The Planning of Smart City Initiatives

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Abstract

The idea of a ‘Smart City’ is increasingly widespread both as a concept and also as a practical reality. The choice of a city to become ‘Smart’ is inherently strategic yet our understanding of why and how cities make that decision is limited. This research addresses this issue by synthesising existing academic debates and evidence from the implementation of smart city initiatives around a coherent framework. The framework makes four contributions. Firstly, it addresses the successful strategic planning of smart city initiatives. Secondly, it emphasises the role of factors such as the urban context, smart city and urban vision, big data technologies, and data governance strategies. Thirdly, it provides a means for comparing cities that have already taken steps toward planning smart city initiatives and puts forward guidelines for those that are at the planning stage of the process. Fourthly, it guides future empirical research investigating the determinants and the outcomes of smart city initiatives.

Keywords: Smart Cities, Smart City Governance, Big Data, Data Governance

1.0 Introduction

> *"cities accumulate and retain wealth, control and power because of what flows through them, rather than what they statically contain"*
>
> *(Beaverstock, Smith, & Taylor, 2000, p. 126)*

Interest has been growing in understanding how governments, both at the local and national level, can tackle complex urban challenges by utilising increasingly available urban data. It is commonly held that cites that best manage data are those that learn best, solve the most problems and provide the most social good for the people. As such, a new impetus is given to understanding how to institutionalise new mechanisms for the assembly, management and processing of data so as to maximise the social goods associated with it.

Today, the urban application of big data has mostly flourished in the form of Smart City Initiatives (SCI) and associated solutions. Based on a recent report from the market research firm OrbisResearch.com, the global market for smart city solutions will continue to grow with a compound annual rate of more than 24% and will be worth $ 1.94 trillion by the end of 2023. The growing interest in the notion of smart city and the rapid expansion of its market raises important questions about how urban leadership should strategically plan their SCI. Although much effort has been devoted to the understanding of smart cities from different perspectives, there has been little work that considers smart cities from a managerial and governance perspective, and from this to provide policy guidelines on the design and planning of such initiatives.

In this paper, we relate the questions around the strategic planning of SCI to more fundamental and broader issues of how urban data is governed and institutionalised. Unlike research that presents a functional or infrastructural representation of smart cities (e.g. smart transport, smart energy etc.) or studies that sketch an outcome-oriented manifestation of smart cities (e.g. sustainability, economic growth etc.), our account of smart cities relates to the various institutional arrangements emerging around the governance of the data that flows within the fabric of urban life and infrastructure. These institutional arrangements come in the form of smart city plans and designs that normally "articulate distinct materialities and spatialities as well as formations of power and governance" (Gabrys, 2014). The strategic planning of smart cities therefore demands an understanding of SCI not just as urban innovations but as a broader matter of urban governance and its relationship to data (Kitchin, 2014).

In our view, the concept of a Smart City promotes a new form of arrangement in the management of urban affairs. Central to the existence of a Smart City is its data. The concept of a smart city elevates and emphasises the role of data so that it is key to the decision structures, power relations, economic incentives, stakeholder participation and operational behaviour of the city. Any form of governance of the city itself is eventually a question of how the data is governed. This further implies that the governance of data takes on a new character as meta to the governance arrangements of various organizations within the city, and it becomes an interface between those organizations, citizens and the institution of the city itself. In this light, we study the role of governance of data and the different possible strategies governments utilise to plan data and hence govern the Smart City.

We therefore understand a smart city as a formal representation of the ways in which a city institutionalises urban data to deliver societal services and outcomes. We interpret the long-standing dispute in the literature over what constitutes a smart city (Glasmeier & Christopherson, 2015; Hollands, 2008; Nam & Pardo, 2011) as evidence that urban data can be institutionalised in various ways with each scholar studying one dimension at a time. In this research, we synthesise these fragmented views of the institutionalisation of urban data and provide a more coherent framework for understanding the strategic planning of SCI that situates each initiative in its wider context. This framework, named the House Model, draws upon a government sponsored research project into questions of governance and data in Smart Cities (Name withheld). The merit of such a framework is threefold. First, it provides a lens through which cities can be compared through their digitization efforts. Secondly, it sketches a roadmap particularly useful to those policy makers who are in the process of designing and planning a smart city initiative. Thirdly, it provides a foundation for future empirical research into the determinants and the outcomes of SCI.

The paper is organised as follows. Section 2 elaborates on the definition of Smart City. Section 3 reviews the already existing frameworks for the planning of SCI. In section 4, we propose a new framework which helps in understanding and planning SCI. Section 5 concludes and provide recommendations for future research.

2.0 Smart City in definition and practice

The notion of 'Smart City' is increasingly widespread both as a concept and also as a practical reality. A definition is not simple to provide. "Smart City" is most commonly defined in terms of its building blocks (e.g. technology, stakeholders, infrastructure), the outcomes that it is supposed to achieve (e.g. sustainability, economic growth, innovation, efficient delivery of public services) or a combination of both.

The complexity is reflected in a definition provided by Kitchin (2014) where emphasis is placed on technology, via computing, and entrepreneurship and creativity “enacted by smart people”. Further elaboration is given by Ruhlandt (2018) whose definition is itself derived from a number of sources:

> “smart cities are a multi-dimensional mix of human (e.g., skilled labor), infrastructural (e.g., high-tech facilities), social (e.g., open network linkages) and entrepreneurial capital (e.g., creative business activities), that are merged, coordinated and integrated into the fabrics of the city using new technologies to address social, economic and environmental problems involving multi-actor, multi-sector and multi-level perspectives.”

This multidimensionality is not limited to the definition but continues in the way these initiatives unfold in practice. Masdar City (initiated 2006) in the United Arab Emirates and Songdo International Business District (initiated 2001) in South Korea are the best-known examples of newly-built Smart Cities. Both have attracted attention, acclaim and criticism (see, for example, Shin (2016) or (Cugurullo, 2016)). Their reality continues to fall short of the vision of their founders, and neither is taking decisions close to their originally intended target populations. As wholly-new and centrally planned entities, arguably Masdar and Songdo inherit from an earlier era of utopian city development characterised most obviously by the work of Le Corbusier (see Fishman (2016)). The further development of this ideal has been taken up by the government of

Saudi Arabia with ambitious plans to develop “New Future”, or NEOM, as a new, sustainable urban settlement enabled by digital technology. NEOM is reported to be the subject of $500bn investment by its government and will eventually occupy an area of 26,500 sq. km[1], approximately thirty-two times the size of the City of New York. Yet, to be meaningful in a wider context, the Smart City concept requires to be more adaptable and multi-faceted than such large-scale newly built ‘utopias.’

The patchwork incrementalism and complex governance of today’s major global cities provides an alternative theatre for the Smart City concept. Barcelona, Berlin, London, Los Angeles, New York, Shenzhen and Singapore are among many famous cities associated with Smart City initiatives, bringing automation, algorithmic intelligence or data-sharing into use as part of the fabric of urban life. In India, in 2015 the government launched its “100 Smart Cities” mission based on an agenda of urban renewal and sustainability. Prominently, in Canada, Sidewalk Labs, part of the Alphabet conglomerate, is working in partnership with the city of Toronto to develop its derelict East Waterfront into a technologically-enabled community. The official website for the project emphasizes high quality urban design alongside technological development, and bottom-up innovation as well as top-down planning.

Prominent commercial firms that seek to develop and market the Smart City concept include Cisco, Deloitte, McKinsey and IBM. The latter took out a trademark on the phrase ‘smarter city’ in 2011, this providing the genesis of a critique of the motives and meanings of Smart Cities by Söderström, Paasche, & Klauser (2014). Of an alternative scale and character again are initiatives such as urban open data movements (Rabari & Storper, 2015), European Living Labs

1 https://medium.com/syncedreview/ai-as-the-new-oil-saudi-arabias-500-billion-smart-city-f7b63f7c9423

(Dutilleul, Birrer, & Mensink, 2010), and Sharing Cities projects[2]. Large, first-tier cities share in such innovations alongside smaller cities like Burgas, Milton Keynes and San Sebastian.

A further element is added to the Smart City concept through infrastructural technology associated with digitization, such as delivery drones, autonomous vehicles, satellite navigation, smart roads and road surfaces, taxi platforms, the physical cloud, and bicycle-sharing. Each of these, though not institutional Smart City concepts themselves, implies some sort of advanced data use, differing implications for different urban stakeholders, implications for urban geography, and from all of this, an assembly of associated governance issues. The existence of such systems implies the involvement of technological corporations in a smart urbanism, even before any deal to institutionalise city/corporate ties through a formal Smart City agreement.

To date, the notion of a "Smart City" has been appropriated as a narrative device in a number of contexts, but a framework to understand this theoretically in a wider context has yet to be developed.

3.0 Planning the Smart City Initiative: Existing Frameworks

Smart cities are typically investigated from a technological perspective but rarely explored as innovation in management and policy. Where a broader framework is proposed, typically it is limited to concern with the SCI as a project to be delivered, rather than as a fundamental shift in

2 http://www.sharingcities.eu/

the governance of the city itself (e.g. Anttiroiko, 2015; Lee, Hancock, & Hu, 2014; Meijer & Bolívar, 2016; Ojo, Curry, Janowski, & Dzhusupova, 2015; Ruhlandt, 2018). The 'Smart City Initiative Design' of Ojo et al. (2015), is a sophisticated example of this. It assists the identification of different Smart City projects, their relation to policy domains, management of expected outcomes, the recording and gathering of knowledge over challenges, and the identification of critical success factors. The intention is to make Smart City projects more successful and better integrated with the ultimate governance of the city.

Writing much earlier, Graham & Marvin (1999) made the distinction between a technological determinism, on the one hand, and a more profound, yet localised redesignation of the potential of the city. The technological determinism tends towards a decontextualised homogeneity as "new information and communications technologies are usually seen to be some disembodied, external 'wave' of change" and that "such scenarios also usually imply that all cities (for example in Europe, London, Leeds, Charleroi, and Athens) will somehow all be 'impacted' in the same ways." The more profound and contextualised vision acknowledges that the nature of the city as an information processing entity is changing, and with this brings forward local implications that are connected to the temporal life of the city (e.g. its transport and behaviour patterns), its environmental values, its culture and identity or its politics. Conceptually in all of these scenarios, 'data' has a pivotal role, described by Shelton, Zook, & Wiig (2015) as occupying a "central place in urban governance, acting as a kind of master signifier or obligatory passage point through which all other functions must position themselves."

Clearly, the Smart City elevates the role of data which has multitudinous effects, leading to changed governance arrangements for the city itself beyond any designation of the Smart City as a project. Substantial and successful SCI will change relations between institutions and other stakeholders, primarily by elevating the value of data so that it is intrinsic to the management of institutions, vital to the interface between different institutions and between institutions and citizens.

4.0 The Planning of Smart City Initiatives: A Conceptual Framework

This section presents the House Model, a conceptual framework which helps us understand the planning of SCI. The framework emphasises the role of factors such as the urban context, smart city and urban vision, big data technologies, and data governance strategies on the successful strategic planning of smart city initiatives. The framework provides a means for comparing cities that have already taken steps toward planning SCI and puts forward guidelines for those that are at the planning stage of the process. The framework also guides the future empirical research that investigates the determinants and the outcomes of SCI.

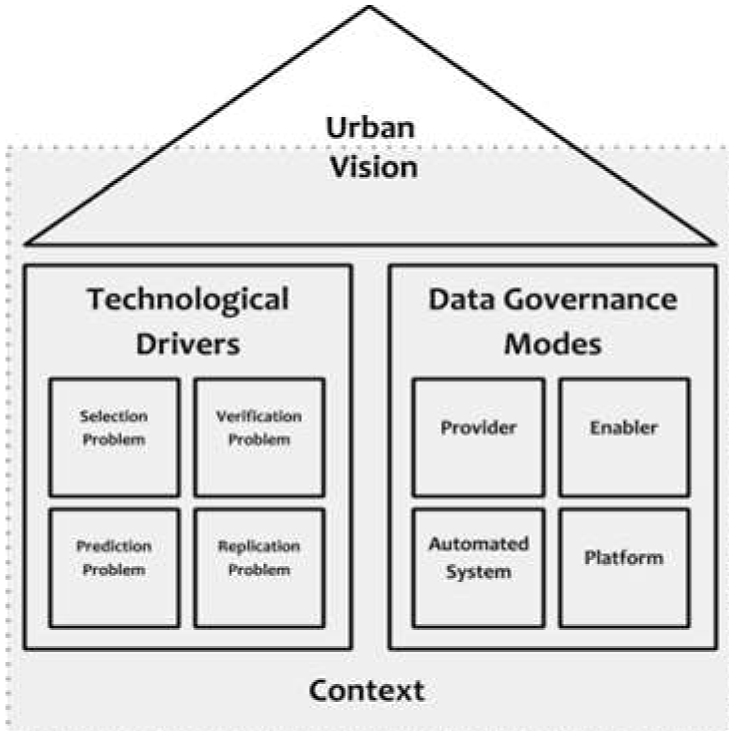

Figure 1: House Model - A Conceptual Framework for Understanding the Planning of Smart City Initiatives

4.1 The Importance of Context

Smart cities are commonly studied in terms of the technological advancements that facilitate the integration of data about physical infrastructures of cities. The focus on the technology in itself diverts attention away from the context where these technologies are implemented. Smart city initiatives are not developed in a vacuum. A vast array of geographical, cultural, political, historical and economical factors can affect the development and outcome of these initiatives. How these initiatives unfold in practice ultimately depends on the context (Datta, 2015; Kitchin, 2014; Neirotti, De Marco, Cagliano, Mangano, & Scorrano, 2014).

To date, the literature on Smart City governance has failed to adequately address the role that contextual factors play as well as the way that the concept is measured (Ruhlandt, 2018). A requirement for an understanding of the context around each SCI is also of concern for Nam & Pardo (2011), where they argue that the unique context of a city shapes the technological, organizational and policy aspects of that city. A study of Smart City initiatives across the European Union identified a need for geographically differentiated policy actions (Caragliu & Del Bo, 2012); a theme that recurs prominently in the international study of Angelidou (2014). Through a unique empirical investigation, Neirotti et al. (2014) provides support for the view that the heterogeneity in the smartness strategy can be attributed to the local socio-economic and cultural background. The question of context is then of growing concern in Smart City studies and raises questions about the span, nature and dynamism of Smart City governance. Is Rotterdam the same as Barcelona, or Barcelona the same as NEOM? Are the goals of a project that seeks to share information about meteorological and environmental phenomena best governed in the same way as a project that algorithmically controls vehicular access to downtown precincts? The general potential of the smart city concept requires that governance be contextualised. As such, a more selective approach to data collection and use is proposed here.

4.2 The Smart City Vision

For newly built smart cities there exists the promise of perfect alignment between what the smart city intends to achieve and the smart city vision. In practice, this alignment may not always occur as the city comes into use and other pressures are brought to bear on urban life in the city. In the alternative case of existing cities, a smart city initiative gains momentum only when it is placed in a broader milieu and its vision is aligned with the overall vision of the city. For example, the city of Copenhagen places its smart city ambition in a broader context of becoming a carbon-neutral city: “Copenhagen, Denmark, is aggressively moving towards becoming a smart, carbon-neutral city by 2025. To achieve this goal, the city is initiating smart city programs such as smart lighting, sensor-based traffic management, intelligent building management and more”. It is expected that cities that ably locate these initiatives at the heart of their vision will be more transformational and develop a stronger commitment.

In an attempt to study the spatial factors affecting the strategic planning of smart cities, Angelidou (2014) notes the tension between the national and regional on the one hand and more local strategies for developing a smart cities. This struggle is not specific to the smart city per se but has roots in how the vision of the city is framed. We therefore focus our attention towards providing an understanding of the dimensionality of urban vision and the city governance.

Problems can arise from conflicting expectations and objectives pursued by the administrations or the stakeholders at different levels (global to local). Some cities set ambitious targets in order to meet global socio-economic and environmental metrics and imagine a more global and competitive brand, while others value locality and set visions that address local problems and are more contextualized. The process of defining a shared urban vision is dynamic, full of contradictions and compromises but predominantly under the influence of the polarity of globalization forces and local demands. The importance of this tension is shown in the case of several cities in Sweden (Andersson, 2010; Gustavsson & Elander, 2012; Rutherford, 2014).

In reaction to Stockholm's 2030 vision to become a world-class city, the local Green Party stresses that the vision "conflicts with the creation of an environmentally sustainable city and with the achievement of the city's climate goals. The process should have been formulated in other ways than the vision of 'Stockholm as a world-class city'. We question the extent to which this captures people's vision of their Stockholm. It is our assessment that most Stockholmers simply want a good place to live, for themselves and their children. We therefore need to jointly define the Stockholm which we want to see in the future. Then we can discuss the means to achieve this" (City of Stockholm, 2010, p. 16). The importance of this kind of "multi-level" governance is also emphasised in a study of Rotterdam (van Waart, Mulder, & de Bont, 2016), The ambition of this kind of "multi-level" study is neatly summarised by the phrase "Grand visions in city hall need to go hand in hand with practices in local neighborhoods" (Meijer, Gil-Garcia, & Bolívar, 2016). The implications of this are that the ICT of the smart city are used hierarchically within the city, between institutions and then out into networks beyond the city boundaries " (Meijer, Gil-Garcia, & Bolívar, 2016).

Not surprisingly, one could expect that the vision of a smart city also follows the same kind of polarity of local vs global but one of a different nature. This is best observed by Neirotti et al. (2014) who provides evidence that there is no dominant worldwide smart city model, but there are at least two models: one focused on a technology vision and one that focuses on a vision of social inclusion and welfare. This is also noted by many scholars who provide a critique of the techno-centric, infrastructure-focused and neoliberal vision of the smart city and its ability to deliver promises such as social equity, sustainable growth or environmental protection and who calls for an alternative smart city vision (Gabrys, 2014; Glasmeier & Christopherson, 2015; Hollands, 2008, 2015; Kitchin, 2014; Shelton et al., 2015).

The infrastructure-focused vision of a smart city, in most cases, is the result of technological determinism promoted by IT vendors, something that is normally set in isolation to the institutional complexity of place. This kind of tension has a partial echo in Sarasa's (2017) account of an initiative in Zaragoza, one which might fall into danger of becoming a "futuristic illusion" of automation. Sarasa writes: "We cannot build cities without the IT industry, but it would not be wise to let the IT industry run cities."

Working out the boundaries and implications of alternative visions of a Smart City is problematic and, as mentioned earlier, is closely tied to the dimensionality of urban vision. The case of Barcelona shows this clearly. Documented by Hoop et al. (2018), Barcelona has negotiated a turn between a post-Olympic smart technology controlled by the democratic, institutional and corporate bodies of the city, and a more grassroots and participatory emphasis on direct urban democracy arising from communal action. The turn between these two emphases is marked by the replacement of Mayor Trias (2011-15) with Mayor Ada Colau. In Trias's term an acclaimed vision for a 'smart' Barcelona was developed. This was to be characterised by open data protocols, automated street systems, MIT-style fabrication laboratories (FabLabs) and a city Operating System "that would interconnect information from across the multiplying sensor networks and data gathering platforms in different city administration departments, and hence boost the ability of city authorities to observe and manage their intelligent city in real time." The intention was that the Smart City initiative would be inclusive, and the initiative was praised for its efforts in cultivating "the grassroots". Nonetheless, a clear implication of the project was that it would be associated with the tech-savvy; with those interested in a strategic vision of a globally significant, technological city. In a restive political environment, this was ultimately partial and inadequate. Trias's replacement, Mayor Ada Colau had been aligned to the mortgage reform group La Plataforma de Afectados por la Hipoteca (PAH), exemplifying an alternative political reality for Barcelona, one concerned with overcoming evictions and debt. Under Colau, a smart Barcelona would be manifest of alternate, cooperative "solidarity economy", that was also enabled in part by digital technology, but was concerned with the prosaic pressures of sharing food among the needy and of fighting evictions. As Hoop et al. (2018) summarise: "Activists saw two different cities: the elite Barcelona using smart city as a brand in its neo-liberal competition for capital – a city rendered into an efficient and convivial location for mass tourism and the global knowledge economy; and the Barcelona of neighbourhood activism, struggling to build from below what they considered to be a more democratic urbanism capable of addressing issues and problems considered inherent to the neo-liberal model." As de Hoop et al., further argue, the newer, grassroots emphasis in Barcelona is for people to participate "not as data points, but as co-designers."

4.2.3 The Smart City Vision Grid

We identify cities based on their overall vision and their vision to become smart. This is done using a Smart City Vision Grid (SCVG), as depicted in Figure 2. The vertical axis illustrates the dimensionality of urban vision as discussed above and is useful in marking the level at which the urban vision is negotiated. The polarity in smart city vision is represented in the horizontal axis with highly infrastructure-focused and highly citizen-centered smart city visions being at the two ends. If it is considered that SCI are a part of a plan to achieve the vision of the city, it is justifiable to argue that the level at which the vision of the city is negotiated can partly determine the nature of the SCI (specified by an oval in Figure 1). Cities that are successful in establishing a vision of becoming a global brand, as one might expect, tend to favour and follow a centralized, infrastructure-focused smart city vision (the smart city is realized somewhere in the top-left quadrant) whereas cities with an established local vision tend to seek a decentralised, citizen-centric smart city vision (the smart city is positioned somewhere in the bottom-right quadrant). The exact position of smart city in the relevant quadrants (inside the oval) can also vary by manageable factors such as existing resources, available technologies, human capital and the built environment.

Newly built smart cities are normally constructed based on a futuristic vision of becoming a key player in the global economy. The smart city vision relies on smart infrastructure, a centralized data governance strategy and real-time automated decision-making. They will be positioned at the top left-hand corner of the SCVG. By contrast, already-existing cities that develop SCI can vary greatly in terms of the level at which the urban vision is realised and the way the vision of the smart city is defined (infrastructure-focused vs citizen-centered).

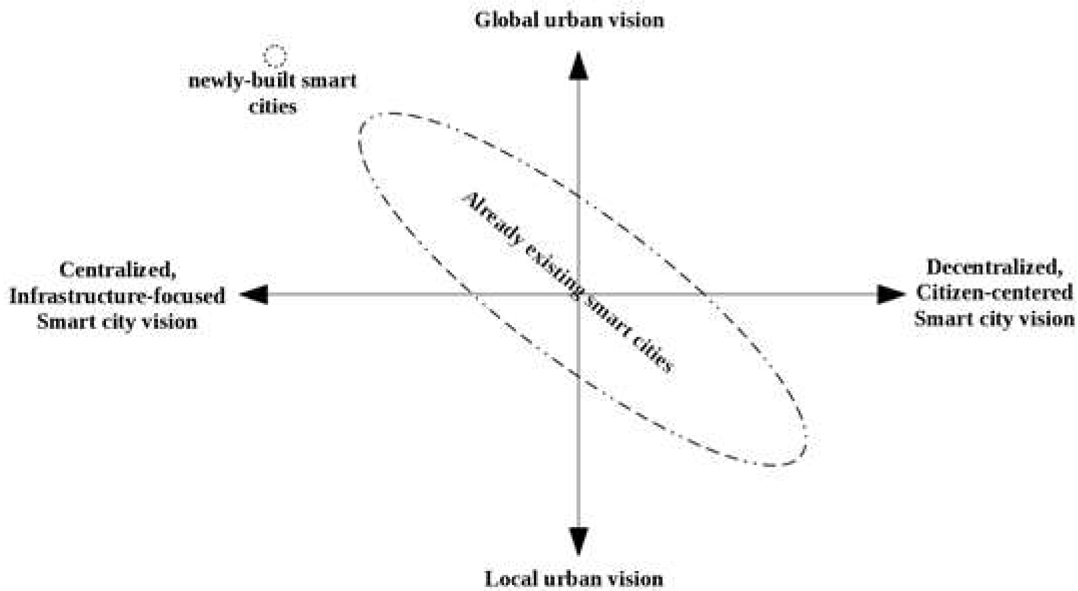

Figure 2: Smart City Vision Grid

4.3 Technological Drivers

Smart City initiatives rely on the implementation of a number of big data and related technologies. These technologies help in the collection, integration, validation, real-time analysis and reporting of a massive amount of urban data. Table 1 outlines an overview of these technologies and the type of problems these technologies can solve. The expectation is that technologies are utilized in bundles and that, combined, they provide solutions to the problems identified in the third column. The bundling effects among technologies makes prioritisation for investment complex and the choices will depend substantially on the data governance mode described in the following section.

Purpose	Technologies	Solution to
Data Collection. Integrating and Unifying Different Sources of data	Sensing (including radar, lidar, sonar, satellite imaging, thermal imaging, quantum sensing and the use of drones), Cloud Technologies and the Internet of Things	Selection Problem
Dimensionality Reduction of Massive Datasets and Real-Time Predictive Modelling	Machine Learning (e.g. Deep Learning)	Prediction Problem
Transaction Verification, Data Accuracy	Blockchain and Distributed Ledger Technologies	Verification Problem
Prototyping, Design Diagnostic and Operation Monitoring	Virtual and Augmented Reality, Digital Twinning	Replication Problem

Table 1: Big Data Technologies and Their Applications

In the third column, the 'Selection Problem' refers to the problem of making the most relevant data accessible. The 'Prediction Problem' encapsulates that range of problems where an outcome is predicted using highly dimensional data. The 'Verification Problem' is concerned with the veracity of records and especially problems where it is hard to establish the validity of data through accurate tracking of a sufficient number of prior transactions. The 'Replication Problem' is related to a range of problems where pattern-matching or learning are vital to the performance of a system but within which it is costly or difficult.

4.4 Data Governance and Strategy

The notion of Smart City is multifaceted because there exists no single universal way of making a city 'smart' in practice. Different forms of governance exist and each embodies certain elements of technology, data, and stakeholders. Each serves a different purpose. Yet, in all cases, data will play an elevated role in the smart city versus the traditional city, and its access and use will be increasingly consequential across different interests in the city.

Drawing upon the literature and evidence of existing SCI, this research formalises the governance modes around four major themes. We describe the governance of urban data based on the way that the concept of the city is conceived. In practice, smart city initiatives will be realized as hybrid data governance arrangements, whereby a combination of data governance modes are put in place.

4.4.1 City as a Provider

The first and most common form of data governance is the designation and release of urban data as a public good. A part of this is data that is generated in relation to public infrastructure. The rationale behind such initiatives (commonly referred to as Open Data Initiatives) is the idea that releasing such data brings about accountability and transparency, and enables a form of participatory governance. Data is considered as a public good and access to this data is a potential right for each and every member of society. It is argued that such initiatives promote participation, increase innovation and facilitate evidence-based decision making.

In this conception, the city is only the provider of the data. The data itself can be used by citizens, bodies such as non-governmental organizations (NGOs) and the private sector for different purposes. Although the provision of data is subject to public request and scrutiny, a hierarchical approach is used to maintain control over the type of content that is released and over issues relating to data privacy. This unidirectional system of control is limited in scope. In order to ensure the maximum potential value to be developed from the data, an open data initiative will impose only a minimal set of controls over the usage of the data. The 'City as a Provider' category can be considered as analogous to the provision of a park wherein the government decides on its location and content but has minimal control on how the park is used. Today, the Open Data initiatives are ubiquitous both at the urban and the national level in cities and countries around the world.

4.4.2 City as an Enabler

An alternative approach is for city managers to provide a unified data marketplace. This approach has been less common than the simpler role of 'City as a Provider', but has recently gained momentum. The view is developed in recognition that local government is not the only entity that has data that is important to the needs of cities. Much of the urban data is in the control of the private sector (e.g. telecommunications companies, IT companies, logistics companies), semi-state organizations (e.g. public transport franchisees), universities and research organizations, and individuals themselves. This approach of enablement also meets the common call that the data held by the government has been gathered at the taxpayers' expense and because data has economic value, it should not be used by businesses free of charge. Faced with this additional complexity and potential, the role of city managers is to design a data marketplace so that there is exchange among suppliers and users, and the optimal value of the data is realized by participants in the market.

In this category, data is considered as a commodity and exchanged via the medium of the market therein. This facilitates more efficient use of the data by a greater multiplicity of interested parties and potentially leads to more data-driven innovations and to economic growth. Examples of this approach include the *Data For London*[3] and *Copenhagen City Data Exchange*[4] initiatives.

4.4.3 City as a Platform

In this approach city governments will seek to develop a network of different providers and users through a specific initiative. It does this in order to manage a research agenda within the network. The research questions and their answers might be attained through this kind of closed or semi-closed environment that relies upon only certain parties and data. Typically this will be known as a 'lab.' A lab allows cities to bring data providers together in order to answer specific policy issues or questions and hence is pro-active and managed through formal research governance.

This formal research governance is concerned with issues of quality in terms of inputs, outputs and process, and also concerned with the interface to urban policy mechanisms themselves. Designing an appropriate ecosystem and providing the right incentives demands a high level of government involvement (at least in the design and maintenance phase) and enriched collaborations and partnerships between public sector, private sectors and citizens. In this sense, the data itself can be considered as embodying a concept. The co-creation processes turns the

3 https://data.london.gov.uk/data-for-london/
4 https://www.citydataexchange.com/

concept into valuable innovations, enabling more efficient use of infrastructure and helping in the delivery of public services.

4.4.4 City as an Automated System

A fourth approach is to develop highly automated and intelligent closed systems that support both the real-time working of the environment and an ongoing process of analysis/learning about the optimisation of this environment (Kitchin, 2014). This ‘smart’ environmental model is most illustrated in the ‘City Dashboard’ concept but also extends beyond this into higher levels of automation. Effectively the concept applies whenever the Internet of Things and other monitoring systems are brought into the wholescale and real-time management of a facility or a geographical area. Given that such a system is controlled by or on behalf of the city government, it can be described as ‘City as an Automated System.’ Regulated algorithms will determine many things that potentially have political or economic ramifications, e.g. who has access to physical space, road-space, natural environments or services. Smart automata will learn through Artificial Intelligence about any issue within their scope, e.g. the best movement of emergency vehicles, crop interventions, patterns of lighting or refuse collection. As data generates the behaviour of infrastructure, it can be said that data is infrastructure (Kawalek & Bayat, 2017) and needs to be maintained and managed through a formal approach, analogous to the way that physical infrastructure itself is managed. This kind of system is necessarily closed for the reason that data quality is key, but the system will also support learning and can be integrated into an overall governance framework alongside other roles of cities (1-3 above).

The management of infrastructural data is possible through centralised data silos drawing from each aspect of physical infrastructure. New algorithmic and storage advances support the collecting, merging, visualising and analysing of massive amounts of data. The Smart City architecture promoted by IT corporations normally relies upon this type of hierarchical arrangement. The closed governance structure is able to provide real-time monitoring of the all infrastructure to which it is linked. This security comes at the expense of issues such as privacy, ownership, flexibility and security.

	City as a Provider	***City as an Enabler***	***City as a Lab***	***City as a Smart System***
Data Considered as	**Public Good**	**Commodity**	**Concept**	**Feedback**
Government Involvement	**Low**	**Medium**	**High**	**High**
Organisational form	**Hierarchy**	**Market**	**Network**	**Hierarchy**
Stakeholder involvement	**Low**	**High**	**High**	**Low**
Motivation	**Transparency, Participatory governance**	**Monetising the value of the data**	**Co-Creation**	**Closed Governance with highly efficient execution.**

Table 2: Data Governance Modes

5.0 Conclusion

Smart City has become a topic of interest to scholars in fields as diverse as electrical engineering, computer science, urban studies, information systems and environmental studies. This research explores smart cities from a management and policy perspective and therefore contribute to a currently marginal but thriving literature that investigates the determinants and outcome of various smart cities initiatives in different context.

The journey to the planning of smart city initiatives starts with envisioning the emerging forms of a city (and its governance) given the choice of data governance (the 'governance mode' in the House Model). Smart city initiatives have only come into existence as a result of big data technologies and solutions that, in the form of bundles, have the ability to process massive amount of urban data ('technological drivers'). The final outcome of a smart city initiative is determined by the city's history and its vision for the future.

This research brings together the key factors important in the planning of SCI under a unified framework. There is potential for further research to explore each component of the House Model in more detail, shedding new light on how these components individually, or in interaction with each other, can predict the outcome of SCI. The idea that Smart City is a representation of the way a city institutionalises urban data is, in itself, interesting and merits further attention. The four data governance modes introduced here can create the basis for comparing and clustering SCI. Finally, progress in the Smart City research has been considerable on the theoretical front but not much on the empirical side. To date, the empirical research in Smart City domain has mainly remained at the level of case studies and interviews. The House Model lists several key variables important in the planning and development of SCI. Future research can operationalise these components, providing a solid basis for large scale quantitative research in this area.

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