

Institutional Development of Data Governance for Smart Cities in China: Opportunities and Challenges in the Case of Shenzhen

Siqi Xie¹

Ning Luo¹

Masaru Yarime^{2*}

¹Division of Emerging Interdisciplinary Areas, The Hong Kong University of Science and Technology, Hong Kong SAR

²Division of Public Policy, The Hong Kong University of Science and Technology, Hong Kong SAR

*Corresponding author: yarime@ust.hk

June 27, 2023

Abstract:

It is a critical challenge to establish an appropriate system for governing various data in developing smart cities across the globe. The mechanism of data governance, however, would vary depending upon the socio-economic environment in which smart cities are located. In China, with its distinctive institutional characteristics, it is not yet well investigated what kinds of data governance mechanisms are introduced, how data are collected, shared, and used, and how potential risks concerning data security and privacy are addressed. In particular, how the open data platform is developed through the institutional arrangements of collaboration with enterprises and engagement of citizens. This paper analyzes the case of smart city development in Shenzhen and examines key opportunities and challenges in data governance. A centralized approach led by the government has been emphasized in data governance, with its focus evolving from addressing the fragmentation of government data to fostering the integration of data in society. Novel policies on sharing principles and data rights have been introduced, and open data platforms have been developed through close cooperation between government and technology enterprises. Rules and regulations have been introduced to protect data security and privacy and facilitate the exchange and use of data for innovation. On the other hand, there are insufficient incentives for various stakeholders to provide accurate information. The value of data is not yet appropriately recognized in industrial activities, discouraging sharing data to facilitate collaborative innovation. Citizens are not necessarily well-informed of what kinds of data are collected and how these data are used and may not have sufficient knowledge to make

use of the data available. It would be crucial to encourage stakeholder participation and engagement in data governance to implement the people-centered approach to smart city development.

Keywords: smart city; data governance; open data; citizen; collaboration; China; Shenzhen

1 Introduction

More than half of the world's population currently live in urban areas. This proportion is expected to increase to two-thirds by 2050 (United Nations Department of Economic and Social Affairs, 2018). The rapid development of urbanization has brought about many challenges, such as housing provision, traffic congestion, environmental protection, and public safety. Modern urban development dilemma requires cutting-edge technologies, citizen engagement, and effective governance systems to tackle pressing social challenges. As a future vision for urban development, the smart city has recently received growing attention and stimulated intensive discussions about its potential benefits and risks worldwide.

Despite the increasing interest, the concept of the smart city remains ambiguous, and there is no unified definition in the literature (Meijer & Bolívar, 2016; Tranos & Gertner, 2012). The previous literature has primarily focused on the application of technologies utilizing various kinds of data for urban functions and argued that rapidly evolving data-driven innovation is the key driver for smart city development. On the other hand, there have been very few studies that empirically examine institutional aspects of collecting, sharing, and using data for smart cities. Data-related issues constitute the core activities of smart city development, including data recording, storing, transmitting, and regulating through new technologies (Abraham, Schneider, & vom Brocke, 2019; Ruhlandt, 2018; S. Y. Tan & Taeihagh, 2020; S. Y. T. Tan, Araz, 2020). It is a critical challenge to design and implement effective systems for data governance to facilitate the use of data to provide technologies and services to citizens while addressing societal concerns about data, particularly data security and privacy.

Various types of data governance can be possible, including centralized, decentralized, and independent approaches, depending on the local socio-economic conditions. Smart cities involve multiple stakeholders, including government, enterprises, academia, non-profit organizations, and the public (Broccardo, Culasso, & Mauro, 2019; Ruhlandt, 2018). How data

governance is established would affect promoting data-driven innovation, facilitating public-private partnerships, and encouraging citizens' participation and engagement in smart cities (Angelidou, 2014; Bakici, Almirall, & Wareham, 2013; Roy, 2014). Data platforms particularly play an important role in data governance. They bridge the distance between the government and the public, providing opportunities for stakeholders in various sectors to understand what kinds of data are available and explore how these data can be used to address their interests or concerns. Collected data also provide a robust basis for decision-making by city managers and improve the efficiency of public services (Borgman, Heier, Bahli, & Boekamp, 2016; Effendi, Syukri, Subiyanto, & Utdityasan, 2016; Ruhlandt, 2018)

As many countries are actively involved in constructing smart cities, China has become one of the leading countries in smart city development in the world. With more than 490 smart cities planned or initiated, China currently accounts for almost half of the smart cities worldwide (Deloitte, 2020). Shenzhen, in particular, is one of the first cities to explore the construction of a smart city in the country. As a city with well-established supply chains for the electronic industry, Shenzhen has developed an industry cluster that can provide critical components for the smart city. A key feature of Shenzhen's smart city development is close cooperation between the government and high-tech enterprises. These companies collaborate with the Shenzhen municipal government by providing their knowledge and expertise on advanced technologies, including big data, the Internet of things (IoT), cloud computing, and artificial intelligence (AI).

Compared with technical development, it is not understood how data is actually collected, shared, and used and how data governance contributes to creating innovation in smart cities in China. Many questions remain unexplored concerning various aspects of data governance, including open data management, institutional arrangement, data security, and privacy protection. Focusing on the case of Shenzhen, this study investigates what kinds of data governance mechanisms have been introduced, how data are collected, shared, and used, and how the government addresses the challenges concerning data security and privacy in China. In particular, we examine the city's experience of developing open data platforms through collaboration with enterprises and establishing institutional arrangements for data collection, sharing, and use, as well as citizens' engagement in smart city programs. The case study is conducted by analyzing information obtained from government documents and websites and

also through interviews. Implications for public policy and institutional design are explored for data governance systems that would be conducive to innovation while addressing societal concerns.

2 Literature Review

Data governance is a critical aspect of smart city development. Sophisticated information and communication technologies and data-intensive devices and equipment are extensively deployed in smart cities (Allam & Dhunny, 2019; Silva, Khan, & Han, 2018). Urban management based upon a large amount of data is expected to enable effective decision-making and broaden public participation and collaborations through smart technologies (Yanliu Lin, Zhang, & Geertman, 2015; Ruhlandt, 2018). Data governance mainly concerns what kinds of decisions to make and who is involved in decision making (Dyche & Levy, 2006; Haggmann, 2013; Khatri & Brown, 2010; Otto, 2011). More specifically, data governance involves cross-functional collaborations, data management framework, enterprise data assets, decision rights, accountability, and related data policies and regulations (Abraham et al., 2019). It is essential to examine how these aspects are implemented in the practice of data governance.

Previous research concerning data governance mainly discusses planning and implementing data management activities, which involve structural, procedural, and relational aspects (Abraham et al., 2019). Structural elements involve the roles, actors, and accountabilities of decision-making (Borgman et al., 2016; Ruhlandt, Levitt, Jain, & Hall, 2020). Procedural issues mainly concern recording, storing, sharing, and using data and protecting data security and privacy. Appropriate policies, standards, and rules are required to guarantee the proper implementation of various stages of data governance (Abraham et al., 2019; Borgman et al., 2016). Relational mechanisms concern how collaborations are facilitated between stakeholders in the public and private sectors in building smart cities.

With the penetration of Information and communication technologies (ICTs) in the electronic government (e-government) (Gil-Garcia, 2007), it increasingly plays a significant role in facilitating the effectiveness of public services delivery and government managerial capabilities (Ma, Christensen, & Zheng, 2021). However, due to the complexity of technologies, governments across the world tend to cooperate with private sectors to co-construct IT infrastructures and data linkage platform to more effectively deliver public services (Medaglia, 2017). Since the principles of open data government were promoted in California in 2007

(opengovdata, 2007), the public demand for open government data has rapidly increased. The advocates and practitioners have to consider the huge management cost of the large volume of data and the huge investment in technical support and technicians. To attract more enterprises and entrepreneurs to participate in the open data movement, it is essential for governments to further explore the business potential and value creation of open data based on the original intention of building a transparent government (Deloitte, 2012; Magalhaes, 2020; Mayernik, 2017). Therefore, how public and private sectors collaborate to create a positive cycle of an open data ecosystem has become a critical issue. Pioneering countries and organizations such as the United States, the United Kingdom, and the European Union have taken the lead in facilitating the cooperation modes between government and enterprises. For instance, Finland has actively adopted various open data strategies and networking initiatives through public-private partnerships, and this action has led to the emergence of data-driven entrepreneurship and the revolution of public sector innovation (Kassen, 2022). In Sweden, a triple helix e-government initiative adopts the public-private partnership that involves 16 organizations from universities, government, and industry to improve real estate development (Ruuska & Teigland, 2009). As the use of public and private collaboration brings benefits to e-government performances, it seems to provide a mode for some developing countries to overcome their public management challenges and to catch up with the advanced countries (Palaco, Park, Kim, & Rho, 2019). In 1999, the Malaysian government implemented an e-procurement system in the form of a Build-Operate-Transfer (BOT), through which the private sector was primarily responsible for setting up and maintaining the online procurement system, and government staff were responsible for reviewing and approving the permits (Kaliannan, 2010). To achieve “Digital Bangladesh” and “Vision2021”, the Bangladesh government has set up 4554 Union Digital Centres (UDCs) to co-deliver public services with local entrepreneurs at low cost in rural areas (Faroqi, 2015; Islam, 2018). Due to the huge heterogeneity of governments in different regions, Chinese governments, adopt a variety of forms of public-private for data governance in the field of smart cities. The term “Public-private partnership” has more broader definitions in Chinese policy arrangements and academic literature. Public-private partnership in China’s digital governance typically includes all types of partnerships between the public and private sectors in e-government, which can be loosely defined as "all types of cooperative institutional arrangements between public and private sector participants". In Chinese policy documents and academic literatures, it is more common to use government-enterprise collaboration/government-business collaboration to refer to public-private collaboration and

broader public-private partnership (X. Yang, Liu, & Zheng, 2020). Specifically, it includes procurement, outsourcing, and public-private partnerships (PPP). The type of cooperation that governments should choose often depends on multiple variables such as performance goals, costs, risks, political pressures, etc (X. Yang et al., 2020). Government procurement is mainly used for the direct purchase of products, services or technological solutions by the public sector from companies and is applied to the one-time transaction (Allen, 2005). Outsourcing in the field of data governance normally refers that the government decentralizing a portion of e-government construction, data management and services delivery to firms or non-profit organizations through contracting to achieve an effective supply of public goods. It usually includes general contracting mode and subcontracting mode in the process of smart city co-construction in China. Public-private partnership is the governance of relationships based on long-term cooperation, shared risks, and common goals between public and private sectors (EfficiencyUnit, 2008). According to Liu, Yang, & Zheng, the collaboration between governments and enterprises for e-government in China has experienced the evolution of four stages: outsourcing, service co-delivery, joint management, and collaborative governance (Liu, Yang, & Zheng, 2020). And with the higher level of engagement of private sectors in e-government construction, the perception of value-added technologies, the roles of government and enterprises in services delivery, the nature of the government-business relationship, the collaborative mechanism, and the outcome achieved have witnessed dramatic changes.

One of key approaches to data governance for smart cities is to utilize various data in a more decentralized way. A data linkage platform can be developed by professional vendors and operated by local governments, whereas private service providers can offer various services. As long as the residents of the smart city agree, it would also be possible for either public agencies or private enterprises to provide services and the platform, making consent by the residents particularly crucial in data governance. The data linkage platform does not need to maintain an extensive central database, as data can be stored in separate databases in a distributed way. The providers of digital data and services would be required to make their application program interfaces (APIs) open to the public so that any information system can be developed through the data linkage platform.

Open data platforms are particularly expected to contribute to facilitating decision-making, improving public services, and encouraging broader collaboration for innovation in smart cities

(Roy, 2014). It has been shown that open data policies promoted the proliferation of innovative products and the development of entrepreneurial industries, which would play a crucial role in the creative economy ecosystem (Jung & Park, 2015). Empirical research shows that smart city plans could promote scientific and technological innovation (Caragliu & Del Bo, 2019). The number of patents filed by cities with smart city policies is higher than the EU average, especially for high-tech patents. For utilizing data for innovation, an ecosystem of supply-side and demand-side participants in open government data platforms needs to be cultivated (Bonina & Eaton, 2020). Innovators can use data sets from public agencies to create novel technologies and services. Open data programs show what kinds of data the government has and stimulate the use of such data to create innovation in various fields. The government would also be interested in collecting data to understand people's reactions to the policies introduced to improve policy-making (Bertot, Jaeger, & Grimes, 2010; Clarke & Margetts, 2014).

Smart city development has raised many concerns about data governance, particularly transparency, data security, and privacy protection. There is an increasing demand for public agencies to release the data they possess as a legitimate right of citizens (Bertot et al., 2010). Transparency in data governance also helps to discourage corruption by making data easy to access and check (Ball, 2009). Open data programs initiated by many governments, however, would not necessarily meet expectations to increase transparency or clarify decision-making processes (Clarke & Margetts, 2014). Open data initiatives hence must be part of more comprehensive efforts to establish data governance by improving transparency, enhancing civil rights, and promoting reform in public services (Ojo, Curry, & Zeleti, 2015).

Previous studies have preferred to discuss intelligent technical solutions in smart cities (Botta, 2016; Jin, Gubbi, Marusic, & Palaniswami, 2014; Piro, 2013; Sun, Song, Jara, & Bie, 2016; Zanella, Bui, Castellani, Vangelista, & Zorzi, 2014), because smart cities heavily rely on technological tools to build smarter and more sustainable cities (Stübinger & Schneider, 2020). However, with the rise of the concept of a "sustainable smart city", some scholars started to question that technology is not the solution for all urban management problems (Thomas, Wang, Mullagh, & Dunn, 2016). Supporters of "Sustainable Smart City" have argued that the smart city paradigm is not only about technology but also about the socioeconomic and environmental aspects. Particularly, the smart city should focus on the needs of citizens and communities (Nam & Pardo, 2011). As the city management paradigm is shifting from

traditional and compulsive management to modern governance with citizen participation and collaboration, there is also a growing call for a citizen-centered approach to achieve social inclusion and innovation in the smart city. Latest studies started to pay attention to governance based on a citizen-centered approach, emphasizing promoting civic engagement and citizen participation in democracy and city affairs (Bolívar, 2017). Some believe this approach has improved the government's capacity to offer proactive, precise and personalized public services to citizens (Baesens, Bapna, Marsden, & Jan, 2014; Linders, 2012), while other studies criticized the level of citizen engagement and public empowerment in smart cities still questionable (Paskaleva et al., 2017). Further, some scholars pointed out that the so-called "citizen-centric" in the field of the smart city is a limited consumption choice and individual autonomy rooted in stewardship and civic paternalism instead of civil, social and political rights and the common good (Cardullo, 2019). The level of citizen participation in public affairs also influences the choice of the open data model, which is at a crossroads of "Data over the Wall," "Code Exchange," "Civic Issue Tracker," and "Participatory Open Data" (Sieber & Johnson, 2015).

Data security and privacy protection are major concerns in data governance. While the existing research points out potential risks and relevant challenges, few studies provide concrete policy recommendations on how to maintain data security and privacy in the context of smart cities. Most of these studies are technical, mainly focusing on information and communication technologies involved. Current approaches to privacy and data security in the smart city data system concern privacy avoidance policy, medium-term privacy policy, and data provenance (Dhungana, Engelbrecht, Parreira, Schuster, & Valerio, 2015). People's concern over data privacy primarily stems from who will deal with their data and their degree of trust in the data management agencies. Information concerning personal issues needs to be dealt with, depending upon whether it is individual or aggregate data and whether it is used for public services or regulatory purposes (van Zoonen, 2016).

Various kinds of data obtained in smart cities to facilitate innovation and create new economic opportunities pose serious challenges to data security and privacy (Elmaghraby & Losavio, 2014). Information sharing and exchange would increase the chance of disclosing or leaking sensitive private data, such as personal name, email and postal address, date of birth, geographical location, bank account number, photo, and political views (Kulk & van Loenen,

2012). Trust in institutions could diminish if their data sharing creates privacy risks that will harm citizens and individuals. An integrated framework to manage diverse types of data would be required to address legal, cultural, and institutional issues in a cross-sectoral manner (Dulong de Rosnay & Janssen, 2014). Government can play a crucial role in leading open data activities and promoting multi-sectional collaborations. Public agencies can take initiatives to cooperate with private enterprises and encourage citizens' participation and engagement in data governance.

Despite these previous studies, little research has been conducted to empirically examine the mode of data governance and the mechanisms and processes involved, particularly in China. Erie analyzed transactional data governance mechanisms taking the case of Beijing city in China's Digital Silk Road (Erie, 2021). Große-Bley and Kostka empirically investigated smart cities in China and provided empirical insights into the implementation of digital governance systems at the local level in China, the barriers they face and their broader implications, using Shenzhen as an example (Große-Bley & Kostka, 2021). Li, Ma and Wu discussed the data privacy issue of post-pandemic data governance through comparing the benefits and risks brought by contact tracing applications in mainland China, Hong Kong, and Singapore (V. Q. T. Li, Ma, & Wu, 2022). And also there is a stream of studies explored the data governance framework in China's healthcare and finance industry (Q. Li et al., 2019; Wang, 2022). It has not been investigated how data is collected and managed and how open data promotes innovation while addressing potential data security and privacy risks in smart cities in the country's socio-economic conditions. In particular, how the Shenzhen government develop open data platform through the institutional mechanisms of collaborating with local high-tech firms and encouraging citizen participation in its data governance system is still unclear.

3 Institutional Background: Data governance in Shenzhen, China

As most other cities in China, local government take the lead in establishing smart city in Shenzhen. However, different entities within the government may be in charge for different duties. Potential obstacles may not only exist in the collaboration with external entities, but also happen in the coordination among various public sectors. In addition, the unique local population conditions had affected the government's decisions in data governance too. To present an overview of data governance of Shenzhen, this section first reviews the roles of

government in smart city development in the past decades and further explores how different actors coordinate in the process of building an open data platform in recent years.

Shenzhen has been regarded as one of the pioneering cities in China's smart city history. Relying on solid foundation in information and electronic technology industries, Shenzhen has explored many practices related to data, and initiated corresponding institutional innovation in governance. In the past two decades, data governance in Shenzhen shows a trend shifting from fragmentation to integration. Since the late 1990s, Shenzhen government has been going through four major stages in the smart city construction: establishing information, communication technology (ICT) infrastructure, E-government practice, Zhi Wang Project, and a mature network of smart city.

3.1 Infrastructure Establishment and E-Government Practices

In the initial stage, Shenzhen's government decided to invest in building ICT infrastructures in all districts regarding the city had not been covered with a comprehensive information system yet. Although the Internet was becoming an worldwide popularity, a shortage in ICT foundation was identifies as a main challenge for Shenzhen to pursue a smart city. After the first national informatization working meeting was hosted in Shenzhen in 1997, a series of projects for communication networks, databases and platform were initiated.

Moving to the 2000s, Shenzhen switched focus from facilities to e-government promotion. As one of the first batch of pilot cities to offer e-government services in China (XinhuaNet, 2002) the city tried to empower the traditional public services with ICT technologies. Different public sectors could internally communicate via online working platform, meanwhile externally facilitated information sharing to the public. Besides, citizens began to enjoy some civil services via Internet without going to public agencies in person.

At this stage, the early investment in ICT infrastructures had been effective in improving the convenience of public services (Yi Lin, 2017). The city, however, still faced challenges from various aspects. First, different departments within the government met problems with coordination in some civil services. For example, citizens may feel difficult to tackle issues that require efforts from more than two sectors, as they could not share data and co-working with other departments in a unified system including all kinds of data (Wu, 2019). Second, digital services were only limited in government issues, which is far away from reaching a

smart living goal. The citizens were still in large demands of services covering more sectors. Third, the government could only provide public services via the system to residents with *hukou*, which did not cover more than 63% migrant workers in Shenzhen (Statistical Bureau, 2010). These migrant workers usually moved or changed jobs frequently. Therefore, the city government could not get sufficient data of them and consider their demand when making decisions. In turn, these residents without *hukou* may not fully enjoy the social welfare. In conclusion, data governance in Shenzhen was fragmented and in short of usage.

3.2 Development of the new smart city

To address the above concerns, Shenzhen government next proposed Zhi Wang project, in Chinese means net weaving, to confirm urban data sources and gather data on the basis of communities (Shenzhen Industrial and Information Technology Bureau, 2013). Our paper will discuss this project in detailed in the following case analysis section. Overall, introducing the Zhi Wang project successfully helped Shenzhen government collect sufficient data for public services and promote collaborations among stakeholders in the smart city.

Based on a comprehensive information network built in the Zhi Wang project, smart city development in Shenzhen stepped forward into a novel stage with integrated urban data platform (S. Yang, 2019). The city's government, private enterprises, and citizens engaged in constructing and using smart city facilities in this period. The structure of the new smart city in Shenzhen is illustrated in **Error! Reference source not found.** (Shenzhen Municipal People's Government, 2018). The scope of open data has also been extended from internal sharing within the government to opening up data to the whole society. In this data platform, the major role of the government changed from services provider to supervisor and manager (China Academy of Information and Communications Technology, 2019). At the same time, local high-tech enterprises became technical supporter and operators. Citizens were main data providers and customers of the data platform. The mature information network and data platform laid a solid basis for Shenzhen' data governance later.

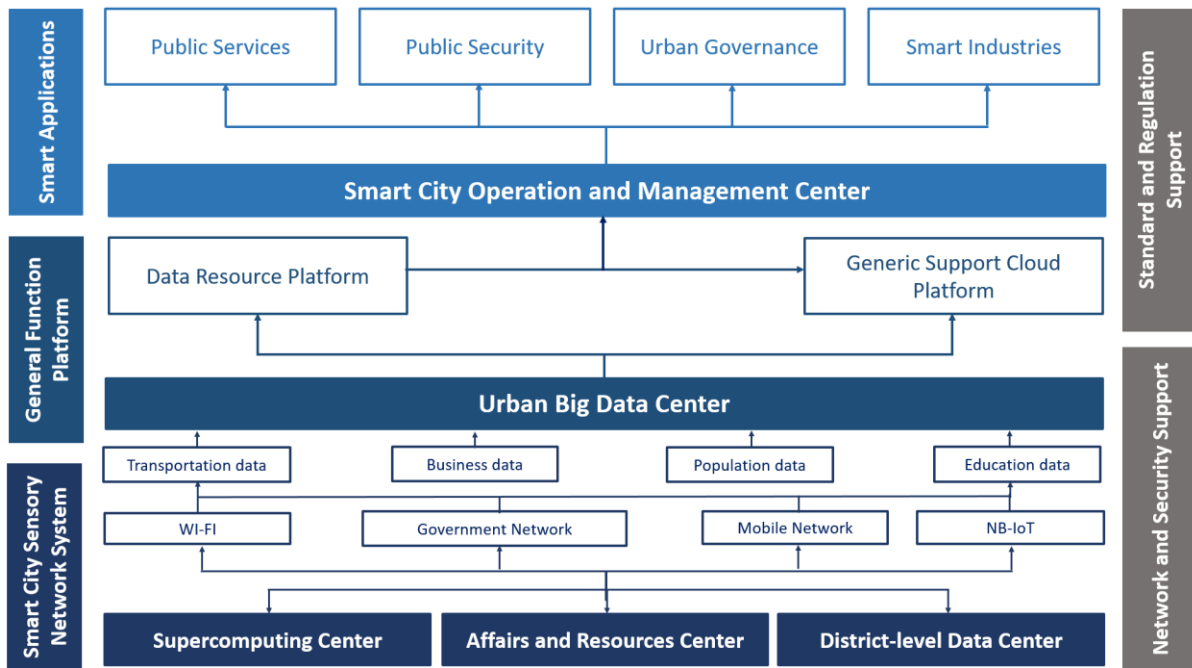


Figure 1 The Structure of the New Smart City in Shenzhen

4 Methodology

This study is an exploratory research investigating how government developed open data platform via institutional arrangements of co-building information system with technology enterprises and encouraging citizens to participate in related activities. The empirical setting relies on the data governance experience of Shenzhen, China. In this paper, our major research method is case analyses that primarily focus on government’s roles in data governance from two aspects: how to cooperate with private enterprises and how can government facilitate citizen engagement in establishing and using the open data platform.

Data of this study is mainly collected from interviews and desktop research on related government documents. For the first analysis on co-establishment open data platform between government and enterprises, we conducted two semi-structured interviews with a representor of Cloud Service department in Tencent Group, which is one of the largest outsourcing technical supporters for Shenzhen government in smart city construction. The first interview focused on experience of previous collaboration between their enterprise and the city’s government. We collected detailed information on the modes of cooperation, how they coordinate with different sectors related to data governance, and how to provide technical supports after the platform was operated. The second interview concerned how government

use the data platform to provide services, including details on data collection, using, sharing, and related policies for privacy protection. In addition, we also collected some government documents guiding government-enterprise collaboration and some related policies.

For the second set of analysis on citizen engagement in data governance, we focused on the how the government encouraged citizens to participate in the Zhi Wang project on the basis of communities. On the one hand, we obtained data on why the government decided to initiate the project and how the project was implemented from open policy documents. On the other hand, to further understand the details of policy implementation, we also had access to some interior government documents summarizing practical experience on when implemented the project from related departments in Nanshan district, which was the first district in Shenzhen that introduced this project. These documents illustrated how the communities' workers collected citizens' information in their daily work, how citizens provided data and used the data platform, and reflections on lessons from project implementation.

Finally, we also discuss policies on data application and privacy concerns. These policies were introduced to help the data platform operate according to the development of above hardware infrastructures. We obtained related data on policies from different public sectors.

5 Government's experience in establishing open data platform

5.1 The Zhi Wang project as a model of a citizen-centred smart city

In addressing the challenge of data fragmentation, the government came to emphasize developing a smart city. The Smart Shenzhen Planning Outlines was published in 2011 for the construction of a smart city (Shenzhen Industrial and Information Technology Bureau, 2013). Recognizing that data is a vital foundation of a smart city, Shenzhen started to assemble various types of data resources in the city. The municipal government proposed to make every citizen become a data provider. In 2013, it started the Zhi Wang (Net Weaving) project, which aimed to connect urban data on a grid basis by promoting multi-stakeholder collaboration. The schematic framework of the Zhi Wang project is shown in Figure 2.

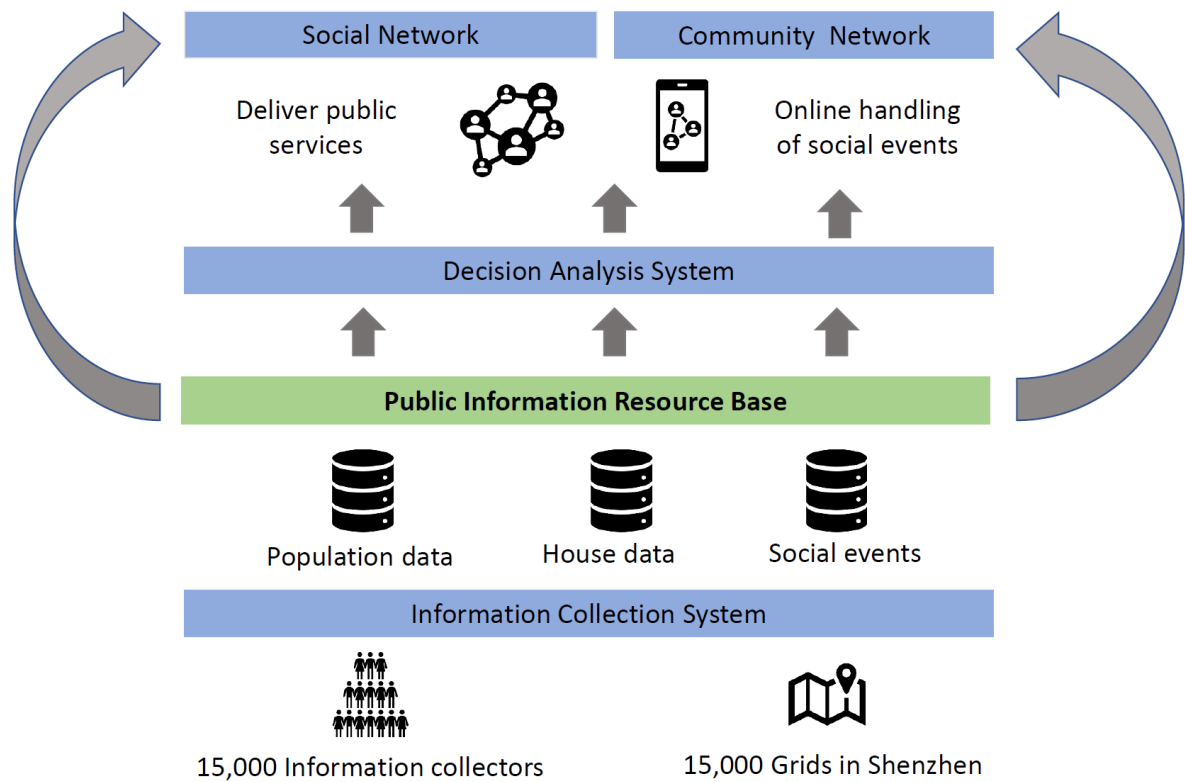


Figure 2 The Schematic Framework of the Zhi Wang Project in Shenzhen

The Zhi Wang project was implemented for social and community networks based on the core of the public information resources base. The public information resource base is a database that covers essential information on population, administration officials, houses, and public events. Shenzhen has set up a unified public information resource base that can access across government departments. The public information resource base operates relying on an information collection system in which data is assembled from the 15,000 community grids in the city through mobile intelligent terminals. All the information collected to the public information base is analyzed in the decision analysis support system to deliver public services to citizens in an efficient way (General Office of Shenzhen Municipal Committee of the Communist Party of China & General Office of Shenzhen Municipal People's Government, 2014). The social network aims to assess, process, supervise, collect feedback, and manage social affairs on an online platform. The community network is more service-oriented as it provides administrative services, public services, and business services to the citizens. It also deals with public opinion surveys, decision-making, and elections of community residents (X. Li, Han, & Cui, 2014). The two networks are supportive of each other; for example, views and opinions from the communities could be incorporated into decision-making by government

departments in handling social issues. Ultimately, these two networks aimed to improve the administrative efficiency of government agencies and provide various kinds of services to citizens in more convenient ways.

The Zhi Wang project addressed the fragmentation of data within the government by linking the data held by different agencies into one public information resource base. The implementation of the Zhi Wang project demonstrated the central role played by the government in establishing data governance of the smart city in Shenzhen. To deal with the fragmentation of data, the government took a top-down approach to implement integrated and coordinated strategies, stressing holistic operation and cross-department collaboration in constructing the smart city (X. Li et al., 2014). All initiatives of the Zhi Wang project were designed and planned at the top level by the highest government agency. That helped break the information silos within the government and share relevant data. The whole-of-government approach made it possible to provide public service channels consistently and allocate necessary resources systematically.

The government also played a vital role in clarifying institutional aspects of data sharing in the smart city. To address the problem of unclear authority and responsibility in data sharing, the government formally issued the Measures of Shenzhen Municipality for the Administration of Government Information Resources Sharing in 2015 (Shenzhen Municipal People's Government, 2015). The policy specified that the municipality government owns the data collected by all departments of the government. The department that has collected specific data has the right to manage the data, whereas other departments have the right to use the data. The new measures have clarified that the government data is shared among the departments by default. Special approval is required if any data are not to be shared. These measures addressed the rights of ownership, management, and use of government data and provided institutional guarantees for data sharing within the (Shenzhen Municipal People's Government, 2015). While these regulations facilitated data sharing among its departments and agencies, it was not extended to the public due to bureaucratic resistance.

Unlike the central role played by the government, the level of citizens' engagement in this project is not as straightforward. To begin with, citizens serve as a data provider in this system, as they provide to the information collectors their relative information, which altogether forms

Zhi Wang's database. Secondly, citizens can express their opinions and complaints through the system. Finally, the Zhi Wang project aims to provide better public services to the public. Comparing to traditional public service systems in China, this project benefits Shenzhen citizens by enhancing the efficiency and accessibility of public services.

According to Cardullo there are four levels of citizen participation: non-participation, consumerism, tokenism, and citizen power (Cardullo, 2019). As for the Zhi Wang project, it matches the description of the highest level of citizen participation that a top-down model can achieve, tokenism, which allows citizens to provide feedback to the government and make complaints but not be a leader or co-creator of the system, and data in the system are not open to the public. Nevertheless, although it does not match the highest level of citizen participation, the citizen power level, it to some degree paves the way to it, as the system facilitates local elections and could potentially enable more democratic decision-making processes. To further increase the citizen participation in the Zhi Wang project, the Shenzhen government can involve the citizens more in the design and management of the system. For example, the citizens could act as a regulator of the data usage in the system, and the voting system enabled by the Zhi Wang project could in return be used to decide what can data in the system be used for.

5.2 The Shenzhen Open data platform as a model of a collaborative smart city

In the Shenzhen smart city, data governance focuses on the centralized approach led by the government. Various activities concerning data governance are illustrated in Figure 4. Government departments and agencies are primarily responsible for collecting urban data (Wu, 2019). The types of data collected by these departments and agencies are diverse (TencentCloud, 2020a). For example, the public security agencies, civil affairs departments, and medical authorities maintain databases on individuals related to their specific domains. Data about enterprises, including business registration, tax, and social security, and those related to citizens' daily life are also collected by different government agencies. The public sector collects data mainly through self-reporting and community workers collecting data door-to-door. Other data collection methods include collection through surveillance cameras and web crawling. While technology enterprises provide technical support for the government to

build data platforms, they are not directly involved in collecting data (Tencent Cloud Employee, 2020a; TencentCloud, 2020a) .

All the data in the data platforms are basically managed by the government. In the early stage of platform development, the enterprises that have provided technical expertise are responsible for maintenance (TencentCloud, 2020a). As the operation becomes stable, all the data are transferred to the government and operated independently from the private companies through the government could platform. Sometimes it would also be possible for the government to set up a subsidiary to run the data platform or seek technical help from the technology enterprises that have collaborated on the platform (TencentCloud, 2020a). For example, the Shenzhen government's service app "Shen i Nin" was initially developed and operated by Tencent (iShenzhen, 2020). At a later stage, the data was transferred to the government and managed by itself (TencentCloud, 2020a) While this approach would ensure that the government is in charge of data management, the government might not have sufficient technical expertise or personnel for proper operation and maintenance (ShenzhenGovernment, 2022).

The collected data are basically available for use by various stakeholders through data platforms such as the Shenzhen Municipal Government Data Open Platform as well as other web portals (i Shenzhen, Shen i Enterprises, Shen Governance Smart and Shen Government Easy) (ShenzhenGovernment, 2022). Currently, data users are mainly government departments that require data to provide various kinds of services to the public (TencentCloud, 2020a). For example, the financial authorities primarily use the financial data for regulatory functions. Police would use the data to crack down on financial crimes. Other ways to use the data through the data platforms include using data for research purposes (TencentCloud, 2020a).

Data involving sensitive data concerning privacy, however, are basically kept in the public sector. The government authorities claim that a high degree of confidentiality is maintained for data related to personal privacy, which is provided by citizens with informed consent. All the agencies and individuals need to undergo strict approval procedures to access the data. Once they have received approval, they can only access datasets that do not involve sensitive personal data, especially data concerning specific target groups with fewer than 20 people involved (TencentCloud, 2020a).

There are many issues and challenges in facilitating the use of data through data platforms. A major obstacle to data sharing is coordination between different government departments. As they do not have well-established rules for sharing and exchanging data, it is still difficult to efficiently establish a comprehensive public data platform (TencentCloud, 2020a). In addition, data cleaning is also a considerable challenge. Much of the data cannot be presented as they are heterogeneous and hence need to be standardized to make them readily available for users to operate. Although the government information center usually takes care of this task, the sheer volume of data slows progress in open data management (TencentCloud, 2020a).

Data platforms are the core of new smart in Shenzhen. The construction of data platform has benefited from the knowledge shared by high-tech companies through outsourcing and government procurement modes. The specific modes of outsourcing include enterprise general contracting, subcontracting, and government purchasing (Tencent Cloud Employee, 2020a, 2020b). For enterprise general contracting, a large firm (also called a system integrator) usually signs an agreement directly with the government for the whole project. The company is basically responsible for the project and needs to undertake most of the platform development work. Local high-tech companies such as Tencent, Huawei, and Ping An Technology will be invited to bid for system integration projects. Some tasks in the project would also be subcontracted to other partners when available technologies or expertise are insufficient. The advantage of this model is that the general contractor takes full responsibility for the project. When there is a problem with the products delivered by subcontractors, the government can directly hold the general contractor responsible for the project without any necessity to deal with many other companies involved. However, because there are so many interested groups involved, the general contractor needs to balance the interests of stakeholders and may bear greater reputational and profit risks in the event of product delivery problems. In the subcontracting mode, the general contractor signs agreements with multiple enterprises in different sectors to complete a project. The subcontractor include services operators (e.g., China Telecom, China Mobile, and China Unicom), hardware developers (e.g., Huawei), software developers (China Electronics Technology Group, iFlytek, and Kingdee) (TencentCloud, 2020b). The government can take advantage of enterprises in different fields, although the government needs to balance the relationships among various stakeholders. In the case of government purchasing, the government can obtain products from enterprises annually

rather than setting up specific projects separately. This model is generally applicable to small-scale projects, as large projects cannot take the mode of government purchasing.

Beyond data sharing among government departments, the processed data will be open to the a variety of users (companies, researchers, and citizens) through data platforms. For example, the municipal government has published standard-formatted data and API interfaces from different agencies (Education, Finance, Labor, and Transportation) on the Shenzhen Municipal Government Open Data Platform (DataManagementBureau, 2022). The platform also provides other resources and tools for analysis and visualization to support the application of data.

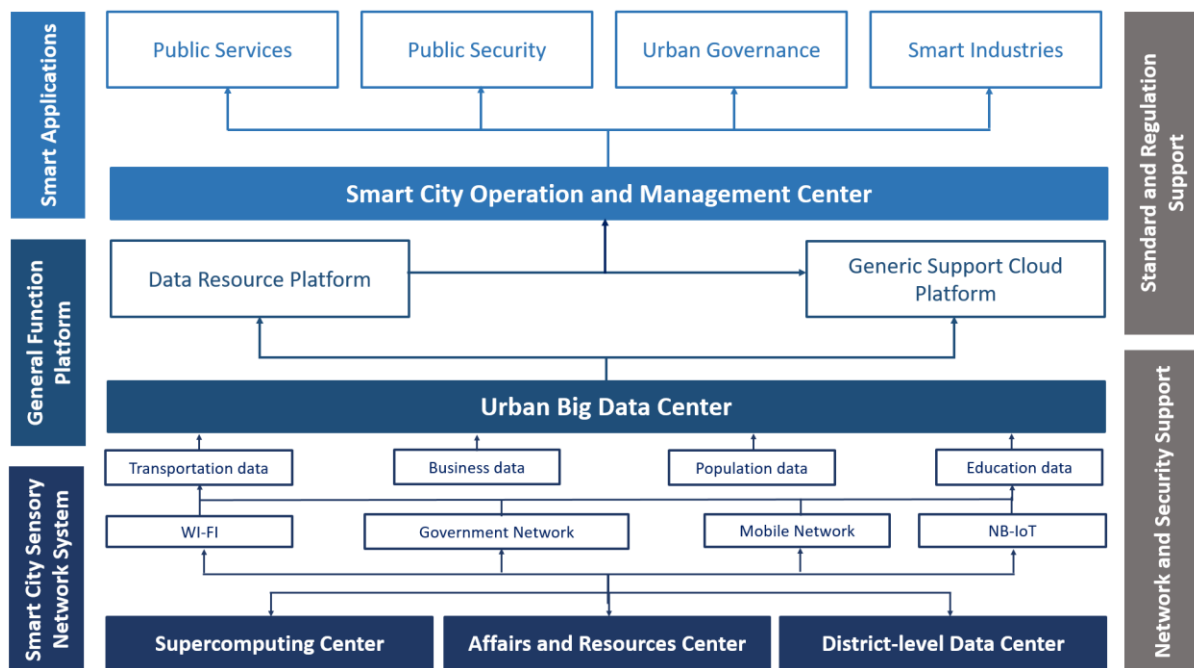


Figure 3 The Structure of the New Smart City in Shenzhen

A notable feature of data governance in Shenzhen is the involvement of Internet giants like Tencent. They often perform as builders and sometimes maintainers of smart city systems. With their advanced technology in big data and artificial intelligence, these tech firms have significantly increased the capacity and efficiency of smart city systems.

Even though the tech firms are deeply involved and indispensable in Shenzhen's smart city projects, their access to sensitive data is carefully managed by the government. It is difficult for the government to keep a balance between utilizing tech giants' data processing technologies and protecting sensitive public data from these private firms. A solution to this

dilemma would be setting up state-owned companies which focus on these data processing technologies and let them gradually learn how to manage these advanced data systems.

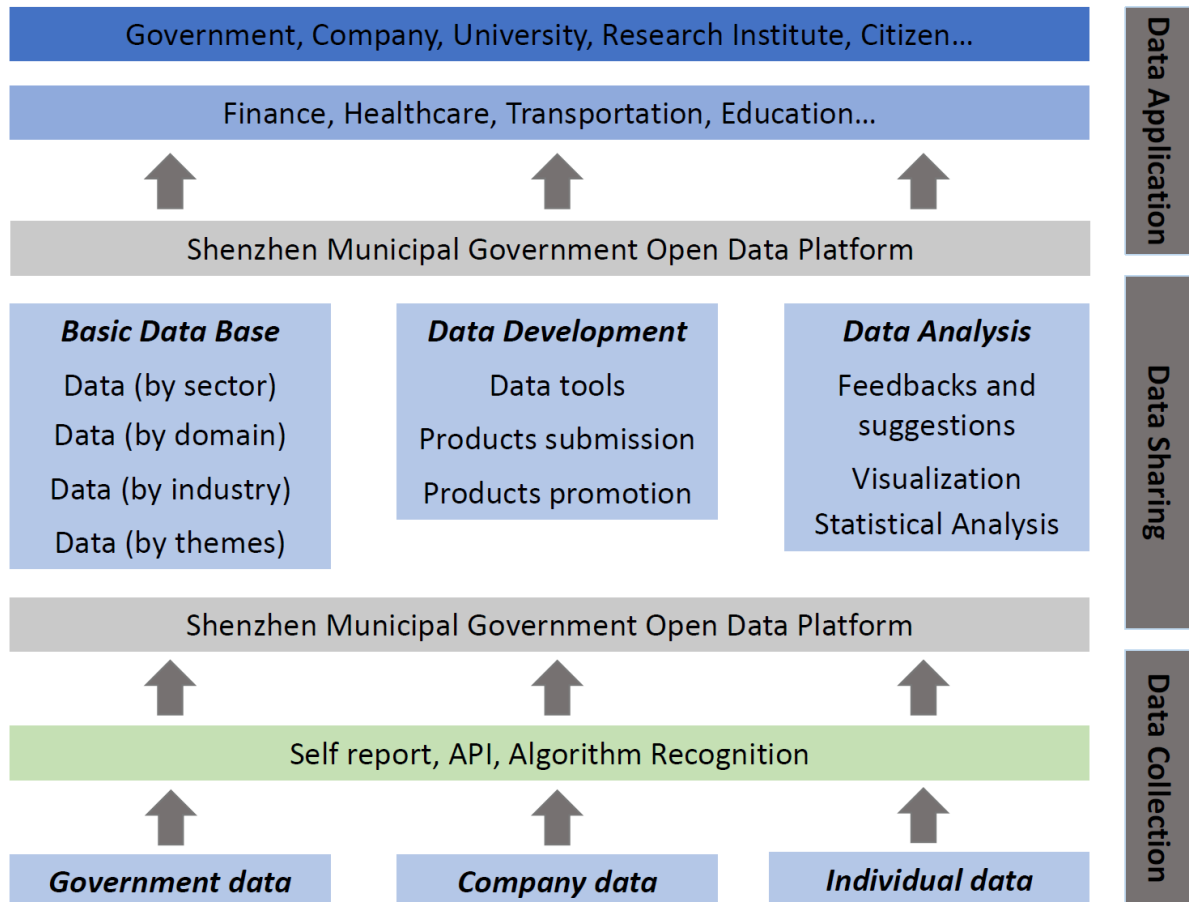


Figure 4 Data Governance in the Shenzhen Smart City

6 Policies coordination in data application and data privacy protection

6.1 Policies for protecting data security and privacy

As data sharing and use are encouraged in smart city development, it is crucial to establish an institutional environment for data security and privacy protection. With the widespread application of data-intensive technologies such as IoT, AI, blockchain, and cloud computing, smart cities in China have been experiencing explosive volumes of data. Serious concerns have been raised about the security of data, as the open data approach would increase the risk of intentionally leaking or mistakenly disclosing sensitive data, including sensitive personal data. The risks associated with the disclosure of confidential data have become a major reason for government departments to refuse to open and share their data (Wirtz, Piehler, Thomas, &

Daiser, 2016). Therefore, it is essential for the government to balance the benefits of open data and the risks concerning data security and privacy.

During the lifecycle of data governance, there are different types of risks to data security and privacy (Zhang, 2022). In data collection, personal data may be collected excessively or without proper consent. In data storage, personal data may be stored indefinitely or be leaked out. On data platforms, sensitive personal data may be disclosed, or governments may focus too much on individual data, neglecting aggregate data. In data usage, different aspects of personal data may be aggregated by AI technologies, potentially leading to identifying individuals. These risks to data privacy and security would reduce people's confidence in collecting, sharing, and using data in smart cities. China's digital industry has developed a complete industry chain, which can cover data collection, storage, process, use, and transmission (Chen, 2020). The institutional environment concerning data security and privacy protection, however, was lagging behind, and there were few laws and regulations for the public and private sectors as well as citizens to follow in conducting data-related activities.

Responding to this challenge, the Chinese government has recently started to introduce a series of laws and regulations for data security and privacy protection. The Cyberspace Administration of China released a new regulation on data security, the Data Security Law, in September 2021 (National People's Congress of the People's Republic of China, 2021). This legislation could be regarded as China's equivalence to the General Data Protection Regulation (GDPR) of the European Union. Compared to the Cybersecurity Law introduced in 2016, the Data Security Law provided legal protection for personal information and essential data. Prior to its release, China had published several policy documents on the protection of personal information. These policies, however, did not possess explicit legal force for implementation. Therefore, the Data Security Law is considered the first legal regulation on data security in China (Jiang & You, 2019).

The Data Security Law concerns the whole lifecycle of data governance, including the collection, storage, transmission, processing, and use of data, as well as the protection, supervision, and administration of data security (State Internet Information Office, 2019). By clarifying regulations, the law is expected to effectively promote the application and transaction of data, which would ultimately promote the development of the digital industry. For data collection, network data operators need to formulate and inform rules about the storage

methods and retention period of personal data before they collect them. For data processing and use, the network operators need to ensure data users' consent and timely responses to users. For supervision and regulation of data security, the Cyberspace Administration of China and relevant departments of the State Council are responsible for the security protection of data provided by network operators. Network operators are required to promptly inform users when security incidents occur. When network operators violate the laws, punishment measures such as confiscating income or suspending operations will be implemented (National People's Congress of the People's Republic of China, 2021). The Data Security Law has also introduced a data protection system according to different types and significance levels of data (National People's Congress of the People's Republic of China, 2021). These provisions would help private companies that participate in data-related activities implement their plans and guidelines for data security.

There are still challenges that remain in the law with regard to data security and privacy protection. For example, the feasibility of implementing regulations and policies needs to be considered carefully in the context of smart cities. The number of subjects and the volume of data would be overwhelming due to the dynamic nature of real-time data and the wide range of network operators. The proposed record system to review and manage the data security mechanism for network operators might be challenging to implement. Also, compared with the significant fines that can be imposed on companies under the EU's GDPR, the measures introduced in China enforce relatively weaker penalties, which are only limited to warnings and exposure to the public.

6.2 Policies for promoting data trading and applications

While data security and privacy protection are increasingly emphasized, with the emergence of the digital economy, data are expected to contribute to stimulating innovation. Hence a significant challenge in data governance is to encourage stakeholders in society to use data for various applications, particularly for economic and business purposes. It is crucial to clarify the conditions and requirements for handling data so that data users would be assured of the protection of their data assets. Intending to address this issue, the Shenzhen Municipal Government issued the Data Regulations of Shenzhen Special Economic Zone in July 2021 (Standing Committee of People's Congress in Shenzhen, 2021). In this legislation, a specific framework for data markets has been introduced to facilitate the exchange of data. That has

brought a new perspective that the digital economy requires serious consideration and clarification in dealing with data for economic and industrial development.

The most fundamental challenge in protecting data assets is to clarify the data definitions and data categories. The Shenzhen Data Regulation elaborates further on data classification, data activities, and security guarantees, taking forward many issues introduced in the Data Security Law. For example, the regulation distinguishes public data from government data. Public data refers to various types of data collected, generated, recorded, or saved in a particular form when government agencies provide public services (Standing Committee of People's Congress in Shenzhen, 2021). Therefore, the definition of public data is broader than that of government data. Even though data are not controlled internally by government departments or are from private sectors, they are regarded as public data as long as they are used for public purposes.

The Shenzhen Data Regulation also provides a legal basis for public management and service agencies to acquire external data from private enterprises (Standing Committee of People's Congress in Shenzhen, 2021). Further clarification would be required about how much the government should pay for the data procured from external organizations and whether data services integrating data possessed by the government and private enterprises can be provided (Lovells, 2021). Nevertheless, these innovative measures of the Shenzhen Data Regulation indicate that the city intends to utilize all the data in society. With a shift from e-government and the traditional smart city to the new one, data resources have expanded just from government data to diverse types of data, including the Internet and enterprise data. Government data platforms that were only for internal use are now integrated into a city-wide big data platform, which would be more convenient for various stakeholders in society to use.

Recognizing personal data rights is also crucial for protecting data assets. Provisions on data rights for stakeholders in society have been provided in the Shenzhen Data Regulation. In particular, personality rights have been specified for individuals in dealing with their personal data. This would be considered to allow individuals to control the commercialization of their data. It is still not clear, however, whether individuals have the right to benefit from the transactions of their data (Lovells, 2021). Data companies also have the data rights to the data they collected legally and the copyright of the data they produced. Overall, the Shenzhen Data Regulation has initiated an innovative approach to data governance. The concept of public data

is clarified, and data rights are recognized for individuals and private enterprises. There is still a lack of detailed instruction about what can be categorized as public data. And the definition of personal data is not necessarily consistent in different policies and regulations. That could confuse private enterprises in implementing data security management and privacy protection and discourage sharing and using data to create innovation as expected in implementing the policy.

The use of data for fostering innovation needs an institutional environment where economic transactions of data can be conducted in a reliable and consistent manner. Addressing this issue, the Communist Party of China Central Committee and the State Council published the Opinions on Improving the Allocation Systems and Mechanisms of Marketization of Production Factors in April 2020 (XinhuaNewsAgency, 2020). Data has been recognized for the first time as a new factor of production, regarded as equal to land, labor, capital, and technology. Specific regulations were called for on the incubation of the data market and the measures for data pricing. For an environment conducive to the marketization of data, it is crucial to implement regulations concerning data handling, integrate government data and public data, and facilitate the commercialization of data applications.

Measures to establish a data trading system have been introduced in the Shenzhen Data Regulation, clarifying the scope and standards of data trading. Trading of data products and services containing personal data obtained without legal authorization or public data that has not been legally released is explicitly prohibited. Rules for data trading and information disclosure need to be developed for platforms. They are required to maintain a secure, controllable, and traceable trading environment with explicit measures to protect personal data, trade secrets, and important data specified by relevant regulations (Lovells, 2021).

A critical element of an institutional arrangement that facilitates data transactions is the pricing of data. As there were very few practices of properly pricing data for economic activities, Shenzhen has become the first city in China to pilot statistical accounting of data production factors (Shenzhen Special Zone News, 2021). In January 2021, the municipal government released the Implementation Plan to Carry Out the Pilot Project of Statistical Accounting of Data Factors (Shenzhen Business Daily, 2021). An accounting system for data factors would include the statistical accounting methodology, statistical reporting system, and the digital

GDP accounting methodology. Close cooperation has been initiated between government agencies such as the Data Bureau and local digital technology companies such as Ping An Smart City, Shun Feng Technology, and WeBank.

At the forefront of China's reform and opening-up policy, Shenzhen plays a leading role in data exchange and international cooperation in the context of the Greater Bay Area. The Outline Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area was published in February 2019 (Xinhua, 2019). This plan proposed to jointly develop a big data center in the region and provide a platform for international innovation. Subsequently, the Implementation Plan for the Comprehensive Pilot Reform in Shenzhen to Build the City into a Pilot Demonstration Zone of Socialism with Chinese Characteristics (2020-2025) was released in October 2020 (Xinhua, 2020). In this plan, Shenzhen is expected to lead new initiatives on data governance to formulate institutional systems for the protection and utilization of data property rights, privacy protection, open sharing of government data, a data platform, and a data trading market in the Greater Bay Area. The Shenzhen-Hong Kong-Macao Data Accommodation Committee has been proposed in the Shenzhen Data Regulation. Its mission would be to establish common governance mechanisms of data security and data integration in the region. As Shenzhen and Hong Kong have different frameworks to protect personal information, it remains to be seen what kind of approach would be taken to a shared system of data governance in the region.

7 Discussion and Conclusion

Data governance is a critical issue in developing smart cities. There are few previous studies, however, that analyzed actual practices of data governance in smart cities in China. More specifically, little empirical research has been done on what kinds of institutional arrangements are introduced for data governance, how data openness promotes innovation, and how potential data security and privacy risks are addressed. This paper aims to examine the development of data governance for smart cities in China by taking the case of Shenzhen as a leading example. Shenzhen has initiated novel policies and introduced innovative concepts, such as sharing principles and data rights, ahead of most cities in the country. Focusing on the city's data governance scheme in the smart city context, we conducted a detailed analysis of the practice of data collection, sharing, and use while addressing concerns about data security and privacy. Moreover, we specifically discussed with a case about citizens' participation in the smart city

projects in Shenzhen, and the public private cooperation in the construction and maintenance of the big data systems.

Compared with other countries, data governance for smart cities in China places a particular emphasis on the centralized approach led by the government. In Shenzhen, data governance has evolved from addressing the fragmentation of data among government divisions to fostering the integration of various kinds of data in society. The municipal government has played a major role in coordinating different stakeholders to join the data-related activities, cooperating with technology enterprises to co-construct the open data platforms through various modes of contracting and outsourcing. With these arrangements, the Shenzhen government intends to build an integrated data governance system covering various sectors of society. Projects such as the Zhi Wang project were implemented to develop open data programs, build data platforms with enterprises through public-private partnerships, and collect data from the public. Open data platforms have provided opportunities for the municipal government to share public data with enterprises and the general public for various applications. Measures to facilitate the trading of data through market mechanisms have been initiated recently. On the other hand, citizens have been recognized to have data rights as data providers and owners. The municipal government has also started to introduce specific standards and rules to protect data security and privacy, implementing the general policy framework provided by the central government.

Nevertheless, there still remain many challenges that face smart city development in China. For data collection, there are not sufficient incentives for private sectors and citizens to provide their information. Under the principle of voluntary data provision, private enterprises or individuals may not necessarily be willing to provide their data or might provide inaccurate information. Close coordination between public agencies is still a significant challenge in sharing data, and many barriers and obstacles remain in effectively establishing a comprehensive public data platform. For data openness, many data sets are not presented in the natural form, making it difficult for enterprises and individuals to use the data. Also, data need to be standardized to enable broader use of data for different purposes and applications. Although the government information center would usually be in charge of this function, the sheer volume of data slows down the progress in the open data platform. Furthermore, the value of data is not necessarily recognized appropriately in the private sector. For enterprises

participating in the smart city, their data assets are hard to evaluate, discouraging exchanging and utilizing data to facilitate innovation through collaboration with other actors. While various kinds of data are collected in the smart city, citizens are not necessarily informed well of what kinds of data are actually collected and how these data are processed and used for what purposes. Institutional mechanisms are not yet sufficiently available for citizens to provide their needs and expectations about their data in smart cities. Also, citizens may not have sufficient knowledge or expertise to make use of the data available through open data platforms. It would be crucial to explore ways to encourage active participation and engagement of citizens in data governance. That would help their views and preferences be reflected adequately for the people-centered approach to smart city development in China.

There are some limitations recognized in this study. The information used in this study mainly comes from open information sources of the government and public agencies and interviews with a corporate employee who has been involved in the smart city development. Views and opinions of other stakeholders, including citizens, are not incorporated into the discussion. Further research is necessary to examine to what extent citizens are satisfied with the policies and regulations concerning data governance, particularly with regard to data security and the protection of privacy. Although a broad historical overview of data governance in Shenzhen is provided in this paper, the city's smart city development is still evolving rapidly, which would require continued investigation. To better understand the data governance in China, future research could focus on more specific aspects of data governance and explore emerging institutional arrangements and stakeholder behavior.

Disclosure statement

The authors have no potential conflict of interest.

Ethics approval

This research has been approved by the Human Participants Research Panel of the Hong Kong University of Science and Technology (HPR #451).

References

- Abraham, R., Schneider, J., & vom Brocke, J. (2019). Data governance: A conceptual framework, structured review, and research agenda. *International Journal of Information Management*, 49, 424-438. doi:<https://doi.org/10.1016/j.ijinfomgt.2019.07.008>
- Allam, Z., & Dhunny, Z. A. (2019). On big data, artificial intelligence and smart cities. *Cities*, 89, 80-91. doi:<https://doi.org/10.1016/j.cities.2019.01.032>
- Allen, B. P., Gilles; Juillet, Luc; Roy, Jeffrey. (2005). E-Government as Collaborative Governance: Structural, Accountability and Cultural Reform. In *Practicing E-Government: A Global Perspective* (pp. 1-15): IGI Global.
- Angelidou, M. (2014). Smart city policies: A spatial approach. *Cities*, 41, S3-S11. doi:<https://doi.org/10.1016/j.cities.2014.06.007>
- Baesens, B., Bapna, R., Marsden, J. R., & Jan, V. (2014). Transformational issues of big data and analytics in networked business. *MIS Quarterly*, 38(2), 629-631. doi:10.25300/MISQ/2016/40:4.03
- Bakici, T., Almirall, E., & Wareham, J. (2013). A Smart City Initiative: The Case of Barcelona. *Journal of the Knowledge Economy*, 4(2), 135-148. doi:10.1007/s13132-012-0084-9
- Ball, C. (2009). What Is Transparency? *Public Integrity*, 11(4), 293-308. doi:10.2753/PIN1099-9922110400
- Bertot, J. C., Jaeger, P. T., & Grimes, J. M. (2010). Using ICTs to create a culture of transparency: E-government and social media as openness and anti-corruption tools for societies. *Government Information Quarterly*, 27(3), 264-271. doi:<https://doi.org/10.1016/j.giq.2010.03.001>
- Bolívar, M. P. R. (2017). User centric services under the web 2.0 era. Coproduction, execution and efficiency of public services. In *User Centric E-Government* (pp. 137-158): Springer.
- Bonina, C., & Eaton, B. (2020). Cultivating open government data platform ecosystems through governance: Lessons from Buenos Aires, Mexico City and Montevideo. *Government Information Quarterly*, 37(3), 101479. doi:<https://doi.org/10.1016/j.giq.2020.101479>
- Borgman, H., Heier, H., Bahli, B., & Boekamp, T. (2016, 5-8 Jan. 2016). *Dotting the I and Crossing (out) the T in IT Governance: New Challenges for Information Governance*. Paper presented at the 2016 49th Hawaii International Conference on System Sciences (HICSS).
- Botta, A. d. D., Walter; Persico, Valerio; Pescapé, Antonio. (2016). Integration of Cloud computing and Internet of Things: A survey. *Future Generation Computer Systems*, 684-700. doi:10.1016/j.future.2015.09.021
- Broccardo, L., Culasso, F., & Mauro, S. G. (2019). Smart city governance: exploring the institutional work of multiple actors towards collaboration. *International Journal of Public Sector Management*, 32(4), 367-387. doi:10.1108/IJPSM-05-2018-0126
- Caragliu, A., & Del Bo, C. F. (2019). Smart innovative cities: The impact of Smart City policies on urban innovation. *Technological Forecasting and Social Change*, 142, 373-383. doi:<https://doi.org/10.1016/j.techfore.2018.07.022>
- Cardullo, P. K., Rob. (2019). Being a 'citizen' in the smart city: up and down the scaffold of smart citizen participation in Dublin, Ireland. *GeoJournal*, 84(1), 1-13. doi:10.1007/s10708-018-9845-8
- Chen, G. (2020). 《数据安全法》公布——数字经济时代下划定数据法律红线 (Announcement of the "Data Security Law" - Delineating the Red Line of Data Law in

- the Digital Economy Era). *Jiemian Newspaper*. Retrieved from <https://www.jiemian.com/article/4646157.html>
- China Academy of Information and Communications Technology. (2019). *新型智慧城市发展研究报告 (2019年)* (*New Smart City Development Research Report (2019)*). Retrieved from
- Clarke, A., & Margetts, H. (2014). Governments and Citizens Getting to Know Each Other? Open, Closed, and Big Data in Public Management Reform. *Policy & Internet*, 6(4), 393-417. doi:10.1002/1944-2866.Poi377
- DataManagementBureau. (2022). Shenzhen Municipal Government Open Data Platform Retrieved from <https://opendata.sz.gov.cn/>
- Deloitte. (2012). *Open data: Driving growth, ingenuity and innovation* Retrieved from <https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/deloitte-analytics/open-data-driving-growth-ingenuity-and-innovation.pdf>
- Deloitte. (2020). *Super smart city 2.0*. Retrieved from <https://www2.deloitte.com/cn/zh/pages/public-sector/articles/super-smart-city-2-0.html>.
- Dhungana, D., Engelbrecht, G., Parreira, J. X., Schuster, A., & Valerio, D. (2015, 14-16 Dec. 2015). *Aspern smart ICT: Data analytics and privacy challenges in a smart city*. Paper presented at the 2015 IEEE 2nd World Forum on Internet of Things (WF-IoT).
- Dulong de Rosnay, M., & Janssen, K. (2014). Legal and Institutional Challenges for Opening Data across Public Sectors: Towards Common Policy Solutions. *Journal of theoretical and applied electronic commerce research*, 9, 1-14. Retrieved from http://www.scielo.cl/scielo.php?script=sci_arttext&pid=S0718-18762014000300002&nrm=iso
- Dyche, J., & Levy, E. (2006). *Customer Data Integration: Reaching a Single Version of the Truth*: Wiley.
- Effendi, D., Syukri, F., Subiyanto, A. F., & Utdityasan, R. N. (2016, 20-21 July 2016). *Smart city Nusantara development through the application of Penta Helix model (A practical study to develop smart city based on local wisdom)*. Paper presented at the 2016 International Conference on ICT For Smart Society (ICISS).
- EfficiencyUnit. (2008). *An Introductory Guide to Public Private Partnerships (PPPs)*. Retrieved from https://www.effo.gov.hk/en/reference/publications/ppp_guide_2008.pdf
- Elmaghraby, A. S., & Losavio, M. M. (2014). Cyber security challenges in Smart Cities: Safety, security and privacy. *Journal of Advanced Research*, 5(4), 491-497. doi:<https://doi.org/10.1016/j.jare.2014.02.006>
- Erie, M. S. S., Thomas. (2021). The Beijing Effect: China's 'Digital Silk Road' as Transnational Data Governance. *JOURNAL OF INTERNATIONAL LAW AND POLITICS*, 54(1). Retrieved from <https://ssrn.com/abstract=3810256>
- Faroqi, M. G. (2015). Financial sustainability of union digital center in Bangladesh *The Journal of Developing Areas*, 49(6), 61-73. doi:10.1353/jda.2015.0096
- General Office of Shenzhen Municipal Committee of the Communist Party of China, & General Office of Shenzhen Municipal People's Government. (2014). *中共深圳市委办公厅 深圳市人民政府办公厅关于印发《关于全面推进社会建设“织网工程”的实施方案 (试行)》的通知* (*Notice of the General Office of the Shenzhen Municipal Committee of the Communist Party of China and the General Office of the Shenzhen Municipal People's Government on Printing and Distributing*

- the "Implementation Plan for Comprehensively Promoting Social Construction "Net Weaving Project (Trial)". Retrieved from
- Gil-Garcia, J. R. M.-M., Ignacio J. (2007). Understanding the evolution of e-government: The influence of systems of rules on public sector dynamics. *Government Information Quarterly*, 24(2), 266-290. doi:<https://doi.org/10.1016/j.giq.2006.04.005>
- Große-Bley, J., & Kostka, G. (2021). Big Data Dreams and Reality in Shenzhen: An Investigation of Smart City Implementation in China. *Big Data & Society*, 8(2). doi:10.1177/20539517211045171
- Hagmann, J. (2013). Information governance – beyond the buzz. *Records Management Journal*, 23(3), 228-240. doi:<https://doi.org/10.1108/RMJ-04-2013-0008>
- iShenzhen. (2020). 助力疫情防控，深圳上线“深 i 您-自主申报平台” (To help prevent and control the epidemic, Shenzhen develop “Shen i Nin - individual reporting platform”). *iShenzhen*. Retrieved from http://www.sz.gov.cn/szzt2010/yqfk2020/content/post_6694921.html
- Islam, M. N. I., Md. Aktarul. (2018). Exploring the shortcomings of Union Digital Center (UDC) in Bangladesh- A Study. *Indian Journal of Library and Information Science*, 12(2). doi:10.21088/ijlis.0973.9548.12218.4
- Jiang, L., & You, Y. (2019). 详解《数据安全管理办法(征求意见稿)》: 备案时代即将到来? (Detailed Explanation of the "Data Security Management Measures (Draft for Comment)": Is the Era of Putting on Record Coming Soon?). Retrieved from
- Jin, J., Gubbi, J., Marusic, S., & Palaniswami, M. (2014). An Information Framework for Creating a Smart City Through Internet of Things. *IEEE Internet of Things Journal*, 1(2), 112-121. doi:10.1109/jiot.2013.2296516
- Jung, K., & Park, H. W. (2015). A semantic (TRIZ) network analysis of South Korea's "Open Public Data" policy. *Government Information Quarterly*, 32(3), 353-358. doi:<https://doi.org/10.1016/j.giq.2015.03.006>
- Kaliannan, M. A., Halimah; Raman, Murali (2010). <Public-private partnership for e-government services- lesson from Malaysia.pdf>. *International Journal of Institutions and Economies*, 2(2), 207-220. Retrieved from https://www.academia.edu/1791387/Public_private_partnerships_for_e_government_services_lessons_from_Malaysia
- Kassen, M. (2022). Open Data Governance in Finland: Understanding the Promise of Public-Private Partnerships. In *Open Data Governance and Its Actors* (pp. 65-96).
- Khatri, V., & Brown, C. V. (2010). Designing data governance. *Commun. ACM*, 53(1), 148–152. doi:10.1145/1629175.1629210
- Kulk, S., & van Loenen, B. (2012). Brave New Open Data World? *International Journal of Spatial Data Infrastructures Research*, 7, 196-206.
- Li, Q., Lan, L., Zeng, N., You, L., Yin, J., Zhou, X., & Meng, Q. (2019). A Framework for Big Data Governance to Advance RHINs: A Case Study of China. *IEEE Access*, 7, 50330-50338. doi:10.1109/access.2019.2910838
- Li, V. Q. T., Ma, L., & Wu, X. (2022). COVID-19, policy change, and post-pandemic data governance: a case analysis of contact tracing applications in East Asia. *Policy and Society*, 41(1), 129-142. doi:10.1093/polsoc/puab019
- Li, X., Han, D., & Cui, X. (2014). 深圳'织网工程': 创新社会治理的新标本 (Shenzhen 'Net Weaving Project': A New Specimen of Innovative Social Governance). *Administration Reform*, 10, 48-53.

- Lin, Y. (2017). *深圳 建设国家新型智慧城市 (Shenzhen: Constructing National New-Type Smart Cities)*. Retrieved from
- Lin, Y., Zhang, X., & Geertman, S. (2015). Toward smart governance and social sustainability for Chinese migrant communities. *Journal of Cleaner Production*, 107, 389-399. doi:<https://doi.org/10.1016/j.jclepro.2014.12.074>
- Linders, D. (2012). From e-government to we-government: Defining a typology for citizen coproduction in the age of social media. *Government Information Quarterly*, 29(4), 446-454. doi:10.1016/j.giq.2012.06.003
- Liu, T., Yang, X., & Zheng, Y. (2020). Understanding the evolution of public-private partnerships in Chinese e-government: four stages of development. *Asia Pacific Journal of Public Administration*, 42(4), 222-247. doi:10.1080/23276665.2020.1821726
- Lovells, H. (2021). Shenzhen finalizes the local data regulation. Retrieved from <https://www.engage.hoganlovells.com/knowledgeservices/news/shenzhen-finalizes-the-local-data-regulation>.
- Ma, L., Christensen, T., & Zheng, Y. (2021). Government technological capacity and public-private partnerships regarding digital service delivery: evidence from Chinese cities. *International Review of Administrative Sciences*, 1-17. doi:10.1177/00208523211018849
- Magalhaes, G. R., Catarina (2020). Open government data and the private sector: An empirical view on business models and value creation. *Government Information Quarterly*, 37(3). doi:<https://doi.org/10.1016/j.giq.2017.08.004>
- Mayernik, M. S. (2017). Open data: Accountability and transparency. *Big Data & Society*, 4(2). doi:<https://doi.org/10.1177/2053951717718853>
- Medaglia, R. H., Jonas. (2017). *It Takes Two to Tango Power Dependence in the Governance of Public-Private e Government Infrastructures*. Paper presented at the ICIS 2017 Proceedings, Seoul Korea.
- Meijer, A., & Bolívar, M. P. R. (2016). Governing the smart city: a review of the literature on smart urban governance. 82(2), 392-408. doi:10.1177/0020852314564308
- Nam, T., & Pardo, T. A. (2011). *Conceptualizing smart city with dimensions of technology, people, and institutions*. Paper presented at the Proceedings of the 12th Annual International Digital Government Research Conference on Digital Government Innovation in Challenging Times - dg.o '11.
- National People's Congress of the People's Republic of China. (2021). *中华人民共和国数据安全法 (Data Security Law of the People's Republic of China)*. Retrieved from
- Ojo, A., Curry, E., & Zeleti, F. A. (2015, 5-8 Jan. 2015). *A Tale of Open Data Innovations in Five Smart Cities*. Paper presented at the 2015 48th Hawaii International Conference on System Sciences.
- opengovdata. (2007). The 8 Principles of Open Government Data. Retrieved from <https://opengovdata.org/>
- Otto, B. (2011). Organizing Data Governance: Findings from the Telecommunications Industry and Consequences for Large Service Providers. *Communications of the Association for Information Systems*, 29(3), 45-66.
- Palaco, I., Park, M. J., Kim, S. K., & Rho, J. J. (2019). Public-private partnerships for e-government in developing countries: An early stage assessment framework. *Evaluation and Program Planning*, 72, 205-218. doi:10.1016/j.evalprogplan.2018.10.015

- Paskaleva, K., Evans, J., Martin, C., Linjordet, T., Yang, D., & Karvonen, A. (2017). Data Governance in the Sustainable Smart City. *Informatics*, 4(4). doi:10.3390/informatics4040041
- Piro, G. C., I.; Grieco, L.A.; Camarda, P. (2013). Information centric services in Smart Cities. *Journal of Systems and Software*, 88(1), 169-188. doi:<https://doi.org/10.1016/j.jss.2013.10.029>
- Roy, J. (2014). Open Data and Open Governance in Canada: A Critical Examination of New Opportunities and Old Tensions. *Future Internet*, 6(3), 414-432. doi:doi:10.3390/fi6030414
- Ruhlandt, R. W. S. (2018). The governance of smart cities: A systematic literature review. *Cities*, 81, 1-23. doi:10.1016/j.cities.2018.02.014
- Ruhlandt, R. W. S., Levitt, R., Jain, R., & Hall, D. (2020). One approach does not fit all (smart) cities: Causal recipes for cities' use of “data and analytics”. *Cities*, 104, 102800. doi:<https://doi.org/10.1016/j.cities.2020.102800>
- Ruuska, I., & Teigland, R. (2009). Ensuring project success through collective competence and creative conflict in public–private partnerships – A case study of Bygga Villa, a Swedish triple helix e-government initiative. *International Journal of Project Management*, 27(4), 323-334. doi:10.1016/j.ijproman.2008.02.007
- Shenzhen Business Daily. (2021). *深圳加快培育数据要素市场 (Shenzhen accelerates the cultivation of the data factor market)*. Retrieved from
- Shenzhen Industrial and Information Technology Bureau. (2013). *智慧深圳规划纲要 (2011-2020) (Smart Shenzhen Planning Outline (2011-2020))*. Retrieved from
- Shenzhen Municipal People's Government. (2015). *深圳市人民政府关于印发深圳市政务信息资源共享管理办法的通知 (Notice of the Shenzhen Municipal People's Government on Issuing the Measures for the Administration of Shenzhen Municipal Government Information Resource Sharing)*. Retrieved from
- Shenzhen Municipal People's Government. (2018). *深圳市人民政府关于印发新型智慧城市建设总体方案的通知 (Notice of the Shenzhen Municipal People's Government on Printing and Distributing the Overall Plan for the Construction of a New Smart City)*. Retrieved from
- Shenzhen Special Zone News. (2021). *数据生产要素统计核算明年全市试点 (Statistical accounting of data production factors will be piloted in the city next year)*. Retrieved from
- Shenzhen Government. (2022). *深圳市数字政府和智慧城市“十四五”发展规划 (Shenzhen Digital Government and Smart City “Fourteenth Five-Year Plan for Development”)*. Retrieved from <http://www.sz.gov.cn/szsj/attachment/0/984/984031/9867741.pdf>
- Sieber, R. E., & Johnson, P. A. (2015). Civic open data at a crossroads: Dominant models and current challenges. *Government Information Quarterly*, 32(3), 308-315. doi:10.1016/j.giq.2015.05.003
- Silva, B. N., Khan, M., & Han, K. (2018). Towards sustainable smart cities: A review of trends, architectures, components, and open challenges in smart cities. *Sustainable Cities and Society*, 38, 697-713. doi:<https://doi.org/10.1016/j.scs.2018.01.053>
- Standing Committee of People's Congress in Shenzhen. (2021). *深圳经济特区数据条例 (Data Regulations of Shenzhen Special Economic Zone)*. Retrieved from

- State Internet Information Office. (2019). *Measures for Data Security Management (数据安全全管理办法 (征求意见稿))*. Retrieved from
- StatisticalBureau. (2010). The Sixth Population Census of China.
- Stübinger, J., & Schneider, L. (2020). Understanding Smart City—A Data-Driven Literature Review. *Sustainability*, 12(20). doi:10.3390/su12208460
- Sun, Y., Song, H., Jara, A. J., & Bie, R. (2016). Internet of Things and Big Data Analytics for Smart and Connected Communities. *IEEE Access*, 4, 766-773. doi:10.1109/access.2016.2529723
- Tan, S. Y., & Taeihagh, A. (2020). Smart City Governance in Developing Countries: A Systematic Literature Review. *Sustainability*, 12(3), 899. Retrieved from <https://www.mdpi.com/2071-1050/12/3/899>
- Tan, S. Y. T., Araz. (2020). Smart City Governance in Developing Countries: A Systematic Literature Review. *sustainability*, 12(3). doi:<https://doi.org/10.3390/su12030899>
- Tencent Cloud Employee. (2020a). *Personal Interview 1*. Retrieved from
- Tencent Cloud Employee. (2020b). *Personal Interview 2*. Retrieved from
- TencentCloud. (2020a, 23 July) *Personal Interview 1/Interviewer: X. Siqu*.
- TencentCloud. (2020b, 30 July) *Personal Interview 2*.
- Thomas, V., Wang, D., Mullagh, L., & Dunn, N. (2016). Where's Wally? In Search of Citizen Perspectives on the Smart City. *Sustainability*, 8(3). doi:10.3390/su8030207
- Tranos, E., & Gertner, D. (2012). Smart networked cities? *Innovation: The European Journal of Social Science Research*, 25(2), 175-190. doi:10.1080/13511610.2012.660327
- United Nations Department of Economic and Social Affairs. (2018). *World Urbanization Prospects: The 2018 Revision*. Retrieved from
- van Zoonen, L. (2016). Privacy concerns in smart cities. *Government Information Quarterly*, 33(3), 472-480. doi:<https://doi.org/10.1016/j.giq.2016.06.004>
- Wang, J. (2022). Performative innovation: Data governance in China's fintech industries. *Big Data & Society*, 9(2). doi:10.1177/20539517221123312
- Wirtz, B. W., Piehler, R., Thomas, M.-J., & Daiser, P. (2016). Resistance of Public Personnel to Open Government: A cognitive theory view of implementation barriers towards open government data. *Public Management Review*, 18(9), 1335-1364. doi:10.1080/14719037.2015.1103889
- Wu, G. (2019). 深圳市政务大数据资源平台的实践 (The Practice of Shenzhen Government's Big Data Resource Platform). *Information China*(6), 80-87.
- Xinhua. (2019). 中共中央国务院印发《粤港澳大湾区发展规划纲要》 (The Central Committee of the Communist Party of China and the State Council Issued "Outline Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area"). Retrieved from http://www.gov.cn/zhengce/2019-02/18/content_5366593.htm#allContent
- Xinhua. (2020). 中共中央办公厅 国务院办公厅印发《深圳建设中国特色社会主义先行示范区综合改革试点实施方案 (2020 - 2025 年) 》 (The General Office of the Central Committee of the Communist Party of China and the General Office of the State Council Issued "Implementation Plan for the Comprehensive Pilot Reform in Shenzhen to Build the City into a Pilot Demonstration Zone of Socialism with Chinese Characteristics (2020-2025)"). Retrieved from http://www.gov.cn/zhengce/2020-10/11/content_5550408.htm

- XinhuaNet. (2002). 深圳投资 6000 万元建设电子政务示范工程 (Shenzhen invested 60 million yuan to construct the e-government demonstration project). Retrieved from <http://tech.sina.com.cn/i/c/2002-08-22/0746133970.shtml>
- XinhuaNewsAgency. (2020). 中共中央 国务院关于构建更加完善的要素市场化配置体制机制的意见 (*Opinions of the Central Committee of the Communist Party of China and the State Council on Building a More Perfect Market-Based Allocation System and Mechanism for Factors of Production*). Retrieved from http://www.gov.cn/zhengce/2020-04/09/content_5500622.htm
- Yang, S. (2019). 智慧城市案例100 / 中电科智慧院孙亭：顶层设计该是“一把手”工程 (*Smart City Case 100 / Sun Ting, Smart City Research Institute, China Electronics Technology Group: The top-level design should be the "leading" project*). Retrieved from
- Yang, X., Liu, T., & Zheng, Y. (2020). Review of Public-Private Partnership Research in Digital Governance: Practice, Issues and Prospects. *Public Administration and Policy Review*, 9(5), 3-18. Retrieved from <http://ggglyzc.ruc.edu.cn/CN/article/downloadArticleFile.do?attachType=PDF&id=394>
- Zanella, A., Bui, N., Castellani, A., Vangelista, L., & Zorzi, M. (2014). Internet of Things for Smart Cities. *IEEE Internet of Things Journal*, 1(1), 22-32. doi:10.1109/jiot.2014.2306328
- Zhang, T. (2022). 政府数据开放中个人信息保护的范式转变 (Paradigm Shift of Personal Information Protection in Open Government Data). *Modern Law Science* 44(1), 125-143.