smart city planning at both national and city levels. SFC’s external experts were drawn from CISCO and from an independent consultants’ association. During semi-structured interviews, we lay out our proposed framework as shown in Table 1 for purposes of validation, that is, in order to determine whether it made a good fit with our research objectives.

4.2. Data analysis

Data relating to the two cities’ smart city practices were analysed using the proposed conceptual framework. Cities’ services were evaluated within each sub-dimension or conceptual label (as shown in Table 1) on the basis of both qualitative information elicited in interviews and quantitative analysis of publicly available material across relevant sub-dimensions. The unit of analysis used in this paper varies with according to the perspective from which analysis is being offered, as indicated in Table 1. Most study perspectives assumed a single smart city service as their unit of analysis, while measures that concerned themselves with the ‘city’s own network’ and ‘smart city governance’ were analysed at city level rather than at service level.

The study thus evaluates (in terms of its dimensions and sub-dimensions) a total of 58 and 34 individual smart city services or related projects in SMC and SFC respectively. Where possible, it draws on supplementary public data and interviews to assess the nature and maturity of these services. In eliciting the data on which to make these categorizations, we systematically analysed interview transcripts through observing a number of iterative process.

In line with the study’s research design, cross-case analysis was then carried out by comparing and contrasting SMC and SFC’s smart city implementations to examine similarities and differences between their smart city approaches. The study presents as its findings 1) a statement of the different maturity levels of city services and 2) a statement of the broad differences between the two case cities’ approaches to building an integrated smart city.

5. Empirical results & analysis

5.1. Urban openness

Both SMC and SFC smart services, as shown in Fig. 1, consist in location-based services that use GPS technology, combined with conventional services, to make information visually available on a map. The concept behind participatory services is much more to drive civic engagement than it is simply to fallout services to be passively taken up by users in the case of both cities. Service app developers, whether using open data or working to the terms of city contracts, are looking to incubate more interactive civic engagement services whose long-run effect should be to foster effective, openly-based participatory government.

Of 58 smart city services or related infrastructure developments in SMC, more than half (60.9%) were led directly by City Hall, which was the uni-directional provider of information. Only a few SMC services (less than 10.9%) involved the processing of data collected through user inputs. One example is ‘ChunManSangSang’, a portal soliciting ideas from citizens to rank proposals for public policy and also to monitor their implementation. Another interactive service, Eco-mileage, currently serves 479,000 participating households in 2800 buildings and promotes green initiatives. The service aims to help users save energy and cut down carbon emissions in and outside the home, in their domestic energy consumption and also through purchase of certified green products and services. The service is also designed to support other spontaneous efforts. Although most developed smart city services are initially driven by e-government initiatives and initially achieve a lower level of user penetration, these services may evolve to be more interactive and to rest on more of a participatory service design through robust incentive systems (such as the Eco-mileage service). At this earlier stage, however, more than 28% of SMC’s services are still dedicated to supporting the development of smart city infrastructures dealing with specific urbanization activities, indicating an on-going implementation process in constructing a smart city.

Compared to SMC, SFC also currently focused on providing a preponderance of uni-directional services (79.4%), as shown in Fig. 1. Similarly, too, SFC is moving towards creating a real-time engagement platform that draws on intimate social networks and crowd-sourcing to seek out new ideas to solve civic problems. Most of these participatory services are based on ICT...
technology and most have been initiated by a local government agency such as SeeClickFix (a mobile app version of 311) or CitysSources (a real-time mobile civic engagement platform). This last service aims to engage with citizens directly while accumulating non-time-critical non-emergency data. ImproveSF, as another instance, aims to resolve civic issues by engaging both government and citizens by fostering smart growth in new cross-departmental initiatives. Other current ImproveSF ideas include facilitating access to potable water and public art, and neighborhood revitalization efforts. Another real-time information service, Cycletracks, delivers data on cycling movements to the SFC transportation authority where an app provides statistical data for cyclists. These services are entrepreneurial and target public participation and engagement. In this way, the evolution of interactive and participatory services will likely be reinforced and facilitated by SFC’s embedded cultural and social capabilities.

Both SMC and SFC recognize that open data platforms have a role in improving public data transparency and are using platforms as a core source of open innovation to create services designed to elicit a high degree of public participation. It is necessary for any smart city to strike a balance between open data transparency, encouraging third-party app development, and strategic constraints on data availability. Fig. 2(a) shows SFC leads SMC on the total number of open data platforms (APIs). The suggestion here is that SFC has been more active on the issue of open data transparency.

Our analysis reveals most SMC smart city services were developed by contracted app developers. Some smart city services, however, were offered through open APIs in forms such as GIS (maps), transportation (u-Topis Sys), BIS (Bus Info. Sys.) and district CCTV systems. SMC has aggressively moved towards promoting service development through open data platforms and an open API portal since 2011.
These services go under the umbrella of ‘Seoul Open Data Square’.

In pooling these open-data efforts, it seems that smart city developers have had to face cultural resistance from other city departments. Although some SMC’s agencies were reluctant to open up their data but citizens may confused by misinterpretation on public data and take critique position, SMC put more weights on creating new service development for citizens, small IT firms or non-profit organizations. While SMC’s open APIs are focused on certain areas as shown in Fig. 2(b) and have placed more weight strategically on open innovation (in the hope that new apps and services will flow from this), SFC has offered a wider range of open APIs, suggesting that many city departments are committed in principle to transparency and open data. This creates new opportunities for entrepreneurs within and outside the SFC to provide services for different cities operating on the same platform (such as SeeClikFix and CitysSources). Both services have open APIs as their platform while accessing open data information from DataSF which was launched in 2009. This portal is running by SFC agencies since 2009 and participation has been quite high with positive response. Since the San Francisco Bay Area culture is creative and innovative, the capability exists for services developers to adopt new technologies to improve citizens’ participation and quality of life. Thus, the primary role of the City Hall is to support and facilitate demands for open data rather than taking a top-down approach in contracting agencies to design and deliver services.

Representatives of both cities acknowledged the importance of being seen to develop interactive participatory services to increase openness and encourage civic engagement. Although most of both cities’ services still take the form of single uni-directional information flows, disseminated over GPS based technologies, each city needs to identify which of its existing services can be made into a sustainable platform for civic engagement. This engagement also has the potential to unlock cross-departmental initiatives within the city by showing the demand exists for open data. The design challenge in launching participatory services is to offer feasible incentives that will stimulate people to collaborate with the city and its contractors in civic activities. The cities take a different stand on public openness in the sense of either targeting across-the-board improvements in public transparency or selecting specific areas for app development (e.g. transportation, parks and recreation). However, some city departments have set their face against an across-the-board approach in being reluctant to open up their data due to its sensitivity or concerns over privacy. A lack of legislation underpinning the open data movement can also stifle cross-departmental initiatives and delay data accessibility.

5.2. Service innovation

As shown in Fig. 3, SMC has the highest service diversity in terms of smart development areas (health, welfare and education). Most initiatives in SMC address the areas of transportation (20%) and public facilities management (20%); the next highest concentration of services is found in public administration (13%), then in tourism, culture and recreation (12%). These services have largely been developed through the IT division since 2006 and coordinated by the smart city team to prevent any duplication of services. However, they are recently moving toward a more demand-pull or participatory service design and beginning to use an open data platform to encourage smart city developers.

SFC tends rather to focus more heavily on certain domains (e.g. Public Administration or Transportation). Most smart SFC services are in transportation (37%), followed by crime or disaster aversion (19%), with tourism and leisure coming next (16%). Smart services targeting facility management,
education and medical/welfare services have not yet been established as participatory offerings, despite structures associated with their delivery having been set up in City Hall. There are many transportation services because SF MTA is recognized as a very early adopter of an open data platform within SFC. While understanding the value of open APIs the department focused on exploiting their services in their own domain using a market-oriented, bottom-up approach. The expectation is that within a few years, SFC’s smart city will be mature to the point where services in a wider range of domains will be offered over open platforms, potentially including health and education.

Both cities currently lack a high degree of service integration; however, SFC shows a higher degree of this (e.g. in transportation). Most services (between 70 and 80%) in both cities run on a single service platform. Integrated services may create more value to users partly through network effects. While some interviewees suggested that innovative services in different urban spaces can boost economic growth, both cities need to consider whether smart services ought to be available in every sector (i.e. exploring every agency’s services and data) or whether certain sectors need more of a model of service exploitation to ensure service quality (for instance, analogue smart service diversity could be considered as a ‘T’ type, where the ‘—’ represents service exploration while the ‘I’ represents service exploitation in the same area). In case of SMC, GIS based application becomes potential services for integrating with various applications where transportation services can be integrated or connected with tourism and entertainment services. Integration levels will vary according to service demands and device accessibility where services are specifically developed for urban spaces integrated with smart city infrastructure such as media boards or specific devices.

These results imply that only a weak correlation obtains between the spectrum of a city’s open data, as described in Section 5.1, and the diversity of smart city services. Nevertheless, the open APIs in SFC have been designed to promote a diverse range of services, suggesting that SFC retains the potential to evolve into a market-oriented organic platform. The likelihood is that this infrastructure model will service some specific domains well but (in the absence of legislation and direction from above) be constrained by the limited availability of open data in others. This raises the question of whether a smart city needs to apply a ‘push’ or top-down strategy in setting out a more comprehensive approach to service development to take account of likely public demand for applications. A more centralized planning function will also be able to meet possible social demands from minorities. Both cities will need to be ‘ambidextrous’ to a degree in service development, partly because service integration will be simpler if they can balance mechanisms between ‘push’ and ‘pull’ and establish different locations of control. We further discuss these questions in Section 5.6 below in considering governance.

5.3. Partnership formation

As shown in Fig. 4, our results reveal that SMC and SFC have adopted different forms of partnerships for building effective smart cities. 93% of the services and infrastructure in SMC were ‘planned’ by central government and either developed by state agencies or outsourced under contract to private bodies. Only 26% of services, meanwhile, have been outsourced by government in SFC. The central government of Korea has underwritten a number of R&D or pilot projects in which different cities joined a bidding process and competed for funds. Most these projects are initiated in a pilot project level or a test-bed for further service development. These initiatives provide new opportunity to innovate and develop new technological capabilities for both large and small firms. However, most SMC services derive from a master plan and in some cases are directly contracted to non-IT divisions. A monopoly structure driven by public partnership may inhibit the development of sustainable service models. SMC is currently changing its view towards a private–public partnership in making concessions to an open data movement; this should encourage user-driven innovation and promote sustainability.

More than 50% of San Francisco’s services are some form of private–public partnership, with participants ranging from start-ups to established firms (i.e. whose business is to provide the same service in other cities). Some exceptions, such as 511
Transit Apps, REC, SF Solar and Wind Map, are owned by government agencies; these are designed to use open city hall data (DataSF) on a Develop-Own-Operate (DOO) model. This illustrates the typical SF culture of creative participation on software application development as well as in exploring potential new service areas. Other publicly owned services suppose a Develop-Transfer-Operate (DTO) model in linking actors in private–public partnerships. SFC projects commonly show more involvement from the private sector, including medium-sized companies and entrepreneurs. Their bottom-up approach is based on an efficient organic, market-oriented system embedded within the SFC culture. The role of SFC was, therefore, not centrally to develop or coordinate smart services but rather to design innovative mechanisms facilitating private–public partnerships and, in turn, a whole eco-system for local firms and entrepreneurs. While the form of contracts drawn up with contractors in SMC and SFC do not appear significantly different, it is fair to say that SFC, in common with some European cities, is pursuing an efficient market-oriented approach to service development, which aims to stimulate competition and innovation in response to user demand. For instance, Amsterdam takes a third approach, which may be thought to contrast to that of both the case cities, in its manner of setting up third party private–public partnerships [1]. This city has a special purpose foundation dedicated to coordinating and controlling several smart initiatives. The foundation functions as an innovation platform building up new technological capability in both large and small European firms. Special purpose companies, together with a measure of centralized coordination in service development, may help to move a city along the ‘S’ curve of adopting smart services and to ramp up technological capability in the local economy.

In sum, SFC and most western cities have adopted a governance model of private–public partnerships using a bottom-up approach, while SMC has pioneered strong initiatives in a top-down way. In particular, the U.S. city is constructing an eco-system to deliver value-added services while being less proactive itself in innovating in urban spaces (for instance, by creating digital walls or digital streets). SMC have gone further with infrastructure development while facilitating relatively fewer innovative services in terms of user-driven initiatives and entrepreneurship. This study is also concerned to understand the forms of collaborative networking and partnership that the two cities have pioneered in seeking to fund, or co-fund, smart initiatives. The two cities have experimented with different forms of partnership and funding (either top-down or bottom-up) in developing ecosystems supposed to have their own momentum. Both cities are trying to foster sustainable smart city partnerships by involving the private sector through adopting appropriate ‘entrepreneur settings’. At an early stage of smart city development, the study suggests, it may be necessary to fund partnerships with public money to foster initiatives in which local start-ups or middle-sized firms have the skills or capability to collaborate with government agencies. It will also be critical to reconcile this source of initial funding with the eco-system model (where apps stores will be specific to each city) in order to engage private sector participation sustainably. It may take a while for the synergy effects that can be generated from market-oriented partnerships to kick in, so the challenge for cities is to engage private participation at an early development stage. In their networking and partnership strategies, then, smart city developers need to formulate public–private relationships that can plausibly develop sustainable eco-systems.

5.4. Urban proactiveness

It will be in the context of public–private partnerships that developers design and implement advanced intelligent technology and services. As shown in Fig. 5, the dominant form of intelligent technology in both cities is based on GPS technology. More than half of SFC’s services are derive from and utilize GPS. SMC is leading the way in exploring a wider range of advanced intelligent technologies (i.e. which feature in more than 37% of its services); these technologies will add value to services as they are implemented and integrated in certain urban spaces. Currently RFID & CCTV technology are used as a sensor network to monitor the safety of primary school students (especially to protect them from kidnapping), while RFID tags have been implemented to ensure that drivers are complying with one-day no-driving environmental campaigns. SMC also uses advanced intelligent technologies in the real-time facility management of public utilities in
such applications as monitoring and maintaining the public drainage system, Han River bridges, the fire service, public parking, garbage trucks, some public buildings and SMC air pollution. In SFC, apart from GPS technology, some intelligent analytical tools run on real-time information in the domains of transportation (26.5%), such as Routesy San Francisco (predictive service using real time information) and SF Park (which uses sensing technology to price parking spaces in response to levels of demand). Urban maps also use sensing data from different sources. SFC, further, has implemented networked metering in water, electricity and gas using low frequency RF sensors. The experience of both SMC and SFC demonstrates that adding intelligent technologies, in particular to sense and analyse big data, can create new value in service innovation and open up economic opportunities for start-ups in the ICT sectors.

Based on case analysis of the environmental sustainability of each city’s service provision, it would seem that SFC has invested more effort in developing green services. More than 44% of the services of SFC, meanwhile, may be taken to have direct or indirect impacts on their environments. SFC reached over 4000 businesses saving them an average of $4500 year; they also achieved a 40,000 tons reduction in local carbon emissions over the past 3 years. SFC integrates GIS technology into services that promote public awareness of solar and wind energy and has already implemented smart meter technologies in households, as mentioned above. All these services target savings in energy consumption by combining monitoring technologies with forms of civic engagement. The 18.8% of SF’s green services have a direct effect on the environment, including the 511 Transit service whose “Go Green” initiative supports alternatives to heavy car use in the form of cycling, walking, car sharing and smart working. UrbanEcomap uses maps to impart information about ecological issues, while Transit Time Map encourages people to live near urban transportation or within walking distance of work. iRecycle provides recycling information, pointing people to nearby recycling points. In the field of renewable energy, an SF solar map provides information on solar power with analysis of how much solar power or solar water heating could feasibly be produced in the city. In addition, automated meters provided by SF Water Power Sewer (the Services of the SF Public Utilities Commission) use low-frequency radio signals to collect hourly water consumption data in both residential and commercial areas. This is supported by AMI (Advanced Metering Infrastructure), whose deployment will be in its pilot phase from late 2012.

By contrast, less than 13% of the smart green services provided by SMC relate to the city’s sustainable environment. Of the few green services the city has, the eco-mileage point system is an incentive system which has induced successful stakeholder involvements from entities including households, business buildings, and banks. A high degree of service participation is also led by four major Korean banks, which offer card services promoting green initiatives. The core element of this service is an incentive system that attracts more participants since 2009. The system itself becomes a hub of green initiatives for SMC while saved energy points get discounts on 30 different public utilities owned by SMC. In addition, this social media platform also provides smart grid products or green products/services in private sector.

In sum, in order to foster smart green growth, all the sustainable services discussed above require citizens to engage and change their behaviors. To secure this measure of public uptake, a robust, effective incentive system will motivate users’ participation and thus create a more sustainable value chain. Seoul boasts a diversity of smart services supported by an apparently adequate infrastructure and capacity for traffic. It needs to make its platforms more open and to encourage a higher level of sustainability and intelligence in the dissemination of its services. The intelligent technology deployed in both smart city infrastructures should in both cases improve the environmental sustainability of services in making them more agile and more capable of responding to various urban problems. Building intelligent urban infrastructure such as networked sensor systems enables smart cities to lay on an extensive range of services for both developers and users. In effect, each city may require a long-term and large scale program of IT infrastructure investment to build up city-wide technology coverage or even coverage in some smaller central area.

5.5. Smart city infrastructure integration

The greater the number of devices can access smart city services, the greater these services’ networks effects. Smart services are accessible over multiple device platforms including IOS & Android apps, mobile webs and other specific devices. Services are also starting to extend into smart appliances like TVs, tablet computers and specific interactive urban spaces (e.g. digital street or parks). As shown in Fig. 6, SFC is leading SMC on multiple device services but has not yet reached the stage where services are fully interactive with smart urban spaces and buildings. The dominant (single) device platform in SFC is IOS, with the next most used the Web; this order may reflect the presence of Apple in the Bay Area. The most used single device platform in SMC is the web browser. This reflects Seoul’s status as an early adopter of smart city services—that is, before the emergence of smartphone apps. SMC has also developed specific devices for web-based services (around 17% of all its services), which have become less useful due to the lack of an open platform on which public data is made available to entrepreneurial private app developers.

Consequently, SMC has stated its intention in time to transform most of its useful service information to an app-based format.

From the perspective of vertical integration, SMC’s IT infrastructure has been constructed as a highly interactive backbone meeting smart city requirements. Different types of infrastructure have been put in place to serve different purposes, such as a sensor network for traffic and a central data management unit for sensor input. The city can count on sufficient network capacity with 20 Gbps to provide many services to its citizens for the foreseeable future, as shown in Fig. 7. More than 97.5% of the population use the national broadband network and 57% have a fiber connection. Moreover, the inhabitants of Seoul are characterized by a very high smartphone penetration rate. The city’s own network reliably supports various smart city projects including service and infrastructure development. In contrast, SFC’s IT infrastructure from this same vertical
integration perspective has been produced only to a moderate standard. Since Earthlink and Google’s deal in 2006 fell through, and Meraki were only partially successful in setting up a WiFi network in 2008, the city has taken a more incremental approach to extending free access in urban spaces such as public parks and libraries. These incremental implementations are facilitated by using the existing city-owned 110 miles of fiber optic cables, which currently remain underutilized (below 10% in 2011). In 2011, there were 8 city-sponsored public Wi-Fi sites with more under development. Although the city aims for a high rate of adoption at 67%, further targeting a 90% level of broadband penetration by 2015, it will need to add on services in different domains and to maximize network usage. In terms of a sensor network, SF Park is currently sensing parking vacancies with real-time information to coordinate the maximization of space take-up; most of these services run on GPS technologies using smart phones.

Along with diversifying the types of platforms that can access services, the city’s proprietary network infrastructure and its usage also plays an important role for both the cities. As cities roll out data-hungry services (in sensing or public media), they may require a higher data bandwidth to meet future service demands. One of these efforts at data and spectrum consolidation, in both the virtual or physical sense, will be a single data center. Besides strengthening its network infrastructure to at least the level of other cities, SMC is currently developing an IDC (Integrated Data Centre) to integrate all public data in the expectation that its operating costs will fall with standardization. It also envisions improved IT services and synergy effects through infrastructural consolidation. Some next steps for the city may be the integration of data from various central management centers, which currently exist for CCTV images collected for security purposes and data on vehicle traffic and capacity usage in public facilities like car parks and workspaces. SMC has focused on integrating all agencies’ server, storage and backup equipment, reducing the number of servers from 171 to 39. Along with network and data integration efforts, efficient IT resource management as a green IT initiative is top of the SMC’s IT division agenda. The city has a consolidation plan currently underway in that it is building a second integrated data centre at Sangham which will house most smart city services. According to the [11], consolidation will take the form of the construction of a data center. This will have three distinct phases: 1) facility consolidation, putting in place one shared data center; 2) equipment consolidation using virtualization and cloud computing, and 3) staff consolidation in this new consolidated environment.

Fig. 6. (a) Service-multiple and (b) service-single device platform.
Currently, three data centers operate. City budgetary approval has not yet been obtained for an integrated center.

Smart city innovation is driven by the development of intelligent infrastructure and incentive systems inducing service takeup; another key driver is the development of diversified complementary networks and device platforms that can connect up new smart services and a city’s developing infrastructure. The sophistication of these linkages becomes critical as services develop and may require a centralized or at least a hybrid form of governing system to coordinate and control smart city operations as the number of smart services grows exponentially.

5.6. Smart city governance

SMC have shown strong smart city leadership in envisioning a long-term strategy since 2006. The city, and particularly its IT department, has planned strategically, liaising with various types of government agencies to develop new services and infrastructures and to frame goals with the mayor’s office. For example, the city has a five year long-term strategy where leadership is shared with a group of corporations; this consortium’s activities are mostly initiated by the municipal IT division. This is a dedicated smart city team which is organized into a number of units concerned with areas demarcated as strategy, policy, infrastructure, regulation and so on. Despite these efforts, the study’s informants broadly took the view that SMC is failing to offer appropriate organizational support to the smart city, especially in failing to provide performance evaluation and feedback channels. To empower such mechanisms, the city framed guiding principles for sharing information and collaboration with related agencies.

Compared to SMC, organizational administrative support in SFC is weaker due to the provenance of smart green infrastructure in the private sector. In 2012, the city mayor has for the first time appointed a chief innovation officer and designed an office of Civic Innovation to initiate new services. Asking what the smart city means, the office is also defining roles and responsibilities for supporting various innovative activities including an open data platform. Should governance shift to an entirely decentralized model, specific forms of coordination and control efforts may become necessary to deliver its activities. However, these efforts will be constrained by limited internal resources. Decentralized agency structures also need to be pushed if they are to set up effective coordination and governance mechanisms that can support innovative services and infrastructural developments for a smart city. In the absence of a centralized governance structure, the existing Dept. of technology is currently serving as an internal IT systems management team, even though some of the city’s public services co-operate with other agencies within the city. A COIT (Committee of IT) currently stands as the governing mechanism for making decisions and overseeing a number of different projects [11]. It does not, though, have the resources to monitor how effectively smart city services are growing. Each agency at SFC currently makes their own decisions on new service development partly in coordination with the department of technology. All agencies follow a standard contracting process with external service development providers. However, the city has no standardized set of performance measurement tools to measure how apps or services are utilized or how their services stack up against those of other cities. Although SFC is the first city to pass open data legislation, the process by which data is diffused to each agency is only working gradually. The office of civic innovation currently provides non-mandatory guidance to each SFC agency to meet certain open data requirements, which are passed on in their contracts with open service providers.

In summary, one of the study’s key findings is that the form of smart city governance set up in the early stages of planning had a significant effect on the range and maturity of services cities have been able to put in place. SMC have shown a strong degree of leadership in setting out formalized, comprehensive strategies, while SFC has taken a more organic or decentralized approach to the coordination of the individual agencies supplying data or services. Integrated smart city planning, driven by a dedicated organization or cross-departmental task force team, may be helpful to set up smart city governance especially at an early stage, while a more decentralized governing system may be more effective at the growth stage (Table 3).

6. Conclusion

6.1. Research summary

This study has been pioneering in integrating technological and institutional perspectives in attempting to understand the process of building a smart city. The study brought these perspectives together in a framework, through which it conducted case studies of smart implementation processes in SFC and SMC. We conclude our general findings by setting out eight ‘stylized facts’ derived from both our quantitative and qualitative empirical results as discussed above Table 3 and shown in Table 4.

These findings can be viewed as making a novel contribution to research describing the development of a smart city, in particular the process of service implementation and the integration of network infrastructure with a governance structure. The eight ‘stylized facts’ make clear what is involved in building an effective and sustainable smart city.

The research confirmed that the open data movement and participatory service design play significant roles in improving a city’s civic engagement. However, the scope and depth of civic engagement platforms varies from city to city, typically in accordance with a city’s social and human capital. A strategic balance between open data, which stimulates app development, and concerns for privacy may require leaders to conceptualize a clear direction for each city’s public data usage. The balancing mechanisms needed will also partly affect smart service innovation. This empirical study reveals that both cities may require a centralized-comprehensive approach to strike an appropriate balance between diverse service exploration in different domains and intensive service exploitation. Portfolio-thinking should also enable the identification of potential service integration opportunities, as well as preventing duplications in infrastructure development. Service exploration (e.g. through integrating urban infrastructure) tends to need strong public funding and fosters innovation in products and services, while efficient market-oriented partnerships contribute to the development of more sustainable smart city models. In terms of the ‘S’ curve in innovation diffusion, top-down and publicly-driven partnerships (creating and exploring new services) may help to accelerate smart city adoption at an early stage, while...
<table>
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<tr>
<th>Dimensions</th>
<th>Interview findings</th>
<th>San Francisco City (SFC)</th>
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<tr>
<td></td>
<td>Seoul Metropolitan City (SMC)</td>
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<tr>
<td>Urban openness</td>
<td>Most services location-based (GPS) combined with conventional services</td>
<td>As SMC</td>
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<td>Uni-directional information services (60.9%) &amp; civic engagement services</td>
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<td>less than 11% of 58 smart services (e.g. Chunmansangsang service &amp; eco-miles point services)</td>
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<td>Early smart services development driven by E-government initiatives; low levels of user penetration</td>
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<td>Services may evolve towards greater interactivity and participation</td>
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<td>Robust incentives (taken from eco-miles point service) may improve participation</td>
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<td>Open data improving transparency and user-sourced innovation</td>
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<td>Open APIs present only in certain areas (e.g. transportation, parks &amp; recreation, construction &amp; housing, arts &amp; culture)</td>
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<td>Aggressively moving towards promoting services through Seoul Open Data Square from 2013</td>
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<td>Some agencies reluctant to open data on privacy grounds; incremental approach to creating open innovation platform for various stakeholders</td>
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<td>Service innovation</td>
<td>SMC’s smart city services cover diverse service domains (inc. transportation, tourism, facility management and public admin.).</td>
<td>Services offered mostly in restricted domains (transportation, crime &amp; disaster prevention, tourism &amp; leisure)</td>
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<td></td>
<td>Prevents service duplication through IT division coordination</td>
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<td>Services moving to demand-pull design to facilitate user engagement on open data platform</td>
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<td>Most services (&gt;77%) run on single service platform using GIS application, not integrated</td>
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<td>Eco-mileage services cross-functionally integrated within single domain</td>
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<td>GIS-based applications will become integrated for different services</td>
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<td>Partnership formation</td>
<td>Most city or central govt. services outsourced to private sectors for development (&gt;93%)</td>
<td>Private sector develops services based on open data (&gt;50% services)</td>
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<td>Test-bed zoning enables exploration of smart city development creating opportunities to innovate</td>
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<td>Technology-push services offered without a sustainable model</td>
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<td>Urban proactiveness</td>
<td>Dominant intelligent technology based on GPS</td>
<td>As SMC (dominant intelligent technology)</td>
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<td>&gt;37% of services employ advanced intelligent technologies providing contextual information and processing organized service data autonomously</td>
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<td>Intelligent services being explored in other domains than transport (e.g. U-Seoul child safety zone, no-driving campaign)</td>
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<td>14% of services have impact on green initiatives</td>
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<td>Effective incentive system drives users’ motivation and participation. Variety of users reduce energy consumption (e.g. eco-mileage incentives for using SMC-owned utilities)</td>
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<td>Smart city infra. integration</td>
<td>Dominant platform is web-browser; some services specific to city owned platforms</td>
<td>Leadership decentralized; different agencies promote smart development; recent expansion in city hall team from 2012</td>
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<td>Highest network capacity (20Gbps/15% usage) able to meet future service demands</td>
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<td>The city’s own network infrastructure complements emerging smart city services (e.g. heavy use of sensing data)</td>
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<td>Second IDC center development under construction will drive public data integration (fewer servers)</td>
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<tr>
<td>Smart city governance</td>
<td>Comprehensive strategic approach with clear objectives in place since 2006</td>
<td>Leadership decentralized; different agencies promote smart development; recent expansion in city hall team from 2012</td>
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<td>Dedicated org. support spells out diverse roles, inc. strategy, services, infrastructure &amp; policies</td>
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<td></td>
<td>Development/managerial processes based on different project types; performance measurement standards inherited by smart city team</td>
<td>Currently defining smart strategy; dedicated org. team will take over from IT division currently responsible for internal IT resource management</td>
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<td>Governance principles work as ‘de facto’ guidelines for other city agencies</td>
<td>Currently providing non-mandatory guidance for each SFC agency</td>
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<td>Centralized governance systems more effective at early stage of development</td>
<td>Decentralized agency-based decision-making for smart initiatives allows for organic growth</td>
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Table 3: Interview findings of SMC and SFC.
In so doing, it hopes to pass on useful insights to managers on how to balance centralized and decentralized coordination/control, encouraging take-up of smart city initiatives within the city’s other divisions and agencies. Along with strong smart city leadership and a clear strategy, systematic management processes also drive engagement (e.g., partnership) with internal and external partners. However, cities still face a challenge in formulating the right governance structure given the possible presence of inherited organizational barriers to supporting smart initiatives. In particular, cities need to consider how best to balance centralized and decentralized coordination/control mechanisms. In effect, managers and policy makers should aware that each city must take account of its local embedded organizational culture and how quickly this culture is likely to be able to roll out or solicit services.

Since most previous work has taken a piecemeal approach to smart cities, tending to focus on individual projects, this study has aimed to set out a more comprehensive approach. In so doing, it hopes to pass on useful insights to managers on how to develop an effective smart city and help research to share best practices in smart city development.

### 6.2. Future research direction

The research findings of this study have been difficult to generalize due to the limited number of smart city cases that lent themselves to analysis. The research is limited in that it emerges from examination of only two cities, SMC and SFC. To further refine and verify this framework, future studies could apply this framework to others. For example, New York in the US currently boasts the largest number of open APIs; Barcelona in Spain is eager to innovate through ‘22@ living labs, and Song-do in South Korea is recognized as the first smart city to have a large number of experimental and innovative infrastructures under development. More case studies would reinforce our understanding of how to develop an effective smart city and help research to share best practices in smart city development.

Other interesting topics for future study include the question of how existing industries within a city are influenced by smart city initiatives and how entrepreneurs and startups can innovate with new green and smart firms or business models. Research on smart cities could shift to industry level or sector-based analysis (e.g., smart transportation), thus broadening the notion of a smart city beyond infrastructure development or energy sustainability to the full-scale creation of a new eco-system bringing together the next wave of innovation and entrepreneurship creating economic growth and value.

Last but not least, this study’s empirical-based framework offers a holistic picture of how smart cities can be analysed through the index model outlined in this work. Future study should begin to elaborate measurement scales for each of the six smart parameters, setting out proposed definitions for successive maturity levels on a parameter-by-parameter basis. Some measurements within these scales are still under development,
indicating that more focused work is needed to validate the scales and suitable evaluation methodologies.

References

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