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Understanding 'smart cities': Intertwining development drivers with desired outcomes in a multidimensional framework

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ABSTRACT

The convergence of technology and the city is commonly referred to as the 'smart city'. It is seen as a possible remedy for the challenges that urbanisation creates in the age of global climate change, and as an enabler of a sustainable and liveable urban future. A review of the abundant but fragmented literature on smart city theories and practices, nevertheless, reveals that there is a limited effort to capture a comprehensive understanding on how the complex and multidimensional nature of the drivers of smart cities are linked to desired outcomes. The paper aims to develop a clearer understanding on this new city model by identifying and linking the key drivers to desired outcomes, and then intertwining them in a multidimensional framework. The methodological approach of this research includes a systematic review of the literature on smart cities, focusing on those aimed at conceptual development and provide empirical evidence base. The review identifies that the literature reveals three types of drivers of smart cities—community, technology, policy—which are linked to five desired outcomes—productivity, sustainability, accessibility, wellbeing, liveability, governance. These drivers and outcomes altogether assemble a smart city framework, where each of them represents a distinctive dimension of the smart cities notion. This paper helps in expanding our understanding beyond a monocentric technology focus of the current common smart city practice.

1. Introduction

Improper and deliberate human activities pushed the planet into the Anthropocene epoch—characterised by significant impacts on geology, ecosystems, and climate change (Dizdaroglu & Yigitcanlar, 2014; Smith & Zeder, 2013). Despite representing only about 2% of the geographic space and accommodating over 50% of the world population, cities today produce 80% of greenhouse gas (GHG) emissions and consume 80% of the world's resources (Arbolino, Carlucci, Cira, Ioppolo, & Yigitcanlar, 2017; Arbolino, Carlucci, Cira, Yigitcanlar, & Ioppolo, 2018; Ioppolo, Cucurachi, Salomone, Saija, & Shi, 2016; Ioppolo, Heijungs, Cucurachi, Salomone, & Kleijn, 2014; La Greca & Martinico, 2016). A heavy reliance on non-renewable resources increases GHG emissions including a vast amounts of carbon-dioxide (CO_2) responsible for global warming (Goonetilleke, Yigitcanlar, Ayoko, & Egodawatta, 2014; Mahbub, Goonetilleke, Ayoko, Egodawatta, & Yigitcanlar, 2011; Szopik-Depczyńska et al., 2017; Yigitcanlar, Dodson, Gleeson, & Sipe, 2007).

At the dawn of the catastrophic global climate change era, 'smart cities' came to the scene as a potential panacea to, somehow, reverse or ease the impacts of ill urbanisation, industrialisation, and consumerism practices (Taamallah, Khemaja, & Faiz, 2017; Trindade et al., 2017; Wiig, 2015). Although the initial rationale for the smart city developments was mostly related to environmental concerns, the practice, unfortunately, indicates that only marginal attention is paid to these concerns. Current practice is mostly unidimensional with technology at the core (Yigitcanlar, 2016). This unidimensional focus is a result of, as well as points to, a number of challenges that smart city practice is facing to overcome. These are briefly elaborated below.

Firstly, the fourth industrial revolution (Industry 4.0) helps leading

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global cities to advance their innovation edges, and hence, further secure their global hub status in innovation and knowledge generation (Edvardsson, Yigitcanlar, & Pancholi, 2016; Yigitcanlar, Guaralda, Taboada, & Pancholi, 2016; Yigitcanlar, Sabatini-Marques, Costa, Kamruzzaman, & Ioppolo, 2017). Subsequently, cities that are falling behind started to strategize their economic development to increase abilities in fostering, attracting, and retaining innovation activities (Holland, 2015; Millar & Choi, 2010; Pancholi, Yigitcanlar, & Guaralda, 2017a; Yigitcanlar, Edvardsson, et al., 2017). Smart cities agenda in many cities—e.g., Amsterdam, Vienna—goes hand-in-hand with these knowledge-based economic development efforts (Carrillo, Yigitcanlar, García, & Lönnqvist, 2014; Esmaeilpoorarabi, Yigitcanlar, & Guaralda, 2016, 2018; Sarimin & Yigitcanlar, 2012). Today, smart cities are seen as the hubs of technological innovation—e.g., San Francisco, Seoul—(urban areas generate 93% of the world's patented inventions) rather than cities of sustainable development.

Secondly, smart city projects, nonetheless, are big and expensive capital investments—supposed to drive societal and environmental transformations—, thus very hard to properly deliver. Current practice is highly ad hoc in nature in transforming cities and societies into truly smart ones. For example, after over a decade of investment, Songdo City (Korea)—widely referred to as the world's first smart city—is still a 'work in progress' project without achieving any concrete desired outcomes (Yigitcanlar & Lee, 2014). This ad hoc approach makes the smart city practice highly risky to accurately identify, produce and/or meet desired socio-spatial outcomes.

Next, Han and Hawken (2018, p. 1) underline the monocentric focus on technology of the present smart city practice by stating: "Current discourse on smart cities is obsessed with technological capability and development. Global rankings reduce cities to a one-dimensional business model and series of metrics. If the term 'smart city' is to have any enduring value, technology must be used to develop a city's unique cultural identity and quality of life for the future." The comprehension of smart cities in current practice carries a risk of leading to a long-term trend towards increasing dependency on technology, and negligence of socio-spatial issues (Yigitcanlar, 2016).

Fourthly, the popularity of smart cities agenda is mainly an outcome of the aggressive promotion/push of major global technology, development, and consultancy firms and their programs—e.g., KPMG and CISCO's partnership in smart cities, and IBM's Smarter Planet, and Smarter Cities Challenge initiatives (Alizadeh, 2017). While smart city sceptics raised their concerns about the ongoing global craze on this new city brand (Anthopoulos, 2017; Grossi & Pianezzi, 2017; Kunzmann, 2014), many governments across the globe are still jumping on the smart cities bandwagon by turning a blind eye to these warnings (Caragliu, Del Bo, & Nijkamp, 2011; Townsend, 2013).

Lastly, there are too many smart city definitions/conceptualisations—focusing on separate aspects of drivers or outcomes—in the rapidly growing literature. These are coined by scholars and commercial, government and international organisations and mostly vague or inchoate in conception (Dameri, 2013). However, due to the infancy, interdisciplinary nature or generally poor conceptualisation, there is not a commonly agreed definition of smart cities. This is due to the lack of a sound and/or common conceptual understanding. Scholars, practitioners, and organisations developed their frameworks that suit their own particular practical perspectives—rather than (in general) a generic framework outlining the complexities and links of various dimensions of smart cities in a comprehensive and at the same time a simple way.

Against this backdrop, this paper aims to address the broad conceptualisation and multidimensionality issues through developing a better understanding of the smart cities notion—in terms of identifying the key development drivers and desired outcomes and placing them under a multidimensional framework. This would, in turn, help urban administrators and smart city practitioners better grasp the smart city notion and assist them in undertaking necessary actions to utilise the smart city drivers to achieve the desired outcomes. The methodological approach adopted in this research includes a systematic but at the same time critical review of the interdisciplinary literature on smart cities focusing on conceptual analysis in order to develop a multidimensional framework. By developing such framework, this study contributes to the efforts of a few other scholars, who have developed multidimensional conceptualisations and frameworks, and expands the understanding beyond a mostly monocentric focus of the current common smart city practice.

2. Smart cities in a nutshell

2.1. Origin and definition

In recent years, the development of smart cities is at the forefront of the urban discourse due to rapid urbanisation rate and associated socioeconomic, environmental and governance challenges, along with the global innovation leadership challenge (Belanche, Casaló, & Orús, 2016). Nevertheless, the concept of smart city is not new. The term was first coined in the mid-1800s to describe new cities of American West that were efficient and self-governed. However, it has its contemporary origins in the 'smart growth' movement of the 1990s—referencing to sustainable urbanisation (Eger, 2009; Albino, Berardi, & Dangelico, 2015; Susanti, Soetomo, Buchori, & Brotosunaryo, 2016).

Since 1990s, the smart city concept has evolved to mean almost any form of technology-based innovation in the planning, development, operation and management of cities, for example, the deployment of smart mobility solutions to combat urban traffic challenges (Battarra, Gargiulo, Pappalardo, Boiano, & Oliva, 2016; Harrison & Donnelly, 2011; Yigitcanlar, Fabian, & Coiacetto, 2008). With the offerings of digital technologies and online urban planning opportunities, this concept increased its popularity among the urban technocrats (Aina, 2017; Pettit et al., 2018; Yigitcanlar, 2005, 2006).

Although originated from the smart growth movement, a smart city can be, sometimes mistakenly, termed in other jargons. These include sustainable city (Bulkeley & Betsill, 2005), digital city (Aurigi, 2005), intelligent city (Komninos, 2008), ubiquitous city (Lee, Yigitcanlar, Han, & Leem, 2008), techno-centric city (Willis & Aurigi, 2017), creative city (Baum, O'Connor, & Yigitcanlar, 2009), and knowledge city (Yigitcanlar, Velibeyoglu, & Martinez-Fernandez, 2008). However, the notion of smart city is not equivalent to these city brands; but smart cities carry some of the common characteristics of other city brands or their conceptualisations. For example, an intelligent city is not equivalent to the notion of smart city, instead it focuses on only either a single aspect of the smart city field (e.g., ICT) or on other less closely related issues (e.g., resilient city). These branding variations have occurred as a result of different interpretations of what an ideal city should be like, and which policies these cities utilise to sustain growth, and address socio-spatial inequalities of resources (Chang, Sabatini-Marques, da Costa, Selig, & Yigitcanlar, 2018). However, subsequent to the increasing popularity of the smart city phenomenon, in recent years many cities across the globe incorporated the 'smart' tag in their brands. For instance, Songdo was initially branded as a 'ubiquitous city', but the new brand is now a 'compact smart city'.

During the last two decades, the pace of globalisation has accelerated a number of large multinational corporations' focus on the lucrative smart urban technology and engineering solutions. IBM, Cisco, Microsoft, Hitachi, Samsung, LG, Siemens, ARUP, KPMG, and a number of national telecommunication companies—e.g., Alcatel, KT Corporation—are among the front-runners of the industry that led the expansion of smart cities movement, and technology deployment across the global cities (Yigitcanlar, 2016). Moreover, today various technology and car manufacturing companies—e.g., Google, Uber, Volvo, Tesla, Audi, BMW, Mercedes-Benz, Nissan to name a few—also joined the smart cities bandwagon with their smart mobility solutions of autonomous vehicles or driverless cars (Shladover, 2017). The global

Table 1
Definition and primary theme of smart cities.
(Derived from Lara et al., 2016; Mora et al., 2017)

No	Reference	Definition	Theme
1	Lara et al. (2016)	A community that systematically promotes the overall wellbeing for all of its members, and flexible enough to proactively and sustainably become an increasingly better place to live, work and play.	Community, wellbeing, sustainability, liveability
2	Yigitcanlar (2016)	An ideal form to build the sustainable cities of the 21st century, in the case that a balanced and sustainable view on economic, societal, environmental and institutional development is realised.	Sustainability, productivity, governance, community
3	Piro, Cianci, Grieco, Boggia, and Camarda (2014)	A city that intends as an urban environment which, supported by pervasive ICT systems, is able to offer advanced and innovative services to citizens in order to improve the overall quality of their life.	Technology, liveability, policy
4	Alkandari, Alnasheet, and Alshaikhli (2012)	A city that uses a smart system characterised by the interaction between infrastructure, capital, behaviours and cultures, achieved through their integration.	Technology, productivity, community, governance
5	Lazaroiu and Roscia (2012)	A city that represents the future challenge, a city model where the technology is in service to the person and to his economic and social life quality improvement.	Technology, prosperity, liveability, wellbeing
6	Schaffers et al. (2012)	A safe, secure environmentally green, and efficient urban centre of the future with advanced infrastructures such as sensors, electronics, and networks to stimulate sustainable economic growth and a high quality of life.	Technology, productivity, liveability, sustainability
7	Caragliu et al. (2011)	A city that is smart when investments in human and social capital and traditional transport and modern ICT infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance.	Community, technology, liveability, sustainability, governance, policy, accessibility
8	González and Rossi (2011)	A public administration or authority that delivers or aims to a set of new generation services and infrastructure, based on information and communication technologies.	Governance, policy, technology
9	Hernandez-Munoz et al. (2011)	A city that represents an extraordinary rich ecosystem to promote the generation of massive deployments of city-scale applications and services for a large number of activity sectors.	Technology, governance
10	Nam and Pardo (2011)	A humane city that has multiple opportunities to exploit its human potential and lead a creative life.	Community, wellbeing, productivity
11	Zhao (2011)	A city that improves the quality of life, including ecological, cultural, political, institutional, social, and economic components without leaving a burden on future generations.	Liveability, governance, sustainability, community, productivity
12	Belissent (2010)	A city that uses ICTs to make the critical infrastructure components and services of a city–administration, education, healthcare, public safety, real estate, transportation, and utilities–more aware, interactive, and efficient.	Technology, accessibility, liveability, governance
13	Eger (2009)	A particular idea of local community, one where city governments, enterprises and residents use ICTs to reinvent and reinforce the community's role in the new service economy, create jobs locally and improve the quality of community life.	Community, governance, technology, liveability, productivity
14	Paskaleva (2009)	A city that takes advantages of the opportunities offered by ICT in increasing local prosperity and competitiveness–an approach that implies integrated urban development involving multi-actor, multi-sector and multi-level perspectives.	Productivity, technology, policy
15	Rios (2008)	A city that gives inspiration, shares culture, knowledge, and life, a city that motivates its inhabitants to create and flourish in their own lives—it is an admired city, a vessel to intelligence, but ultimately an incubator of empowered spaces.	Community, liveability, productivity
16	Giffinger et al. (2007)	A city well performing in a forward-looking way in economy, people, governance, mobility, environment, and living built on the smart combination of endowments and activities of self-decisive, independent and aware citizens.	Community, governance, accessibility, technology, productivity, policy
17	Partridge (2004)	A city that actively embraces new technologies seeking to be a more open society where technology makes easier for people to have their say, gain access to services and to stay in touch with what is happening around them, simply and cheaply.	Technology, community, accessibility, liveability
18	Odendaal (2003)	A city that capitalises on the opportunities presented by ICTs in promoting its prosperity and influence.	Technology, productivity
19	Bowerman et al. (2000)	A city that monitors and integrates conditions of all of its critical infrastructures including roads, bridges, tunnels, rails, subways, airports, sea-ports, communications, water, power, even major buildings, can better optimise its resources, plan its preventive maintenance activities, and monitor security aspects while maximising services to its citizens.	Policy, governance, accessibility, liveability
20	Hall et al. (2000)	An urban centre of the future, made safe, secure environmentally green, and efficient because all structures–whether for power, water, transportation, etc. are designed, constructed, and maintained making use of advanced, integrated materials, sensors, electronics, and networks which are interfaced with computerized systems comprised of databases, tracking, and decision-making algorithms	Sustainability, technology, governance

market for smart city solutions and services is expected to grow from $40.1 billion in 2017 to 94.2 billion by 2026 (Pyzyk, 2017).

After two decades into the commencement of contemporary conceptualisation and practice of the smart cities notion, it is still in its infancy (Alizadeh, 2017; Praharaj, Han, & Hawken, 2018). Unparalleled to its raising popularly, there is no commonly agreed definition of smart cities, and what they represent in the international economic order. A selection of the most popular definitions of smart cities—based on Lara, Costa, Furlani, and Yigitcanlar (2016) and Mora et al.'s (2017) studies—are listed in Table 1. The fast-growing literature on smart cities comes from the streams of academic, commercial and (inter)national organisations researching on and practicing smart cities. These groups have a different take on the concept as they see it from different lenses such as disciplinary, practice- or conceptualisation-orientation, and domain-orientation—e.g., technology, economy, society, environment, governance (Yigitcanlar, 2017).

2.2. Technology

The original intention or rationale, as devised from the smart

growth movement, was predominantly to provide environmental sustainability (Dizdaroglu, Yigitcanlar, & Dawes, 2012). Today, smart city projects seemed to pay more attention to provide economic development and quality of living outcomes using the capabilities of modern technologies (Afzalan, Sanchez, & Evans-Cowley, 2017)—perhaps as, in the short run, these are more profitable and relatively easier tasks to deliver (Hollands, 2008). In other words, during the last decade the smart city concept became a buzz word predominantly for techno-centric urbanisation with recognition of flexible and mobile means of production and innovation (Neirotti, De Marco, Cagliano, Mangano, & Scorrano, 2014).

A bibliometric analysis, undertaken by Mora, Bolici, and Deakin (2017), underlines that smart cities are a fast-growing topic of scientific enquiry. However, much of the knowledge generated about them is singularly technological in nature—thus, lacking social intelligence, cultural artefacts, and environmental attributes. Similarly, Angelidou (2017) identifies the characteristics of smart cities from the literature and checks these characteristics in 15 smart cities best practices. The study finds that most smart city strategies are focused on the role of technology in improving the functionality of urban systems and advancing knowledge transfer and innovation networks.

Smart cities' primary focus being exclusive to technology has been heavily criticised by a number of scholars. For instance, Yigitcanlar & Lee's (2014, p. 112) research on the Korean context, revealed that smart cities "are typically prone to problems related to the lack of social infrastructure, market restrictions, political quagmires and vested financial interests. Such cities have been built from the perspective of technical computing with an emphasis on supply-side technology, which has put in place advance technologies with impressive budgets. However, through such a computing-driven approach, social and cultural aspects have been neglected and absent from discussions of the design of cities, which have emphasised physical aspects and industry portfolios and veered off from the idea of a knowledge culture".

The darker side of smart cities—particularly the extreme dependency on technology, and on corporations dominating technology and related services—is mentioned in the literature as threatening. As stated by Kunzmann (2014, p. 17), "sooner or later society will not manage any more to live without the ICT-based services. Like addicts, or chronically sick patients who are extremely suffering from the lack of some substance, respectively the medicine they are relying on, citizens will become sick, if the access to smart ICT services will be cut-off. They will soon forget how to survive in cities, once smart ICT technologies are not available any more. The concentration processes, which characterize the global market of smart technologies, are threatening".

2.3. Economy

One of the main reasons behind the increasing popularity of the smart cities notion across local governments is the economic premise of such development to the city. In their recent study, Caragliu & Del Bo (2018b, p. 81) find that "smart city policy intensity is associated with a better urban economic performance. Moreover, instrumenting smart policies with smart urban characteristics suggests that the causality direction goes from policy intensity to growth, and not vice versa".

There is, however, conflation of smart cities and creative class (or innovation) economies, which tends to reflect policies that support amenities that benefit persons in higher socioeconomic groups rather than focus on broadening economic gains to a more inclusive population. This issue is also elaborated by Costa and Oliveira (2017) highlighting the need for a humane approach that is where technology responsive to needs, skills and interests of users, respecting their diversity and individuality. They state that "a smart city is in general associated with technology: sensors, cameras, fast internet connections, and control centres. While useful, technology should not be the central focus. A humane smart city addresses first of all people and their needs. Then comes technology and only in direct connection with these needs. The point here is to raise the right questions. Rather than needing a solution to traffic jams, we need a solution to the mobility of the people who today are trapped in the chaotic jams" (p. 228).

2.4. Society

Smart cities face the risk of social exclusion and gentrification. For instance, as part of the Abu Dhabi government's long-term development agenda of Vision 2030—targeting a move from petro-urbanism to smart urbanism—the idea behind Masdar smart city was to build the future of sustainable living model for all (Yigitcanlar, 2016). Despite the frequent presence of the concepts of social justice and equity along with social sustainability in the vision, the city only reserves a small area for the unprivileged groups. This indicates that the project is not as socially sustainable as it is claimed to be (Cugurullo, 2013). This issue is also evident in many other smart city initiatives—e.g., gentrification in Brooklyn, Los Angeles, the Bay Area in the US, and Toronto in Canada (Abbruzzese, 2017; Bronstein, 2009).

Although, the Tianjin smart city project received attention for its environmental sustainability, and eco-technologies, it is criticised due to its design, and to the lack of recognition of the complex web of socio-cultural and economic processes, which link the lived environment of the city to its environmental characteristics (Yigitcanlar, 2016). On that very point, Wong (2011) argues that the city lacks of a human scale as giant blocks that are about four times the size of a typical block in Manhattan and make pedestrian and bike journeys cumbersome. As for Caprotti (2014), one of the critical issues in Tianjin is the internal social resilience and the emergence of new communities. Moreover, Caprotti (2014) highlights that the project's needs to consider not only the high-tech, new urban environments materialised as smart cities, but also the production and reproduction of large, often transient populations of low-paid workers that builds the city and who forms the 'new urban poor', forming 'worker cities' on the edges of flagship smart and sustainable urban projects.

As a solution to societal challenges, Caragliu & Del Bo (2012, p. 97) highlight the importance of "space-specific characteristics in shaping the economic effect of smart urban qualities, providing grounding to place-based public policies that account for local characteristics". In other words, incorporation of local communities and actors in place-based decision-making process to build the development on endogenous assets is an integral element of forming prosperous and sustainable and smart cities (Pancholi, Yigitcanlar, & Guaralda, 2017b).

2.5. Environment

Limited environmental aspects of smart city projects—despite their promise—are highly criticised. For example, Songdo, the Korean model smart city, was subjected to strong opposition from environmentalist groups, both local and international. According to Shwayri (2013, p. 53), this smart city is "built on the destruction of precious wetlands, home to some of the rarest species on the planet, causing the disappearance of some. Once reclaimed, its developers have pursued sustainable building practices, applying guidelines and materials that promote efficient energy use, and recycling 75% of construction waste". The impact of this smart city project on the local natural ecosystem is evident (Ko, Schubert, & Hester, 2011). The relationship between the concepts of smart and sustainable is currently a hot topic of academic debate as smart cities tend to fail to keep their sustainability promises (Ahvenniemi, Huovila, Pinto-Seppä, & Airaksinen, 2017). In their investigation on 15 UK cities, Yigitcanlar and Kamruzzaman (2018) find no clear evidence that smart city policy leads to sustainability of cities.

Likewise, as stated by Cugurullo (2016, p. 2429), "the way sustainability is expressed in Masdar city associates environmentalism with consumerism. The environmental attention of the developers is put almost exclusively on CO_2 whose reduction can be capitalised through the development and commercialisation of clean technologies

designed to decrease the carbon emissions of urban environments. As a result of this profit-driven selection of environmental targets, a plethora of other important themes (ecosystem services in particular) are cut off because they are perceived as unattractive from an economic perspective. More problematically, the extreme reliance on technology as the solution to global environmental problems reiterates the very origin of those environmental problems".

As a solution to environmental challenges, Martin et al. (2018, p. 1) suggest that "the potential to empower and include citizens represents the key to unlocking forms of smart-sustainable urban development that emphasise environmental protection and social equity, rather than merely reinforcing neoliberal forms of urban development".

2.6. Governance

In terms of smart city development governance, the top-down state-led process with no or minimal public participation in Northeast Asia is heavily criticised. Particularly referring to the Songdo, Yujiapu and Lingang smart city initiatives, Kim (2014, p. 352) states that these state-led mega projects "are devoid of the planners' consciousness of the 'social'. Instead, the technological paradigm, an abstract and utopian view of social diversity and codified images of nature (symbolized in the colour green) are viscerally reinvented in order to benefit the privileged few and commoditized under the tyranny of environmental emergency. After a century, for those who do not necessarily align their interests with the majority urbanites or for those who rarely make themselves available for the contesting, dynamic and spontaneous construction of everyday urban spaces, these colossal modernist schemes stand as a testimony to the burgeoning urban fantasies in Northeast Asia".

As a solution to governance challenges, Deakin (2013, 2014) advocates a 'triple helix model' approach—public-private-academia partnership—to overcome the governance and development limitations. Additionally, Bolivar (2018, p. 57) analyses the public value creation in smart cities and finds that "public value creation surpasses the capacities, capabilities, and reaches of their traditional institutions and their classical processes of governing, and therefore new and innovative forms of governance are needed to meet it. This way, the creation of public value under the context of the smart cities is based on smart urban collaboration, which promotes the use of new technologies to adopt a more participative model of governance".

2.7. Drivers

The interdisciplinary literature highlights a number of smart city drivers. According to Kunzmann (2014) these drivers are: (a) Technology—smart city technology makes life in the city easier, more convenient, and more secure; (b) Community—beneficiary of smart city services, and also decider of which problems to be tackled; (c) Policy—enabler of smart city initiatives and taking measures to minimise the negative impacts of smart city disruption. Almost identical to these drivers, Nam and Pardo (2011) conceptualise the drivers of smart cities as: (a) Technology; (b) People; (c) Institutions. They state that given the connection between these drivers, "a city is smart when investments in human/social capital and ICT infrastructure fuel sustainable growth and enhance a quality of life, through participatory governance" (p. 286).

2.8. Desired outcomes

After placing 10 cities—Abu Dhabi, Amsterdam, Auckland, Barcelona, Brisbane, Incheon, Istanbul, Rio de Janeiro, San Francisco, Tianjin—under the smart cities microscope, Yigitcanlar (2016) advocates the need for smart city projects to generate desired outcomes, in economic, societal, environmental and governance terms, in a sustainable and balanced manner. Yigitcanlar (2016) suggests that for a successful:

- *Economic development in smart cities*: We need to give our cities the capability of developing their technologies unique to their own developmental problems and needs. This in turn contributes to the establishment of a local innovation economy and prosperity that is a central element of smart cities;
- *Sociocultural development in smart cities*: We need to develop our cities wired with smart urban technologies not only exclusive to urban elites, but also inclusive to those unfortunate. This in turn helps in establishing socioeconomic equality that is an essential element of smart cities;
- *Spatial (urban and environmental) development in smart cities*: We need to reform our cities by adopting sustainable urban development principles—e.g., minimising urban footprint, limiting emissions, establishing urban farms. This in turn helps in generating ecological sustainability that is a critical element of smart cities;
- *Institutional development in smart cities*: We need to equip our cities with highly dynamic mechanisms to better plan their growth and manage their day-to-day operational challenges. This in turn helps in performing appropriate planning, development, and management practices that is a core element of smart cities.

2.9. Frameworks

Scholars highlight that the challenges of the smart city practice might be due to limited conceptualisation of the smart cities phenomenon—particularly the limited number of multidimensional framework developments is an issue (Harrison & Donnelly, 2011; Nam & Pardo, 2011; Yigitcanlar, 2016). Although there seems to be, so far, a few multidimensional smart city definitions and frameworks developed (e.g., Caragliu et al., 2011; Fernandez-Anez, Fernández-Güell, & Giffinger, 2017), not many of them adequately addressed the above-mentioned balanced and sustainable approach.

For instance, among the existing frameworks, perhaps the most known one is the EU's smart city wheel. According to this wheel, smart cities can be characterised by having: smart economy (e.g., productivity), smart people (e.g., community with high social and human capitals), smart governance (e.g., good governance and policy), smart mobility (e.g., transport and technology accessibility), smart environment (e.g., sustainability), and smart living (e.g., liveability and well-being) (EU, 2014). Despite covering all primary smart city domains and serving as a model to integrate smart city practice areas, this popular wheel is far from being a comprehensive framework—as it lacks of underlining relationships among the smart city domains. However, it serves a noble purpose particularly in emphasising a holistic view for moving smart city projects' focus beyond the technology realm.

Additionally, Angelidou (2015) conceptualise a smart city based on four major forces, namely: (a) Urban futures; (b) Knowledge and innovation economy; (c) Technology push; (d) Application pull. While these driving forces are highly relevant, this framework is highly abstract to be easily adopted in a local smart city planning context. Similarly, Kummitha and Crutzen (2017) propose a framework, consisting of four elements—(a) Restrictive; (b) Reflective; (c) Rationalistic; (d) Critical—to critically analyse various stages in the development of the smart cities field. This framework, rather, focuses on how smart cities differ in their meanings, intentions and offerings.

2.10. Gaps

Despite the heavy criticisms of smart city sceptics of this type of urban form and development practice, as presented above, there is a general sense among the scholars that rethinking our cities' planning and development paradigms and processes in the age of digital disruption and climate change is a good thing (Caragliu & Del Bo, 2018a; Yigitcanlar, 2009). Nevertheless, this still requires a clear definition and

elaboration of: (a) What a smart city is; (b) What are their key drivers and desired outcomes are; (c) How the smart city paradigm can be conceptualised. This necessity, despite a few multidimensional definition and framework examples (e.g., Caragliu et al., 2011; Fernandez-Anez et al., 2017), calls for further investigation to synthesise a new framework for smart cities. This forms the rationale of the paper at hand.

3. Methodology

This research applies a systematic review of the literature to achieve the research aim—following the procedures suggested by Bask and Rajahonka (2017).

Firstly, a research plan involving the research aim, keywords, and a set of inclusion and exclusion criteria was developed. Research aim was framed to explore links among various aspects of smart cities and to develop a framework. As the keyword, we decided to use 'smart cities'. We identified the inclusion criteria as peer-reviewed research articles in English language. An online search was conducted using a university library search engine—Queensland University of Technology—that connects to 393 different databases, including ScienceDirect, Scopus, Web of Science, Wiley online library, directory of open access journals. We excluded dealing with edited or authored books, conference proceedings, journal editorials, articles in other languages than English, grey literature such as government or industry reports, and non-academic research. The search included only peer-reviewed and full-text journal articles available online.

Secondly, the search was conducted in January 2018 for journal articles published between January 2000 and January 2018. Although there were some articles predating-2000, due to the negligible numbers and limited relevance, the review focused on the post-2000 articles. Several thematic searches were specified through a combination of multiple keywords. The keywords used in all thematic searches were directed to the title of the articles. The resultant search items were initially checked by reading the abstract, and then by reading the full-text in order to verify the scope against the research aim.

Thirdly, the initial thematic search was conducted using the keywords of 'smart cities', 'framework', and 'model' to identify articles that contain smart cities frameworks—keyword of 'model' was included to broaden the coverage of the search. The Boolean search line was: ((TitleCombined:("smart cities")) AND ((TitleCombined:(framework)) OR (model))). The search resulted in 105 papers, which were reduced to 33 articles after checking their abstracts, and further reduced to 26 articles after reading their full-texts.

Then, we have undertaken a conceptual analysis to determine new keywords—or general themes or broad concepts or key elements—using the selected 26 full-text articles by following the methodological steps as suggested by Jabareen (2008). These steps were: (a) Recognition of similarities or patterns among the general themes; (b) Synthesisation of general themes; (c) Formation of a multidimensional framework. As a result of the abovementioned conceptual analysis steps, we determined three general themes—i.e., 'community', 'technology', 'policy'—from the literature as the main areas that drive smart cities development. These drivers are placed at the inner middle-ring of the proposed framework (see Fig. 1). These three themes (or drivers) were then used as keywords to further search the smart city literature.

The second thematic search was conducted using the keywords of 'smart cities', 'community', and 'society' to identify articles on the community aspects of smart cities—keyword of 'society' was included to broaden the coverage of the search. The following Boolean search line was performed: ((TitleCombined:("smart cities")) AND ((TitleCombined:(community)) OR (society))). The search resulted in 366 papers, which were reduced to 48 articles after checking their abstracts, and further reduced to 14 articles after reading their full-texts.

Next, we conducted another search in the database using a combination of the keywords of 'smart cities', 'technology', and 'innovation' identify articles on the technology aspects of smart cities—keyword of 'innovation' was included to broaden the coverage. For this, the following Boolean search was conducted: ((TitleCombined:("smart cities")) AND ((TitleCombined:(technology)) OR (innovation))). This search resulted in 433 papers, which were screened through by reading their abstracts (resulted in 36 articles) and then their full-texts (resulted in 25 articles).

The final thematic search was conducted using a combination of the keywords of 'smart cities', 'policy', and 'plan' identify articles on the policy aspects of smart cities—keyword of 'plan' was included to broaden the coverage of the search. The Boolean search line was: ((TitleCombined:("smart cities")) AND ((TitleCombined:(policy)) OR (plan))). The search resulted in 302 papers. We have gone through their abstracts and limited the selection to 15 articles. After reading their full-texts, the final selection was limited to 13 journal articles.

As a result, 78 journal articles fulfilled our selection criteria (out of 1206 articles), and these papers were then read, reviewed, and analysed. We categorised the reviewed papers according to themes—i.e., 'framework', 'community', 'technology', 'policy'. We undertook a conceptual analysis to determine the new concepts/themes or framework elements related to the outcomes of smart cities by following the aforementioned methodological steps. The analysis produced six new subthemes—i.e., 'productivity', 'sustainability', 'accessibility', 'wellbeing', 'liveability', 'governance'—from the literature that are then considered as desired outcomes of smart cities. These desired outcomes are placed at the outer middle-ring of the proposed framework (see Fig. 1).

We, subsequently, extracted data from the reviewed papers in tables, formulated according to the four themes—i.e., framework, community, technology, policy (Tables 2–5). Each table contained the following information against each of the selected article: authors, year of publication, title of the article, name of the journal, framework, and desired outcome (or subtheme).

We, then, discussed and linked up the individual findings of each theme and subtheme into one. Some reviewed papers were discarded at this stage as those did not directly match with issues relevant to specific themes of smart cities. This helped us to better understand the conceptual/thematic issues relating to smart cities—based on themes (smart city drivers), and subthemes (smart city desired outcomes).

The final stage of the review process was to write up and present our findings in the format of a literature review paper. In this process, some other relevant papers, which do not fulfil the pre-determined selection criteria, are also included as supporting material to better appreciate the background context, and discuss the findings—e.g., books, book chapters, conference papers, government policy documents, and online reports. With these, the total number of the reviewed and cited references is increased to 192.

4. Results

4.1. General observations

An initial review, on how smart cities are defined, has shown that there is no consensus on what a smart city is. Provided 20 popular definitions (Table 1) revealed that technology perspective is the dominant feature of smart cities. Different conceptualisations include other features—e.g., community, policy, productivity, sustainability, accessibility, wellbeing, liveability, governance—but not in a single definition. This is mainly due to disciplinary and sectoral perspective differences, and infancy of the smart cities concept and practice in the 2000s and 2010s.

In reviewing the literature on smart cities, selected 78 academic papers (out of 1206 articles that abstracts are read) are assembled under four broad categories—as explained in the methodology section. These are: (a) Smart city frameworks—containing 26 articles; (b) Smart

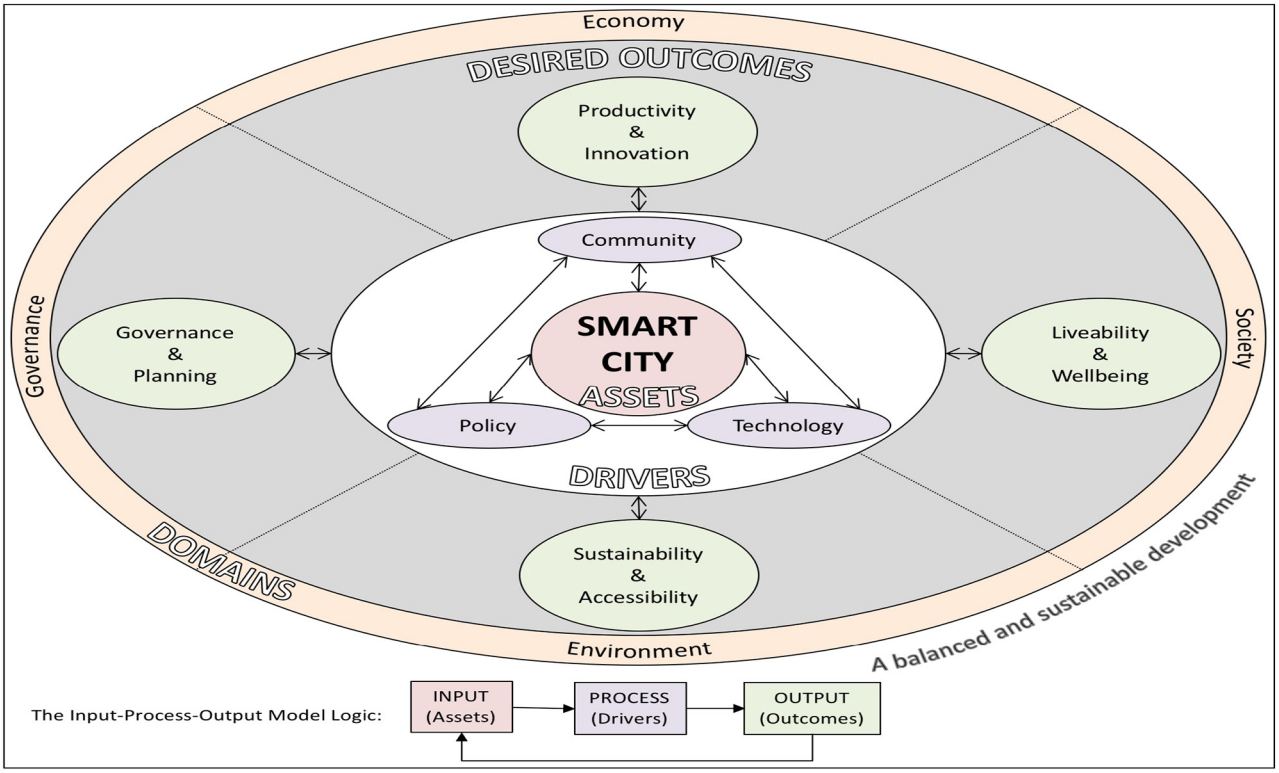

Fig. 1. Multidimensional smart city framework.

city and community—14 articles; (c) Smart city and technology—25 articles; (d) Smart city and policy—13 articles. In looking at the distribution of the papers, it can be stated that framework development and technology aspects have a larger coverage than community and policy aspects.

The reviewed literature, in all categories, illustrates that research on smart cities is mostly limited to developed countries of Europe, North America, Oceania, and Southeast Asia—even though there were some papers focusing on the cities of emerging economies such as Brazil. This finding shows parallels with the smart city initiatives taking place in the major cities of the world. For example, a recent smart city ranking exercise has placed the following cities at the top of the list—New York, London, Paris, San Francisco, Boston, Amsterdam, Chicago, Seoul, Geneva, Sydney (IESE, 2016). According to another smart city ranking top-10 cities are: Copenhagen, Singapore, Stockholm, Zurich, Boston, Tokyo, San Francisco, Amsterdam, Geneva, Melbourne (EasyPark Group, 2017).

The earliest study on smart cities of the reviewed publications—in four categories—dated only back to 2012 (Walravens, 2012). Although there were studies prior to 2012 on smart cities—for instance Bowerman, Braverman, Taylor, Todosow, and Wimmersperg (2000) and Hall et al. (2000)—Walravens's (2012) paper was the earliest one that satisfied the selection criteria as applied in this research. Almost two-third of the papers were published in 2016 and onwards (64%), which indicates an exponential growth trend of research on this topic during the last couple of years.

4.2. Smart city frameworks

Among the reviewed 78 literature pieces, 26 of them had a framework focus. Most of those papers used a framework approach to develop a component of a smart city, rather than having a holistic approach to conceptualise and develop smart cities. Only 17 of them actually presented or proposed a framework on smart city or a feature of it. Among the articles outlining a framework, four had a broader smart city focus, four contained a technology framework, two of them provided service provision frameworks, two showed business model and integration frameworks, and the remaining five contained transport procurement, public participation, and management frameworks. The desired smart city outcomes are varied in these frameworks due to their specific focus, but most of them had (good) 'governance' as a desired outcome. A summary of the literature on smart cities with a framework focus is presented in Table 2.

One of the frameworks with broader smart city focus has adopted the EU's smart cities framework to explore innovation networks in the development of smart city services (Errichiello & Marasco, 2014). The second one, by Lee, Hancock, and Hu (2014), was a smart city analysis framework, which includes the following dimensions: (a) Urban openness; (b) Service innovation; (c) Partnerships formation; (d) Urban proactiveness; (e) Smart city infrastructure integration; (f) Smart city governance. The third one, by Joshi, Saxena, and Godbole (2016), identified six significant pillars for developing a smart city framework: (a) Social; (b) Management; (c) Economic; (d) Legal; (e) Technology; (f) Sustainability. The last framework, by Fernandez-Anez et al. (2017), sees smart city as an integrated and multidimensional system, and attempts to link three main issues: (a) The key role of governance and stakeholders' involvement; (b) The importance of displaying a comprehensive vision of smart city projects and dimensions; (c) The understanding of smart city as a tool to tackle urban challenges. While these frameworks made contributions to the smart city conceptualisation, they have limitations in providing a solid and widely acknowledged conceptual framework with a big picture view of smart cities.

4.3. Smart city and community

From the reviewed 78 smart city literature pieces, only 14 of them had a community focus. Limited number of research on the community aspect of smart cities rings alarm bells, and indicates the negligence of considering local communities as the key player of smart city development. Despite this, most of the papers raised the issue of critical

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Table 2
Literature on smart cities with a framework focus.

No	Author	Year	Title	Journal	Framework	Outcome
1	Kousiouris et al.	2018	An integrated information lifecycle management framework for exploiting social network data to identify dynamic large crowd concentration events in smart cities applications	Future Generation Computer Systems	N/A	N/A
2	Meijer & Thaens	2018	Urban technological innovation: developing and testing a sociotechnical framework for studying smart city projects	Urban Affairs Review	N/A	Sustainability, liveability
3	Bhide	2017	Smart cities: developing a regional framework	Institute of Transportation Engineers Journal	N/A	Productivity, liveability, accessibility
4	Chen et al.	2017	An open framework for participatory PM2.5 monitoring in smart cities	IEEE Access	N/A	Sustainability, wellbeing
5	Fernandez-Anez et al.	2017	Smart city implementation and discourses: an integrated conceptual model—the case of Vienna	Cities	Smart cities framework	Sustainability, liveability, governance, accessibility, wellbeing, productivity
6	Khan, Pervez, & Abbasi	2017	Towards a secure service provisioning framework in a smart city environment	Future Generation Computer Systems	Smart city secure service provisioning framework	Sustainability
7	Liu, Heller, & Nielsen	2017	CITIESData: a smart city data management framework	Knowledge and Information Systems	Smart city technology framework	Governance
8	Pierce, Ricciardi, & Zardini	2017	Smart cities as organizational fields: a framework for mapping sustainability-enabling configurations	Sustainability	N/A	Sustainability
9	Romão, Kourtit, Neuts, & Nijkamp	2017	The smart city as a common place for tourists and residents: a structural analysis of the determinants of urban attractiveness	Cities	Conceptual model for smart city local-visitor interests	Sustainability, liveability, accessibility, productivity
10	Anthopoulos & Reddick	2016	Understanding electronic government research and smart city: a framework and empirical evidence	Information Polity	N/A	Governance
11	Brooks & Schrubbe	2016	The need for a digitally inclusive smart city governance framework	UMKC Law Review	N/A	Governance
12	Damurski	2016	Smart city, integrated planning, and multilevel governance: a conceptual framework for e-planning in Europe	International Journal of *E*-Planning Research	Smart city integrated planning framework	Governance
13	Fassam, Copsey, & Gough	2016	Network Northamptonshire: total transport smart city procurement theoretical framework for sustainable economic and social change	International Journal of Advanced Logistics	Smart city transport procurement framework	Productivity, liveability, accessibility
14	Joshi et al.	2016	Developing smart cities: an integrated framework	Procedia Computer Science	Smart cities framework	Sustainability, liveability, governance, productivity
15	Puiu et al.	2016	Citypulse: large scale data analytics framework for smart cities	IEEE Access	Smart city technology framework	N/A
16	Villanueva et al.	2016	Data stream visualization framework for smart cities	Soft Computing	N/A	N/A
17	Zhang, Chen, Chen, & Chen	2016	Semantic framework of internet of things for smart cities: case studies	Sensors	N/A	N/A
18	Aamir et al.	2014	Framework for analysis of power system operation in smart cities	Wireless Personal Communications	Smart city management framework	Productivity, governance, sustainability
19	Cano, Hernandez, & Ros	2014	Distributed framework for electronic democracy in smart cities	Computer	Smart city public participation framework	Governance
20	Errichiello & Marasco	2014	Open service innovation in smart cities: a framework for exploring innovation networks in the development of new city services	Advanced Engineering Forum	Smart cities framework	Governance
21	Jin, Gubbi, Marusic, & Palaniswami	2014	An information framework for creating a smart city through internet of things	IEEE Internet of Things Journal	Smart city technology framework	N/A
22	Khan, Kiani, & Soomro	2014	A framework for cloud-based context-aware information services for citizens in smart cities	Journal of Cloud Computing	Smart city citizen services framework	Governance
23	Lee et al.	2014	Towards an effective framework for building smart cities: lessons from Seoul and San Francisco.	Technological Forecasting & Social Change	Smart city analysis framework	Sustainability, wellbeing, liveability, productivity
24	Sanchez, Elicegui, Cuesta, Muñoz, & Lanza	2013	Integration of utilities infrastructures in a future internet enabled smart city framework	Sensors	Smart city platform framework	Governance
25	Vlacheas et al.	2013	Enabling smart cities through a cognitive management framework for the internet of things	IEEE Communications Magazine	Smart city technology framework	Governance
26	Walravens	2012	Mobile business and the smart city: developing a business model framework to include public design parameters for mobile city services	Journal of Theoretical and Applied Electronic Commerce Research	Smart city business model framework	Governance

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Table 3
Literature on smart cities with a community focus.

No	Author	Year	Title	Journal	Framework	Outcome
1	Beretta	2018	The social effects of eco-innovations in Italian smart cities	Cities	N/A	Sustainability, wellbeing
2	Cowley, Joss, & Dayot	2018	The smart city and its publics: insights from across six UK cities	Urban Research & Practice	N/A	Liveability, wellbeing
3	Damiani, Kowalczyk, & Parr	2017	Extending the outreach: from smart cities to connected communities	ACM Transactions on Internet Technology	N/A	Liveability, wellbeing
4	Deakin & Reid	2017	The embedded intelligence of smart cities: urban life, citizenship, and community	International Journal of Public Administration in the Digital Age	N/A	Liveability
5	Kaika	2017	'Don't call me resilient again!': the new urban agenda as immunology … or … what happens when communities refuse to be vaccinated with 'smart cities' and indicators	Environment and Urbanization	N/A	Sustainability, liveability, accessibility
6	Joss, Cook, & Dayot	2017	Smart cities: towards a new citizenship regime? A discourse analysis of the British smart city standard	Journal of Urban Technology	Smart city standards	Sustainability, liveability, wellbeing
7	Marsal-Llacuna	2017	Building universal socio-cultural indicators for standardizing the safeguarding of citizens' rights in smart cities	Social Indicators Research	N/A	Liveability
8	Smith	2017	Smart cities and communities	Institute of Transportation Engineers Journal	N/A	Liveability
9	Garau, Zamperlin, & Balletto	2016	Reconsidering the Geddesian concepts of community and space through the paradigm of smart cities	Sustainability	N/A	Sustainability, wellbeing, liveability
10	Granier & Kudo	2016	How are citizens involved in smart cities? Analysing citizen participation in Japanese "smart communities"	Information Polity,	N/A	Liveability, accessibility, governance
11	Ianuale, Schiavon, & Capobianco	2016	Smart cities, big data, and communities: reasoning from the viewpoint of attractors	IEEE Access	Smart cities taxonomy	N/A
12	Lara et al.	2016	Smartness that matters: towards a comprehensive and human-centred characterisation of smart cities	Journal of Open Innovation: Technology, Market, and Complexity	Smart city domains	Liveability, wellbeing
13	Snow, Håkonsson, & Obel	2016	A smart city is a collaborative community: lessons from smart Aarhus	California Management Review	N/A	Sustainability, liveability, productivity
14	Chichernea	2015	Smart cities communities and smart ICT platform	Journal of Information Systems & Operations Management	Smart city model	Productivity, liveability, sustainability

Table 4
Literature on smart cities with a technology focus.

No	Author	Year	Title	Journal	Framework	Outcome
1	Abella, Ortiz-de-Urbina-Criado, & De-Pablos-Heredero	2017	A model for the analysis of data-driven innovation and value generation in smart cities' ecosystems	Cities	N/A	Productivity
2	Branchi, Fernandez-Valdivielso, & Matias	2017	An analysis matrix for the assessment of smart city technologies: main results of its application	Systems	N/A	N/A
3	He, Cui, Zhou, & Wang	2017	Distributed proxy cache technology based on autonomic computing in smart cities	Future Generation Computer Systems	N/A	N/A
4	He, Weng, Mao, & Yuan	2017	Anonymous identity-based broadcast encryption technology for smart city information system	Personal and Ubiquitous Computing	N/A	N/A
5	Hui, Sherratt, & Sánchez	2017	Major requirements for building smart homes in smart cities based on internet of things technologies	Future Generation Computer Systems	Smart city technology architecture	Liveability
6	Hung & Peng	2017	Green-energy, water-autonomous greenhouse system: an alternative-technology approach towards sustainable smart-green vertical greening in smart cities	International Review for Spatial Planning and Sustainable Development,	N/A	Sustainability
7	Marek, Campbell, & Bui	2017	Shaking for innovation: the (re) building of a (smart) city in a post disaster environment	Cities	N/A	Sustainability, liveability
8	McFarlane & Söderström	2017	On alternative smart cities: from a technology-intensive to a knowledge-intensive smart urbanism	City	N/A	Wellbeing
9	Petrolo, Loscri, & Mitton	2017	Towards a smart city based on cloud of things, a survey on the smart city vision and paradigms	Transactions on Emerging Telecommunications Technologies	N/A	Sustainability, wellbeing, liveability
10	Tucker et al.	2017	Connected OFcity: technology innovations for a smart city project	Journal of Optical Communications and Networking	N/A	Sustainability, liveability, accessibility
11	Yaqoob et al.	2017	Enabling communication technologies for smart cities	IEEE Communications Magazine	Technology taxonomy smart cities	N/A
12	Pollio	2016	Technologies of austerity urbanism: the smart city agenda in Italy (2011–2013)	Urban Geography	N/A	Productivity
13	Sun et al.	2016	Blockchain-based sharing services: what blockchain technology can contribute to smart cities	Financial innovation	Smart city conceptual framework	Productivity
14	D'Aquin, Davies, & Motta	2015	Smart cities' data: challenges and opportunities for semantic technologies	IEEE Internet Computing	N/A	N/A
15	Khorov, Lyakhov, Krotov, & Guschin	2015	A survey on IEEE 802.11ah: An enabling networking technology for smart cities	Computer Communications	N/A	N/A
16	Lynggaard & Skouby	2015	Deploying 5G-technologies in smart city and smart home wireless sensor networks with interferences	Wireless Personal Communications	N/A	Liveability
17	Popescu	2015	The economic value of smart city technology	Economics, Management, and Financial Markets	N/A	Productivity
18	Stratigea, Papadopoulou, & Panagiotopoulou	2015	Tools and technologies for planning the development of smart cities	Journal of Urban Technology	Smart city methodological framework	Governance
19	Orlowski	2014	Rule-based model for selecting integration technologies for smart cities systems	Cybernetics and Systems	N/A	N/A
20	Paroutis, Bennett, & Heracleous	2014	A strategic view on smart city technology: the case of IBM smarter cities during a recession	Technological Forecasting & Social Change	Smart city strategic view	Productivity
21	Viitanen & Kingston	2014	Smart cities and green growth: outsourcing democratic and environmental resilience to the global technology sector	Environment and Planning A	N/A	Sustainability, wellbeing
22	Wang, Ruan, & Li	2014	Effects of information technology on rural economic development from the perspective of smart city	Applied Mechanics and Materials	N/A	Productivity
23	Wenge, Zhang, Dave, Chao, & Hao	2014	Smart city architecture: a technology guide for implementation and design challenges	China Communications	Smart city technology architecture	Liveability
24	Lee, Phaal, & Lee	2013	An integrated service-device-technology roadmap for smart city development	Technological Forecasting & Social Change	Smart city technology roadmap	Sustainability, liveability
25	Sidawi & Deakin	2013	Diabetes, built environments and (un) healthy lifestyles: the potential of smart city technologies	Sustainable Built Environment	N/A	Wellbeing

Table 5
Literature on smart cities with a policy focus.

No	Author	Year	Title	Journal	Framework	Outcome
1	Kourtit, Nijkamp, & Steenbruggen	2017	The significance of digital data systems for smart city policy	Socio-Economic Planning Sciences	N/A	Sustainability, liveability
2	Pinna, Masala, & Garau	2017	Urban policies and mobility trends in Italian smart cities	Sustainability	N/A	Accessibility
3	Trindade et al.	2017	Sustainable development of smart cities: a systematic review of the literature.	Journal of Open Innovation: Technology, Market, and Complexity	N/A	Sustainability
4	Caragliu & Del Bo	2016	Do smart cities invest in smarter policies? Learning from the past, planning for the future	Social Science Computer Review	N/A	Sustainability, liveability
5	Castelnovo et al.	2016	Smart cities governance: the need for a holistic approach to assessing urban participatory policy making	Social Science Computer Review	Smart city governance framework	Governance
6	Glasmeier & Nebiolo	2016	Thinking about smart cities: the travels of a policy idea that promises a great deal, but so far has delivered modest results	Sustainability	N/A	Sustainability, liveability, wellbeing
7	Marsal-Llacuna & Segal	2016	The intelligenter method (I) for making "smarter" city projects and plans	Cities	Smart city subsystem collaboration framework	Governance
8	Crivello	2015	Urban policy mobilities: the case of Turin as a smart city	European Planning Studies	N/A	Accessibility, liveability, wellbeing
9	Syväjärvi, Kivivirta, Stenvall, & Laitinen	2015	Digitalization and information management in smart city government: requirements for organizational and managerial project policy	International Journal of Innovation in the Digital Economy	N/A	Governance
10	Wiig	2015	IBM's smart city as techno-utopian policy mobility	City	N/A	Sustainability, liveability, productivity, governance
11	Yigitcanlar	2015	Smart cities: an effective urban development and management model?	Australian Planner	N/A	Sustainability, liveability, productivity, governance
12	Angelidou	2014	Smart city policies: a spatial approach	Cities	N/A	Sustainability, liveability
13	Sivarajah, Lee, Irani, & Weerakkody	2014	Fostering smart cities through ICT driven policy-making: expected outcomes and impacts of DAREED project	International Journal of Electronic Government Research	N/A	Governance

importance of local communities for the formation of smart cities, and some suggested ways to achieve this. For example, Beretta (2018) discusses the social implications of eco-innovations in the context of smart cities. Among the reviewed papers, four of them developed or adopted various frameworks, including smart city frameworks with specific interest on standards, taxonomies, domains, and models. The only paper that had a generic smart city model, or framework, was Chichernea's (2015) study. However, the model was based on the EU's smart city wheel. The desired smart city outcomes in these literature pieces varied, but almost all of them included 'liveability' and 'wellbeing'. A summary of the literature on smart cities with a community focus is presented in Table 3.

4.4. Smart city and technology

From the reviewed 78 articles, 25 of them had a technology focus. This area of smart city research seems to be the one that generated the biggest portion of academic writings. From these 25 papers seven of them used or proposed a framework. These frameworks mostly focused on smart city technology architecture, technology taxonomy, or technology roadmap. However, there was a framework that covered the broader or generic smart city conceptualisation aspect. Sun, Yan, and Zhang (2016) propose a framework that views smart city being based on technology, human, and organisation, and service relationships among them. While the framework provided a big picture view by bringing technology, human (or community), and organisation (or policy) aspects of smart cities together, it remains too coarse, and too sharing economy perspective focused.

Desired smart city outcomes in the reviewed literature on smart city technology are diverse, without a concentration on specific outcome item. This is an indication of a large number of smart city technologies and their numerous application areas. A summary of the literature on smart cities with a technology focus is presented in Table 4.

4.5. Smart city and policy

Despite some of the eminent smart city scholars indicating the critical importance of policies in transforming cities into smart ones (e.g., Caragliu & Del Bo, 2012), from the reviewed 78 smart city articles, only 13 of them had a policy focus. This is a surprising finding as one would hope that in such a popular area there would be plenty of research to inform national, regional and local policy and decision-making processes. This indicates the existence of a major gap in the policy domain of smart cities research—and possibly has undesired implications on the practice. Reviewed papers looked at different policy aspects of smart cities ranging from accessibility and mobility issues to digital infrastructure planning, from developing public participatory mechanisms to urban governance, and from development planning to urban sustainability policies. Desired smart city outcomes in the smart city policy related literature vary, with 'sustainability' and 'liveability' being the most common outcome items. A summary of the literature on smart cities with a policy focus is presented in Table 5.

Among these papers only two of them presented a smart city framework. The paper, by Castelnovo, Misuraca, and Savoldelli (2016), proposes a smart city governance assessment framework. The framework comprises five key evaluation dimensions: (a) Community building and management; (b) Vision and strategy formulation; (c) Public value generation; (d) Asset management; (e) Economic and financial sustainability. The framework measures how city governance performs in pursuing sustainable and participatory public value generation, while the intersections of the five dimensions define four perspectives from which to assess smart city governance. The other study, by Marsal-Llacuna and Segal (2016), proposes a smart city subsystem collaboration framework to coordinate complex smart city governance tasks. While both of these frameworks are found useful in improving the governance dimension of smart cities, they are not equipped to form an

overarching framework.

5. Towards a multidimensional framework

Many cities across the globe became highly keen on smart city recognition and jumped on the bandwagon to apply this concept. Planners, practitioners, politicians, and urban administrators eagerly used smart cities as a jargon in their day-to-day tasks. Many cities are claimed as smart cities—or at least they declared themselves as smart (Anthopoulos, 2017). The analysis reported in this paper revealed that even though the movement of smart cities is a hot topic in urban development circles, it is a largely uncharted territory of research and practice, particularly from the conceptual viewpoint.

Stated by Harrison & Donnelly (2011, p. 6), "the current ad hoc approaches of smart cities to the improvement of cities are reminiscent of pre-scientific medicine. They may do good, but we have little detailed understanding of why. Smart cities are a field in want of a good theoretical base". Surely as the smart city practice become more common, the concept will eventually mature. This was the case for other concepts, for instance sustainable cities (Jabareen, 2008). However, the delay in the conceptualisation will highly likely to result in inefficient policies, poor investment decisions, and not being able to properly address the urbanisation challenges in a timely and adequate manner.

Besides, the current hype around smart cities tends to be mostly technocratic, beyond speculation, there is no strong evidence to suggest that a smart city can provide genuine answers to a number of complex problems cities face today. As underlined by Mora et al. (2017, p. 20), "the knowledge necessary to understand the process of building effective smart cities in the real-world has not yet been produced, nor the tools for supporting the actors involved in this activity". Desired outcomes from the smart city initiatives have to be identified and articulated at the initial stage of the planning process. However, the planning process is not clearly stated in the smart city initiatives (Yigitcanlar, 2016)—for a good reason, there is no widely accepted sound smart cities framework. The messiness of outcomes is due, in part, to a lack of clarity of what are we trying to measure and plan for in the first instance.

Ensuring liveable conditions within the context of such rapid urban population growth worldwide, while considering a sustainable and balanced development, requires a deeper understanding of the smart city phenomenon. The body of work reviewed in this paper provides evidence that so far the attention is given to the smart city drivers (e.g., technology, community, policy) in the literature. However, coordinated actions to identify and achieve desired outcomes such as economy (e.g., productivity), society (e.g., liveability, wellbeing), environment (e.g., sustainability, accessibility), and governance (e.g., transparent and participatory policymaking and governance) are more or less neglected.

After analysing the existing smart city frameworks in the academic literature, the findings suggest that smart cities and their development have not been adequately conceptualised yet—even though there are some highly promising recent attempts such as Fernandez-Anez et al. (2017). Existing frameworks have some limitations in advancing our understanding on the smart city phenomenon—either inadequate or not widely promoted, accepted or adopted. There is, hence, room for development of new smart city frameworks. At the conceptual level, in order to develop a thorough understanding, theoretically and practically, of designing smart cities for sustainable and balanced growth, this study proposes a smart city development framework, as a system of systems (see McLoughlin, 1969)—by intertwining smart city drivers with desired outcomes. The proposed framework—that builds on the reviewed key smart city characteristics—is illustrated in Fig. 1 and elaborated as follows.

First of all, the framework conceptualises a smart city as a balanced and sustainable development. The framework adopts an input–process–output (IPO) model logic with a 'systems view' (Chadwick, 2013; Fincher, 1972). In this IPO model, the 'city' itself—as the 'asset'—is the 'input'; the three 'drivers' (community, technology, policy) form the 'process'; and the 'desired outcomes' (productivity, sustainability, accessibility, wellbeing, liveability, governance) constitute the 'output'. Given the IPO model works effectively and efficiently, 'output' eventually transforms the city ('input') into a smart city. In a diagrammatic representation, the framework places the four fundamental development domains at the most outer-ring of the framework diagram—i.e., 'economy', 'society', 'environment', 'governance'—suggesting a quadruple bottom line approach (Teriman, Yigitcanlar, & Mayere, 2009). Then, desired outcomes (output) from a smart city project are placed at the outer middle-ring of the framework—i.e., 'productivity', 'sustainability', 'accessibility', 'wellbeing', 'liveability', 'governance'. Lastly, the inner middle-ring is allocated to the key smart city drivers (process)—i.e., 'community', 'technology', 'policy'. In the inner-ring '(smart) city' is located as the key asset (input) (Fig. 1).

The internal logic of the framework is that there is a chain of causal links starting with the drivers through desired outcomes to sustainable urban development—initially originated from the assets-base of the city. The description of the causal links from drivers to sustainable urban development is a complex task which is broken down into individual elements (e.g., desired outcomes and overall sustainability outcomes). A driving force is denoted here as an opportunity (new technological development, policy changes) for smart city and how this can be translated to achieve desired outcomes (e.g., new technology can be used to deliver good governance—remove the barriers of distance to participate in economic and social activities) for the benefit of the environment (e.g., reduced travel decreases GHG emissions).

Distinctive than many other smart city approaches, the framework emphasises smart 'communities' as the essential ingredient of smart cities and determines it as the most critical driver of smart city development. This approach involves providing access to appropriate technologies, services and platforms, and modifying the perceptions and behaviours of local communities via various awareness campaigns and engagement projects (Hughes & Spray, 2002). Additionally, it advocates the customisation and development of local and culturally sensitive solutions by the local residents and companies not only to provide locally tailored/accepted solutions, but also make contributions to the local knowledge-based economic development, sustainable urban development, and participatory governance practices.

In terms of 'technology', this framework, in parallel to Kanter and Litow (2009), considers a smart city as an organic whole–a network and a linked system. While systems in industrial cities were mostly skeleton and skin, post-industrial cities—i.e., smart cities—are like organisms that develop an artificial nerve system, which enables them to behave in intelligently coordinated ways. The new intelligence of cities, then, resides in the increasingly effective combination of digital telecommunication networks (the nerves), ubiquitously embedded intelligence (the brains), sensors and tags (the sensory organs), and software (the knowledge and cognitive competence). However, in this perspective technology is only seen as a 'mean'—not an 'end'—to achieve desired outcomes.

The proposed framework highlights the 'policy' context as vital to the understanding of the use of technology in appropriate ways (Aurigi, 2006). Hence, an innovative local government stresses the change in policies because a government cannot innovate without a normative drive addressed in policy. Whereas innovation in technology for a smart city can be relatively easily observed and broadly agreed upon, subsequent changes in the policy context are more ambiguous. The policy context characterises institutional and non-technical urban issues and creates conditions enabling smart and sustainable urban development.

Besides abovementioned drivers—i.e., 'community', 'technology', 'policy'—, the comprehensive conceptual view of the framework focuses on finding ways to achieve desired outcomes in the development domains—i.e., 'economy', 'society', 'environment', 'governance'. Smart

city desired outcomes—i.e., 'productivity', 'sustainability', 'accessibility', 'wellbeing', 'liveability', 'governance'—play a critical role in determining the performance of smart cities. An analysis of the 20 popular definitions and their reference documents—based on Lara et al. (2016) and Mora et al.'s (2017) studies—also confirm these desired outcomes (Table 1). There is also a vast literature on each of these outcomes, thus, rather than elaborating them here, we highlight the crucial importance of integration of these desired smart city outcomes with the mentioned smart city drivers—which the framework emphasises this integration or in other words intertwining.

The proposed multidimensional framework—first of its kind in bringing the key smart city drivers and outcomes under the same roof—may not be an ultimate solution to the conceptualisation issue, even though it contributes to the theorisation and better practice of smart cities along with guiding the development of sustainable smart cities. However, in the absence or limited supply of sound smart city frameworks, the proposed framework is a step towards making scholars, urban administrators and smart city practitioners think about linking smart city drivers and outcomes in an effective way under a development approach that advocates balanced and sustainable development.

6. Conclusion

Smart cities are a global phenomenon today, as there are well over 250 smart city projects underway across 178 cities around the world—for example, India alone hosts 100 of those projects (Praharaj et al., 2018). Despite high-level popularity of smart cities concept and practice, there is no consensus on what a smart city is, what are the key smart city drivers and desired outcomes are, and how the smart city paradigm can be conceptualised. Furthermore, scholars seem to have not reached to a conclusion on whether smart city is an urban model or a corporate business plan (Rosati & Conti, 2016; Yigitcanlar & Lee, 2014).

This paper placed smart city literature under the microscope of a systematic review and conceptual analysis to address the smart city development issue. The literature review findings revealed that apart from limited good definitions (e.g., Caragliu et al., 2011) smart cities have not been adequately conceptualised, and most of the existing conceptual frameworks have limitations to advance our understanding on the smart city phenomenon or has potential but not been widely adopted yet (e.g., Fernandez-Anez et al., 2017). The analysis finds that smart city policies are not extensively covered in the literature, it comes as no surprise. This is mainly due to infancy of the field—naturally it takes time to accumulate evidence on smart city programs. In this instance, the role of scholars, however, is to generate guiding principles and frameworks to inform public and/or private decision-making circles for competent smart city policy and practice to take place. For that very reason, this study develops a new multidimensional smart cities framework.

The analysis findings revealed a number of generic (sub)themes clustered under smart city drivers and desired outcomes. Intertwining these (sub)themes helped us to assemble a new multidimensional smart city framework. This research contributes to both theory and practice of smart cities. It contributes to the theory by intertwining smart city drivers and desired outcomes in a novel way under a new framework. This will encourage/attract smart city researchers to undertake investigations on the planning and development processes (input-process-output mechanisms) of the claimed smart cities, and evaluate their performances, and come up with consolidated versions of the framework put forward in this paper. It contributes to the practice of smart cities by providing guiding principles—such as balanced and sustainable development, technology as a mean not an end, desired outcomes to be clearly identified and articulated at the initial stage of the smart city planning process—for urban administrators and smart city practitioners. The approach presented also highlights the importance of focusing on the assets-drivers-outcomes trio to better plan the smart city development and then monitor/evaluate the progress.

Nevertheless, in interpreting the specific findings of the research, the reader must be aware of the following limitations: (a) Exclusion of literature outside the peer-reviewed full-text articles available online, might limit the spectrum of the review as a relatively new field smart city research has been mostly published in conference proceedings, book chapters, and white papers; (b) Selection of the search keywords might omit inclusion of some relevant literature; (c) The authors' unconscious bias might have an impact on the execution of the review, and interpretation of the findings; (d) Although the smart city asset issue is raised in the paper, this matter has not been systematically investigated—in order to not to extend the length of the paper any further; (e) The methodological approach is limited to a manually handled literature review technique; further analytical techniques could have been considered—such as scientometrics, content analysis, cognitive mapping, concept clustering—to generate a clearer picture of the investigated topic. These limitations will be addressed in our prospective studies.

Despite these limitations, the proposed framework is an invaluable effort in forming a better conceptual and practical understanding on smart cities and their complex natures. In other words, the framework brings together the aspects of smart city into a practical framework that can be used by local governments and other actors to better understand and tackle the complex nature of smart cities. This way the proposed framework can be of assistance in creating a step-change in the practice by intertwining smart city drivers with desired outcomes to develop truly smart cities and communities. The development of an outcome-oriented framework also helps in framing how smart cities can address their socio-spatial inequalities.

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