An investigation of smart transportation system (STS) data integration within Chinese cities: A socio-technical system perspective

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"Always be yourself, express yourself, have faith in yourself, do not go out and look for a successful personality and duplicate it."

—— Bruce Lee

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Abstract

In March 2014, the Central Committee of the Communist Party of China and the State Council of China jointly released the National New-type Urbanization Plan (NUP) (2014-2020). Smart City development is one of the main objectives of this policy. Amongst many smart city domains, smart transportation systems (STS) are considered an important component that leverages information and communication technologies (ICT) to effectively improve urban transportation efficiency and address transportation-related urban pathologies. However, the state of play of the current STS is that various sub-systems are functionally and technically independent, with much of the data remaining in silos and being difficult to integrate due to varying socio-technical barriers. There has been very little research that looks at the potential for data integration solutions in STS from both social and technical aspects, particularly in the Chinese context. The aim of this research is to fill the gap.

The study aims to explore the challenges and opportunities for initiating a data-integrated smart transportation system application in the context of China's new-type urbanisation from a socio-technical system perspective. To achieve this aim, this study adopted a qualitative, interpretative, single case study methodology. Data were collected in three successive phases. These research methods and phases were *six focus groups* with citizen end-users aged between 25 and 60 years old who use different means of transport, *15 semi-structured interviews* with private STS enterprise experts holding various positions, and *five semi-structured interviews* with government transportation agencies with various administrative responsibilities. All three stages of data collection were conducted in the case city of Shijiazhuang, Hebei, China. A thematic approach was used to analyse the research data from these sites.

The findings of this research are presented separately according to each of the three perspectives (i.e. citizen end-users, STS enterprises and government transportation agencies), then synthesised to develop a systemic understanding of the potential socio-technical challenges and opportunities that would occur if efforts to initiate a data-integrated STS application were initiated within the distinctive Chinese socio-political context. The study revealed that the current centralised, top-down political and legal systems determine that private sectors are constrained in co-creating STS initiatives with little self-autonomy under the partnership with government. The existing form of STS governmentality in Chinese cities

is techno-political in nature, pro-business and technologically deterministic, overlooking grassroot societal demand and local contingencies. While citizens as end-users are encouraged to participate in building STS initiatives, they have rather limited roles in the initial design and decision-making process. Meanwhile, the study also found that potential opportunities reside in (1) the continuing effort to refashion the current organisational structure in both government and private sites in order to become more efficient in information dissemination and resource distribution; (2) building on the sector alliances and coordination mechanisms with more transparent and efficient channels for data governance and exchange; and (3) the growing marketisation and entrepreneurship with many urban indigenous business opportunities and good innovation conditions which stimulate economic competitiveness and diverseness of future initiatives. This study also develops a theoretical framework to visualise the factors influencing the successful design and implementation of future data-integrated STS initiatives in Chinese city context based upon these defined challenges and opportunities.

This study concludes by providing both theoretical and practical implications of initiating future STS solutions. It provides an enhanced theoretical understanding of using a socio-technical approach to examine the challenges and opportunities that are likely to be faced with the initiation of future STS solutions. It also delivered practical guidance for smart city practitioners to initiate more citizen-engaged, value co-created and sustainable STS solutions.

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Chapter 1: Introduction

1.1 Research background

In March 2014, the Central Committee of the Communist Party of China and the State Council of China jointly released the National New-type Urbanization Plan (NUP) (2014-2020). According to this plan, China's urban population increase was estimated to be approximately 30 million each year with about 400 million people immigrating into cities by 2020; ten super cities with populations above 10 million are also predicted to exist by this date (China's National Development and Reform Commission [CNDRC], 2014; Qian, 2014). In addition, as an important reform of this plan, the upgrade of urban household registration system ("Hukou" in Chinese) indicated that 100 million people who currently hold agricultural "Hukou" would be granted urban "Hukou" by 2020. As such, residents with urban "Hukou" have been increasingly involved in both producing and using public services. Such figures suggest that, although China's urbanisation is under significant pressure, it would be able to stimulate more job opportunities in urban areas, and was expected to generate 'entrepreneurial cities', 'smart cities', 'sustainable cities' and 'cultural cities' on a pilot basis.

Nevertheless, such reform requires significant social and political commitments, with emphasis on empowering bottom-up grassroot citizens to participate in urban planning to advance urban initiatives (Huifeng Li & De Jong, 2017), propelling social organisations and businesses to enhance capacity and capabilities in innovation development (De Jong et al., 2016; Qian, 2014), and strengthening government agencies in terms of setting political imperatives and legitimising those innovative solutions (CNDRC, 2014; Griffiths & Schiavone, 2016; D. Wang et al., 2015). In other words, smart innovative solutions involve interactions between innovative solutions per se and various stakeholders, such as citizens, business enterprises and government.

The new urbanism process aims to provide cities with a more efficient use of resources, a more citizen-centric mode of urban life and a more optimised living environment, namely technology-enabled, citizen-focused and sustainable urbanism (J. K.-S. Chan & Anderson, 2015; M. Chen et al., 2016; CNDRC, 2014; Griffiths & Schiavone, 2016; Sun et al., 2017). As such, the Chinese government has been providing an increasing number of 'smart' services designed to help relieve the pressures of high resource consumption and creating a better life for people living in cities (M. Chen et al., 2016). The Smart City concept, therefore, emerged as the main strategy and direction of both city development management and social and economic development. The smart city has so far gained much traction amongst scholars of both information systems and urban studies to generally refer to the more efficient running of city operations and sustainable residential living conditions driven by ubiquitous and pervasive computing (Hollands, 2008; Kitchin, 2014c; Luque-Ayala & Marvin, 2019).

However, smart city developments face many challenges, which, in the organisational context, reflect issues rooted in the implemented information systems. The smart city depicts a complex urban system that is composed of various sub-systems (Falconer & Mitchell, 2012; Lombardi et al., 2012). The literature indicates that a big challenge of the smart city is 'rooted' in Information Technology (IT) systems. IT systems are developed to meet the core business objectives, such as improving competitiveness and increasing productivity and efficiency. A lot of organisations and enterprises, therefore, attempted to design and implement a large number of innovative e-commercial application systems (Pai & Tu, 2011). However, the performance increases of these information system applications were only based on software and hardware developments as well as the integration of individual computer systems. Organisations' final aim was to integrate the entire information system that would replace functionally oriented and badly linked legacy software, which would reduce the costs of infrastructure support (Hendricks et al., 2007). The integration of information systems also suggests the integration of data processed by these independent systems, through which the integrated data possess the attributes of all of previous separate applications (Litan et al., 2011). As a result, the integration of information systems has become a necessity for organisations.

However, the integrated information system is built upon socio-technical conditions. Within the context of organisations, tested the political, social, organisational, cultural and technological conditions, which contributed to information-based decision-making and effective system management of organisations (Chapman & Kihn, 2009). The fact was highlighted that the open communication, data and information-sharing and data use of the integrated system are based on the technical capacity that is accompanied by the creation and nurturing of new organisational culture as well as relevant government data policies (Zeng et al., 2007). This indicates that compared with past isolated information systems, the integrated system has reformed not only technologies but also organisational structure and culture, and political and social requirements. This is to say, exploring challenges and opportunities of integrating information systems should not only focus upon the technical aspect (e.g. system architecture, hardware and software), but also the social dimension which emphasises the changes brought about by technology wherein human has interactions and participation help to form an integration process (Mumford, 2000). Hence, it is imperative to apply a socio-technical system design vision to the innovative system design process.

This study places a particular focus on the smart transportation system (STS) in the Chinese smart city context. Urban transportation systems provide facilities and infrastructures necessary for the movement of passengers and vehicles. With the development of information and communications technologies (ICT), many previously developed transportation systems have already become ‘smart’ by implanting them with microchips and sensors, and authorizing them to communicate with each other via wireless technologies (Nagappan & Chellapan, 2009). The STS maximises infrastructure capacity, which significantly contributes to having additional highway capacity and reducing congestion. Nevertheless, rather than highlight digital and networked technologies used to enhance the efficiency of system operation and the mobility of means of transport and infrastructures (Boyce, 2009), the STS is concerned more with better quality of life, shifting the focus towards being sustainable, citizen-centric, and political and economically benign (HUAWEI, 2016). Hence, innovative STS efforts hinge on how people imagine them in terms of who they benefit, by what means, and under what socio-technical conditions.

The STS developments are experiencing the same situation discussed above: many existing STS applications and their associated data are also functionally and technically isolated. This means that data produced from one particular sub-system of the STS might not be integratable with data produced from another. The general goal of data integration for a particular system is to offer different parties with uniform access to data, though created by varying political, commercial, financial or administrative purposes, which can be reprocessed and used towards the same end (Doan et al., 2012). With this unified access, authorised users of data can extract and modify data at their own sites. Difficulties or failures to integrate data could be caused by a diverse range of socio-technical factors and may bring about further problems such as information asymmetry between users. Some of these challenges exist in all countries even though the smart city is advanced therein; others are difficulties faced in specific countries like China. The reviewed literature, and governmental and industrial reports, highlight the imperative to develop an integrated STS to replace the current applications in both global and the particular Chinese contexts (e.g. An et al., 2016; EUSME, 2015; Hall et al., 2000; Vakali et al., 2014). Based on the past experience of integration of organisational information systems, the STS could be transformed to realise the integration of all data, information and relevant functionalities.

All in all, the two most important notions of this study – the STS and its data integration – are conceptualised as follows:

- **The smart transportation system** is defined as an inclusive urban transportation system that, driven by information and communication technologies and big data, offers convenience to everyday mobility, enables sustainability of urban transportation networks, and realises instantaneous communications across modes of transport, people, devices and infrastructures.
- **STS data integration** refers to a system protocol that normalises heterogenous STS data sources to offer users with universal access, a unified view of data, and comprehensive transportation information and services into which data are turned.

There are different types of research regarding STS applications that have been conducted, which include the studies aiming at technologically functional system development, social dynamics, political requirements and constraints, and data processing issues. Each of these researches focused on a particular one or two STS applications. No research has been undertaken that investigates how different STS applications and their associated data, could be functionally integrated as a central and unified system capable of providing more intelligent and comprehensive transport services to citizens of Chinese cities. This research aims to fill this gap.

1.2 Research context

The research project will be conducted within the context of Chinese cities. The development of smart cities in China is highly significant. Firstly, urbanisation increases the pressures caused by growing populations within cities (X.-R. Wang et al., 2015). An increasing number of people in rural areas are moving into cities, making the gap between rich and poor greater still. The current rate of building cities cannot meet demand. Secondly, the increasing demand for natural resources and the speed at which they are being consumed is unsustainable. The speed of urban land resources being used is faster than that of the urbanization population increase (Seto & Kaufmann, 2003). Government focus currently remains on the ‘quantity’ rather than the ‘quality’ of particular smart city initiatives, but the concept of smart cities can bring in to focus upon the quality of citizens’ lives. Thirdly, the pressure on ecology is gradually escalating. The traditional mode of high consumption, high urban expansion, high waste disposal and low efficiency has been threatening the living environment of urban residents (Chang & Sheppard, 2013). Based on these basic national conditions within China, it is crucial to initiate smart city innovations which can be used to reduce ecological pressures especially in urban areas, in-turn, helping to improve the quality of citizens’ lives. Moreover, transportation is especially important in urban construction. Transportation systems act as arteries in the development of society and the economy (Xu et al., 2005). The proposed integrated STS could address some of the main issues of city development in China.

However, given the socio-political context of China’s ‘New-Type Urbanisation’, there might be impediments that stand in the way of the development of STS innovations. Information-based communication is hindered by the government not allowing access to their resources and not making data and information available to the public, including private sector enterprises. Data cannot be effectively shared between enterprises, and between the government and enterprises, resulting in isolated “information islands” (Economic Observer Online, 2014).

Much of the relevant data have remained in silos and have both technical and socio-political obstacles to integrate and interlink. This is leading to a necessity to expand various data-driven, networked urbanism initiatives (Kitchin, 2015a). Most of these initiatives are human-centric, focused upon interactions amongst human actors (e.g. end-users, system developers and policy-makers) and between human actors and technology, from which smart city practitioners could understand how data flows across diverse sites. Some other initiatives are built on possible solutions for future scenarios with need to take local contingencies into account, in a way of offering city managers valuable insights for planning and decision-making, and political legitimacy, with which effective and efficient smart urban governance could be achieved. In the sense of STS, this is to say, a potential scenario for STS data integration might be able to help to address the problems brought about by the "information islands". It may rely on a close-knit relationship and interaction between citizen (as end-users), STS enterprises (as system developers) and government agencies (as policy-makers), and how these actors - in a concerted effort - interact with essential technology.

Therefore, the aim of this research is constructed by an investigation into three Chinese social stakeholder perspectives – i.e. citizen end-users, STS enterprises and government agencies. Previous studies have evidenced that it was useful to place attention on the role of citizens at the consumption level, commercial companies at the production level, and governments at the policies level. Capdevila and Zarlenga (2015) develop a broader view on smart city initiatives to explore both top-down (adapting new technologies to the current citizens' needs) and bottom-up (developing new technologies on the basis of citizens' needs) dynamics in a smart city. They argue that the implementation of both types of initiatives are shaped by, and can reinforce, the collaboration of major stakeholders, such as citizens, firms and local governments. Moreover, Solano et al. (2017) highlight the need to instil corporate social responsibility among citizens, firms and political leaders as a frame of reference of the philosophical discourse about why sustainability is important in a smart city context. Likewise, as evidenced by these existing literature of smart city initiatives, the current study also pays attention to the social constructs of STS data integration initiatives from the perspectives of citizen end-users, STS enterprises and local government agencies to examine what each type of stakeholders would perceive, and the interactive roles they play in initiating the proposed data-integrated STS application.

The proposed data-integrated STS application in Chinese cities would have data that are generated from various types of transportation services. The integrated application would play an important role in collecting, processing and updating data in one place. Whilst the end-user citizens, STS enterprises and government agencies could benefit from such an integrated application, they would also face difficulties and obstacles in deploying, implementing and using such a proposed data integration solution, and the proposed solution may result in unintended consequences for society (e.g. digital marginalisation, privacy risks). Driven by the objectives of the NUP agenda as pursuing technology-enabled, citizen-centric and sustainable forms of urbanism, the purpose of this research is to explore the challenges and opportunities for initiating a data-integrated STS within the context of Chinese cities from each of the citizen end-users, transportation enterprises and governments' points of view.

To address this purpose, it is necessary to position the concept of the STS in a wider literature regarding the notion of the smart city. As suggested earlier, there are critical issues revolving around basic conceptualisations, socio-technical conditions, and civic shaping of smart city initiatives that need to be unravelled in the first place before stepping into those of the STS and more in-depth exploration of the proposed data-integrated STS initiative.

1.3 Research questions and objectives

Based on the research background and context above, the research question of this study is formulated: **What would be the potential challenges and opportunities for initiating a data-integrated STS application in China's new-type urbanisation from a socio-technical perspective?**

In order to answer the research question, the following research objectives will be addressed:

(1) To examine the nature, characteristics and major components of the smart city concept in general context.

(2) To investigate current STS's development and STS data integration based on the relevant literature and desk research in the context of China and the wider world.

(3) To explore the citizen end-user perspective regarding their potential desires for, and their understanding of possible benefits and challenges related to, the implementation of a data-integrated STS application in the context of Chinese cities.

(4) To explore the STS commercial enterprise perspective of the potential challenges and opportunities for designing and implementing a data-integrated STS application in the context of Chinese cities.

(5) To explore the government perspective of the potential challenges and opportunities for designing and implementing a data-integrated STS application in the context of Chinese cities.

(6) To generate framework-based guidance and recommendations to guide Chinese cities considering the initiation of a more integrated, efficient and data-driven STS application.

1.4 The structure of the thesis

This thesis consists of eight chapters, including an introduction (Chapter 1), a literature review (Chapter 2), the methodology (Chapter 3), three findings chapters (Chapters 4-6), discussion (Chapter 7), and a conclusion (Chapter 8). A brief summary of each chapter is presented as below:

The Introduction Chapter unfolds the research backdrop and context from which the motivation and purpose of this research originates. The research aim and objectives are presented at the end of this chapter.

The Literature Review is conducted in a way that critically reviews and discusses the previous studies. It was strategically divided into two segments. The first segment (Section 2.2 to Section 2.5) conceptualises smart city in both general and specifically Chinese contexts and demonstrates theoretical framings of initiating the proposed data-integrated STS application in Chinese cities. After laying the theoretical foundation of this research, the second half (Section 2.6-2.7) is particularly focused upon smart transportation systems and data integration issues in Chinese cities.

The methodology illustrates the research strategy that this study will use, which is case study research. The chapter firstly orients the research philosophy, followed by rationales of qualitative research design, including data collection and data analysis. Next, the chapter demonstrates the ways in which research data are collected (by conducting focus groups with citizen end-users and semi-structured interviews with commercial enterprises and government officials) and the way in which data are analysed (by applying Thematic Analysis).

The three findings chapters present the three rounds of research findings in a perspective-based sequential order – citizen end-users participants, STS enterprises participants and government agencies participants. The thematic analysis adopted in all three rounds of data analysis transforms the focus group and interview data into codes and themes which explain what participants perceive to be potential challenges and opportunities for initiating the proposed data-integrated STS application in China.

The Discussion Chapter synthesises both the findings and literature, and presents an in-depth discussion of the identified key dimensions of the potential challenges and opportunities for initiating the proposed data-integrated STS initiative. After demonstrating the main arguments, the chapter visualises the key contributions by presenting the theoretical framework of this study.

The Conclusion Chapter begins by revisiting the study's research questions and objectives and how they have been answered, before presenting the empirical, theoretical and methodological contributions. The chapter concludes by stating the limitations and providing suggestions for future research.

Chapter 2: Literature Review

2.1 Introduction

The purpose of this literature review is to enhance the researcher's theoretical, practical and contextual understanding of the existing literature related to the development of smart cities (including smart city conceptualisation, vision and domains; smart city initiatives and the way in which they are designed and implemented based upon a fine-grained analysis of socio-technical system vision of smart city initiatives), citizen participation in Chinese smart city solutions, and issues of data integration in the STS. This process will develop the researcher's ability to synthesise ideas and concepts and enhance his critical thinking capability. This review of literature follows a top-down structure. The first half (Section 2.2 – Section 2.4) concentrates on conceptualisation and theoretical framing of smart city and associated initiatives; the second half (Section 2.5 – Section 2.6) is focused particularly upon smart transportation system (STS) and its data integration issues.

The new-type urbanisation reflects its data-driven nature; there are troves of urban big data being converted into smart city services and applications that are eventually used by citizens. Based on this, the researcher argues that smart city initiatives need to be constructed on a basis of philosophy of knowledge rather than simply computational ones, namely the necessity of examining both technical concerns and those pertaining to socio-material and perhaps epistemic underpinnings (e.g. democratic and participatory vision of data-driven smart city initiatives). Moreover, smart city systems can also be interpreted as a complex system in which a set of algorithmic and computational infrastructures and technologies require and enable a variety of social agents (e.g. citizen end-users, STS enterprises and government agencies) and their contingent human, organisational, political, environmental, infrastructural contexts, to come together in the design and implementation of applications. To address the potential socio-technical issues latent behind these two ideological aspects (i.e. embodied as the philosophy of knowledge and identified as a complex system), rudimentary smart city conceptualisations, principles, and theoretical foundations need to be examined, in order to support the subsequent analysis and exploration of data integration issues in the specific STS context in Chinese cities.

Therefore, to be more precise, the review aims to:

(1) obtain the rudimentary knowledge related to smart city rationales, including its definitions, vision, domains, services, and the role of smart cities;
(2) build a holistic vision of developing smart city initiatives based upon an exploration of a set of theoretical frameworks;
(3) review the current state-of-play of STS development in China, including its main technologies and challenges;
(4) examine the main issues of data integration in the current STS in China, from various points of view (i.e. political and social, organisational and cultural and technological dimensions).

2.2 Smart city conceptualisation

'Smart City' has become a buzzword, and the proliferation of this concept has grown quickly in recent years. Under the 'Smart City' bandwagon, an increasing number of empirical practitioners have attempted to roll out myriad innovative solutions that are designated as smart city initiatives. At the same time government authorities have put forward a bulk of smart city agendas, policies and political banners with regard to smart and sustainable urbanism; and meanwhile, academic researchers have excavated in depth the smart city concept and its applications from a variety of dimensions and frames of reference (e.g. Bibri & Krogstie, 2017; Caragliu et al., 2011; Cocchia, 2014; Hollands, 2008; Kitchin, 2016a; Nam & Pardo, 2011a; Neirotti et al., 2014; Shelton et al., 2015; Söderström et al., 2014; Townsend, 2013; Vanolo, 2014; Wolfram, 2012). The diversity of smart city practices from across different sectors, organisations and social contexts drives the researcher to explore what constitutes a smart city, including its definitions, visions and application domains. The following sub-sections will explore these issues.

2.2.1 Smart City definition

To date, there has not been a universal and systematic definition that can be used to conceptualise smart city to all types of urban contexts with different local characteristics. Accounts of the most popular smart city conceptualisations in the current literature basically are divided into two types. The first emphasises neo-liberal ethos that are concentrated upon refashioning city managerialism and strengthening entrepreneurship and innovation in order to enhance city competitiveness (Hollands, 2008; Söderström et al., 2014; Vanolo, 2014).

The second type highlights upon the bandwagon of networked urbanism, which explores more about the interrelations between ICT and cities (Cocchia, 2014; Steve Graham & Marvin, 2002; Kitchin, 2015b; Komninos, 2009, 2013). By investigating such stacks of relevant studies related to the definition of the smart city and combining both types of conceptualisation, the researcher defines the 'Smart City' as *a data-driven, networked city in which sustainable urbanism, urban entrepreneurship and city competitiveness, and the maximisation of the better offering of public services to citizens are fuelled by the monitoring and integration of all critical infrastructure and high technologies, such as Information and Communication Technologies (ICT).*

However, 'Smart City' is often seen as synonymous with several adjacent notions, such as 'Digital City', 'Wired City', 'Ubiquitous City', 'Information City', 'Knowledge City' and 'Intelligent City' (Anthopoulos & Fitsilis, 2010; Cocchia, 2014; Dameri, 2013; Dutton et al., 1987; Stephen Graham & Marvin, 1999; Hollands, 2008; Ishida & Isbister, 2000; Komninos, 2013; Nam & Pardo, 2011a; Vanolo, 2014). Rather than presenting the distinctions between each of these terms and the 'Smart City', the researcher instead focuses upon 'Digital City' and 'Intelligent City' only, as these two seem to be the most recurrent notions that always puzzle us in understanding Smart City (Cocchia, 2014; Dameri & Cocchia, 2013). The investigation into the differences between each of these two concepts and the 'Smart City' suggests that:

- *Digital City versus Smart City.* 'Digital City' is more focused upon virtualisation processes wherein people, relationships and services virtually interplay in order to transform a material city into a virtual city. Its technological basis is perfectly expounded, which is highly represented by ICT. People in 'Digital City' must be able to use ICT so that they can enjoy the services in the city. However, the role of people appears to be less imperative, namely that people in digital cities generally do not take the initiative and do not participate in digital city building. In contrast, the 'Smart City' concept not only focuses on communication technologies, but also the sustainable technologies which can reduce pollution and minimise energy consumption for instance. People in 'Smart City' are not necessarily able to use ICT but all of them must embrace the 'smart' culture in order for the sustainability of the city to exist. Therefore, people in 'Smart City' are titled 'Smart People', meaning that they are somehow participating in smart city construction. Herein, the research argues that ‘digital city’ reflects, and is not beyond, technological and infrastructural imperatives that drive a city to be ‘smart’. (Caragliu et al., 2011; Cocchia, 2014; Dameri, 2013, 2012; Dameri & Cocchia, 2013; Hollands, 2008; Nam & Pardo, 2011a; Qi & Shaofu, 2001)

- *Intelligent City versus Smart City.* ‘Intelligent City’ embraces digital components. But superior to the ‘Digital City’ is an intelligent urban system that facilitates innovation and knowledge management. This suggests that an ‘Intelligent City’ emphasises concerted effort made by a knowledge society (i.e. knowledge-driven social collaboration amongst government, public institutions and private sectors) to harness ICT to enhance work and life quality and uphold city infrastructure, with a particular highlight upon its capabilities to support digital learning, technological advancement and innovation in cities. However, ‘Intelligent Cities’ does not consider much of the power, rights and privileges of their citizen end-users; for example, to what extent citizen end-users are engaged in the decision-making process. Further, in policy terms, ‘Intelligent Cities’ place priority to bureaucratic administration in order to support the market rather than to serve as a platform for the mass community and citizenry so as to further enable democratic governance. Whereas in ‘Smart City’, citizens are adopters, and users, and sometimes even influencers of the systems and applications, that contribute to a ‘smart’ culture and co-design of a ‘smart’ initiative. (Albino et al., 2015; Allwinkle & Cruickshank, 2011; Komninos, 2009, 2013, 2015; Komninos & Sefertzi, 2009; Malek, 2009; Nam & Pardo, 2011a; Yovanof & Hazapis, 2009)

The digitalised infrastructures and the ‘intelligence’ these infrastructures embed are thus, argued by Hollands (2008), considered as the main driving force of Smart City initiatives which are supposed to sustain social, economic and cultural progress (Hollands, 2008). The fact, that human factors play an important role in the Smart City concept allows Smart City solutions to embrace more user-oriented services in order to enhance life efficiency, echoes Holland’s (2008) view upon progressing smart(er) cities, which he claims, must seriously take people and the human capital into consideration rather than seldom deeming that digitalised and intelligent infrastructures can automatically transform and enhance city functions (Allwinkle & Cruickshank, 2011; Hollands, 2008). This means that the construction of Smart City should enable more citizen-centric innovations in order to enhance overall city capacity, and should eventually aim to bring benefits to the smart citizens who are better engaged in Smart City initiatives (Albino et al., 2015; Nam & Pardo, 2011b).

2.2.2 Smart city vision and domains

Given that the smart city is driven by ICTs which uphold the interoperability of involved systems, and that human factors stand out in the concepts of the smart city, it is imperative to set out visioning the smart city architecture as a conceptual and structural whole.

The current smart city literature demonstrates a significant number of conceptualised smart city visions, namely the constitution and foundations of a smart city system, some of which are focused upon technological and infrastructural configurations, whilst others include social dynamics (e.g. Albino et al., 2015; Allam & Newman, 2018; Finger & Razaghi, 2017; Joshi et al., 2016; Letaifa, 2015; Silva et al., 2018; W. Yu & Xu, 2018), and many discourses regarding smart city domains, including their applications, political stipulation, end-user interactions, social dynamics, etc (Arroub et al., 2016; Gaur et al., 2015; Jucevičius et al., 2014; Silva et al., 2018). However, most of these works do not systemically combine the vision and domains, except one that was proposed by Nam and Pardo (2011a). In their study, they point out that the conceptual relatives of smart city (e.g. smart urbanism, entrepreneurial city) and smart city domain initiatives are actually conceived within technology, human and institutional dimensions (Nam & Pardo, 2011a). Herein, the technology dimension embraces ideas of intelligence, digitalisation, virtualisation and informatisation. The human dimension includes concepts of creativity, education, knowledge and learning processes. The institutional dimension refers to the notion of smart community, which is understood as a community that consists of various stakeholders, vested interests and individuals with shared interests, who work in partnership to create benefits and enhance productivity. Circumscribing smart city domains into the three dimensions, Nam and Pardo (2011a) further dug out the core components of each dimension and formulated strategic directions of smart city initiatives. Specifically, technology factors mainly refer to a series of ICT-driven and computation-based tools, hardware, software and infrastructure, to name a few; human factors incorporate human and social capital, social inclusion and participation, stakeholder collaboration and cultural dynamics, etc; institutional factors emphasise policy, administrative environment, and organisational management and governance, and so on. Figure 1 presents a modified version of Nam and Pardo's (2011a) framework of strategic direction of smart city, with the aim to showcase the core factors of smart city vision and different domains.

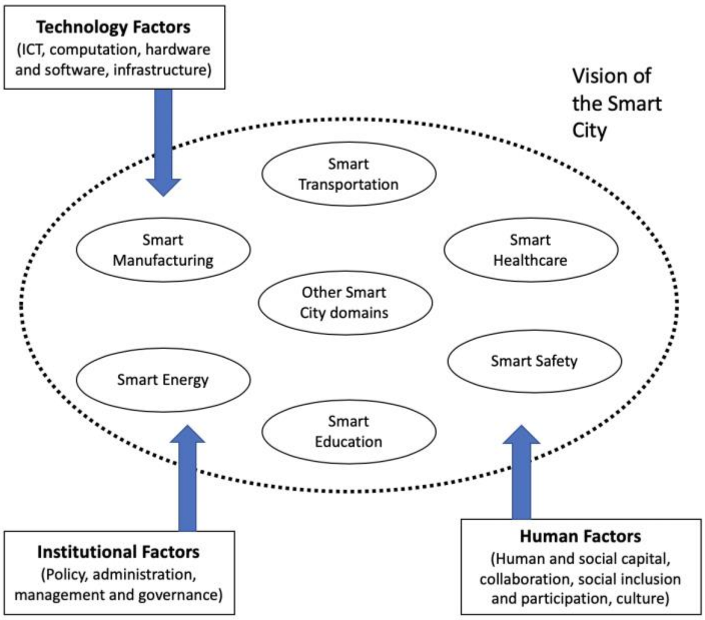


Figure 1: Strategic Directions of Smart City
(Modified from Nam & Pardo, 2011a)

Based on Nam and Pardo's (2011a) strategic direction model, Chourabi et al. (2012) further developed a conceptual smart city initiatives framework to guide future smart city studies. They synthesised insights from across a trans-disciplinary literature that identified and discussed obstacles, success factors and impacts of designing and implementing smart city initiatives that make a city smart (Chourabi et al., 2012). This framework incorporates eight different factors that are referred to in order to assess the extent of smart city initiatives design and implementation; and wherein technology is considered as a meta-factor since it could exert heavy influence on each of the other factors, such as organisation, policy, economy, governance, people and wider communities, the natural environment, and built environments. The review of this conceptual framework will be presented in Section 2.3.

More importantly, it is imperative for both academic and practitioners to have a comprehensive and holistic understanding of the complicatedness and interrelations between technology and the social aspect of smart city initiatives (Caragliu, del Bo, et al., 2011; Hollands, 2008; Nam & Pardo, 2011a; Washburn et al., 2009). Therefore, there is a need to untangle longstanding problems, for instance the way in which organisational structure, governance and stakeholder participation interplay with smart technologies, and the extent to which the synergetic effects of these very aspects lead to the success or failure of the design and implementation of smart city initiatives. In this sense, developing smart city initiatives needs a socio-technical system view. More detail about socio-technical system design will be explored in the next section.

2.3 Socio-technical system vision of smart city initiatives

Having conceptualised what smart cities are, this section illustrates a holistic vision of developing smart city initiatives. As this research aims to explore the challenges and opportunities for initiating a data-integrated STS initiative, it is argued that such an initiative could be regarded as a Socio-technical System. This research as such, applies Socio-technical System theory to frame the theoretical underpinnings of smart city initiatives, with the focus upon the key components, including who is to be involved, and what should be concentrated on in the designing and implementation of the initiative. The following sub-sections excavate the rudimentary principles of the Socio-technical System in the wider information systems context and illustrate a smart city initiatives framework that is framed by the Socio-technical System view.

2.3.1 Technical systems and social systems of smart city initiatives

Socio-technical System is a work system that requires co-design of both technical systems and social systems. Technical systems emphasise technical configurations that continuously uphold human needs and enhance human capabilities, while social systems underline production, diffusion and use of technology (Clegg, 2000; Fischer & Herrmann, 2011; Geels, 2004; Mumford, 2000, 2006), and are focused upon continuous change and evolution that may refashion work relationship structures (Fischer & Herrmann, 2011; Luhmann, 1995; Mumford, 2000). In this sense, a sophisticated technical system is more reliable, adaptable and predictable to the human actors; for example, big data-driven traffic monitoring systems are used to predict traffic flows. However, the sophistication of such technical systems requires social interactions that are contingent upon organisational and coordination issues, decision and sense making, stakeholder power relations, resource distributions and the creation of an environment that these entities will exist within.

Smart city initiatives can be considered as socio-technical systems that involve both technical underpinnings and social components. Meijer and Bolivar (2013) state that smart city innovation involves three strands: technical strand (i.e. the use of ICTs for the provision of smart services), human resource (HR) strand (e.g. smart citizen, technology firms and smart government) and collaboration strand (i.e. interactions between technology and social structure). On the side of the city and society, smart technologies and their associated applications have been regarded imperative to mitigate and remedy social unease and longstanding problems that are entrenched in the whole fabric of society. However, technologies per se do not work efficaciously without taking into account facets of smart governance (Chourabi et al., 2012; Meijer & Bolívar, 2016), e.g. social structure, organisational tasks and human behaviours, especially when tackling potential challenges behind these areas (Fischer & Herrmann, 2011; Mumford, 2000). This suggests that, to develop smart technology-driven innovative systems, both technology imperatives and social system dynamics ought to be viewed as equally crucial, and therefore, a Socio-technical System view would be a necessity to initiate smart city initiatives (Cherns, 1976; Fischer & Herrmann, 2011). The next subsection will 'unbox' in detail both the technical and social components of a general socio-technical system for smart city initiatives. In order to achieve this, a smart city initiative framework (Chourabi et al., 2012) will be referred to, to untangle specific facets that affect both the design and implementation of smart city initiatives.

2.3.2 Socio-technical shaping of smart city initiatives

In order to better envision smart city initiatives and both their design and implementation processes, Chourabi et al. (2012) proposed a Smart City Initiatives Framework (Figure 2), consisting of two levels of influential factors: inner factors (that shape and frame smart city initiatives) and outer factors (that have indirect influence on the success of smart city initiatives). The inner consists of technology per se, organisation-related factors, and policy-driven stimulus. The outer factors involve communities of people, governance, economy, natural environment and built infrastructure. Both layers of actors have a two-way impact on smart city initiatives, with each likely to be influenced by, whilst also influencing, other factors (Chourabi et al., 2012). Overall, these factors as a whole and the ways in which they interrelate to each other depict a socio-technical system of the smart city initiatives, i.e. the 'system of system'.

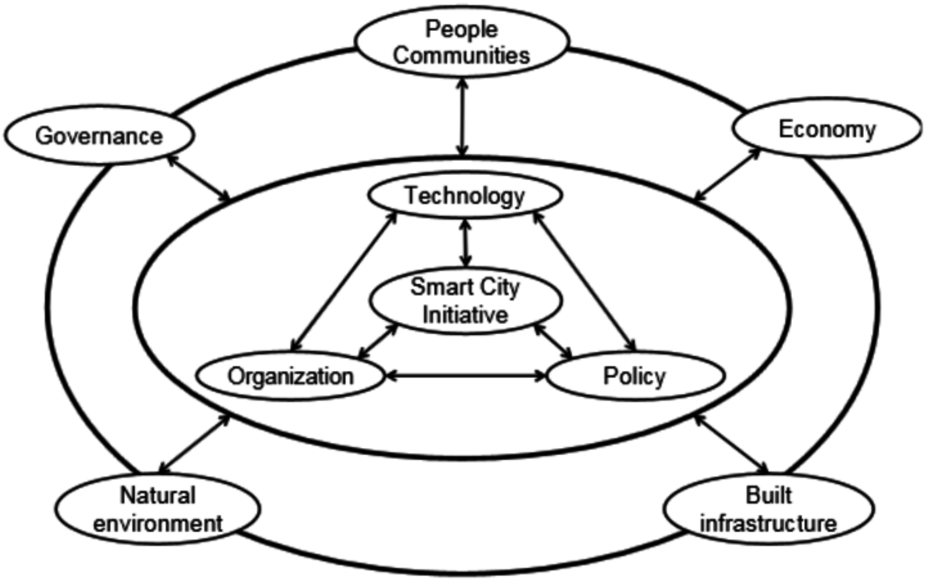


Figure 2: Smart City Initiatives Framework
(Chourabi et al., 2012)

2.3.2.1 Inner factors

Each of the three inner factors not only work independently but also tie in with one another to exert influence upon the success of smart city initiatives design. Although each of these three factors are defined as indispensable based upon certain kinds of contexts and conditions of localities (Alawadhi et al., 2012), technology might be regarded as a meta-factor in smart city initiatives that has significant influence in some way upon all other success factors in this framework, including those which stand on the outer level (Chourabi et al., 2012). Therefore, this sub-section will start by exploring fundamental smart city technologies which provide technological underpinnings of successful design and implementation of smart city initiatives.

Technology

On the basis of previous sections of literature, it is easy to see that the development of new-type urbanisation in China and Smart City initiatives is highly reliant on ICT-driven technologies. A large range of ICT-driven technologies exist, such as cloud computing technology and big data applications, which determine the implementation of Smart City applications in different areas.

Cloud data centre

The growth of Internet of Things (IoT) and relevant internet technologies within the context of Smart City have produced a large amount of cloud data on the internet (Simmhan et al., 2013). It is an urgent need to manage and analyse the data for a range of applications in which a systematic and integrated ICT approach is required (Bonomi et al., 2012). Thus, the required information that has been synthesized by a series of cloud data activities such as data collection, data integration, data processing and data analysis facilitate strengthening the city to become more resilient and sustainable (Khan et al., 2013).

Regardless of which layer the data can be acquired from, the data are always linked with city data repositories which can generate demanding and required information in order for better city governance (Goldsmith & Crawford, 2014, p. 42-44). However, such a method of city governance needs a standard, which can also be regarded as a uniform and an integrated information model of cross-field Smart City data within a cloud data environment, which offers the benefits of developing a lot of information services for different data applications (Suciu et al., 2013). Consequently, the data within this uniform and integrated information model can be identified as '*Cloud Data*' (Beloglazov & Buyya, 2010; Dey et al., 2012; Khan et al., 2013, 2015; Jin Li et al., 2010). The data repositories can be called '*Cloud Data Centres*' (Beloglazov & Buyya, 2010). Within a cloud data centre there are a number of servers working together where communication can take place between any two of them at one time allowing them to interact with each other effectively and constantly (Filiposka & Juiz, 2015). The cloud data centre is a complicated integrated system sharing a lot of resources that all users can take advantage of.

Though cloud data technologies are facing a lot of challenges, the establishment of cloud data centres plays an important role in social components, especially organizations. They vary significantly from the smaller size in-house data centres to the bigger scale service-provided data centres (Benson et al., 2010; Greenberg et al., 2008). The latter one can provide a large number of services that users in smart cities can gain access to. To provide more comprehensive and synthesised smart city services, smart city practitioners have switched their focus to big data technology exploration and development, which is a crucial component of smart city technology (Khan et al., 2013).

Big data applications

The future development of smart city is highly linked with not only the smart city technology infrastructure, but also the development of smart devices that are able to integrate data generated from the sensors within those infrastructures. The cluster of such data can be regarded as ‘Big Data’. The fast development of internet technologies creates big data and enables it to be effectively and efficiently applied to a variety of Smart City applications (Al Nuaimi et al., 2015; Batty, 2013; Hashem et al., 2016; Kitchin, 2014c, 2015a; Rathore et al., 2016; Townsend, 2013).

There is a variety of different definitions of big data, from which it is possible to summarize as '3Vs' (Laney, 2001), known as 'volume' - the size of the data set, 'velocity' - the speed of data input and output, and the 'variety' - the range of data types and sources. Some researchers extend this definition adding the fourth ‘V’ which can be described as 'value'. Zikopoulos and Eaton (2011) provide a more specific definition of big data based on Laney's perspective, which is that big data are a set of high-volume, high-velocity and high-variety information that can increase and optimize the decision making and insight discovery for businesses (Zikopoulos & Eaton, 2011). Both perceptions reflect that big data generation is actually continuous, exhaustive to a processing system, relational and highly flexible (Kitchin, 2014b; p. 71-78, 2015)

For a city to be smart, it must have smart functions that enable efficiency, such as a big data processing system. Hence, the smart city can provide intelligent analysis and services to citizens, which relies upon big data technology. However, the scale and scope of big data cannot be easily identified and summarized particularly when data volumes are large, because there are various types of big data and there are also a large number of different big data applications for each type (J. Liu et al., 2016).

In terms of big data applications, there are four types of big data identified by Zhou et al. (2016): ‘*AMI data’ (smart meters), ‘distribution automation data’ (grid equipment), ‘third-party data’ (off-grid data sets),* and *‘asset management data’ (firmware for all smart devices and associated operating systems)* (p. 216), which all play a crucial role in city production activities Additionally, the big data applications are indispensable to the complicated smart systems, such as STS (Al Nuaimi et al., 2015; Moreno-Cano et al., 2015). For example, the government or relevant transportation organizations are able to examine if the current transportation has already met the demand through the use of big data technologies and IoT-configured transportation infrastructure, such as sensor-based public transports and car parks. They can also provide essential advice on how to utilise, allocate and dispatch the transportation resources in order for the effective balance between supply and demand.

However, there are both advantages and disadvantages of big data applications. The advantage is that commercial activities enable big data to be increasingly necessary and precious, which can generate a great number of opportunities for us to make economic progress in different business areas. However, big data technologies and big data applications are facing a range of challenges, which include big data capture, storage, analysis and visualization that disable the applicability of big data. Kitchin (2014a) particularly points out that the challenges reside in the fact that much of data are generated with no specific business or industrial objectives in mind or are seen as by-products of another activity (Kitchin, 2014a). These challenges vary from the design to the analysis of processing systems from the initial stage to the later stages (Ammu & Irfanuddin, 2013). The cause of these challenges mainly originate from the limitations of the capacity of these processing systems (Tole, 2013), but till recently have become less problematic because of high-powered algorithmic computation and analytical techniques (Kitchin, 2014a). For smart city development, the reviewed literature suggests that for prioritisation of data capture and analysis can be identified as a means to support evidence-based policy development, technocratic city governance, transparent and open data practices, empowered citizen participation, and economic prosperity (Hashem et al., 2016; Kitchin, 2014c; Lim et al., 2018; Strohbach et al., 2015).

Organisation and policy

Beyond technology, organisation and policy are another two core factors, usually being discussed together as a whole, that play a vital role in smart city initiatives. At this point, the framework would help municipal leaders, i.e. the government and relevant authorities, better regulate and guide smart city projects by virtue of effective organisational managerial strategies – organisational structure configurations, collaborations and communications across internal and external stakeholder organisations (e.g. government agencies, public institutions, private organisations, vested interests, charitable institutions, to name a few), and the role of organisational culture and top management; and political power – hegemonic government power and authority, smart city related legislations and policy agendas, and contingent rules and regulations. What is noteworthy is that these factors ought to be contextualised and conditionalised to localities, otherwise the planning of smart city initiatives would be meaningless (Alawadhi et al., 2012).

As discussed above, smart city initiatives are driven by ICT enabled technologies. Managing risks that emerge from implementing these initiatives thus becomes essential to guarantee smooth operational practices. These risks are not only 'hard' issues (e.g. technology and infrastructures), but also emerge from 'soft' aspects (Albino et al., 2015) such as, a lack of judicious organisational planning, organisational information and knowledge management, failure to re-design organisational structure and re-adjust organisational strategy, confrontation with changes, and poor understanding of government political agendas and policy-making implications (Albino et al., 2015; Anttiroiko et al., 2014; Nam & Pardo, 2011b; Neirotti et al., 2014). Consequently, interoperability becomes vital to resist these risks in order to better implement smart city initiatives. The interoperable services and functions enacted by the initiatives enable a 'hyperlink' across government organisations, enterprises and citizens (Nam & Pardo, 2011b). As such, institutional readiness (e.g. removal of jurisdictional and political barriers) and organisational practices (e.g. cross-organisation cooperation, organisational change management, leadership) are imperative for smooth design and implementation of smart city initiatives. In other words, tackling the risks generated by the deployment of technologies is not independent from managing organisational and political challenges. A smart city initiative can thus be considered as *"a contextualized interplay among technological innovation, managerial and organizational innovation, and policy innovation"* (Alawadhi et al., 2012)

Faced with difficulties of initiating smart city innovations, Chinese cities leverage a strategic planning approach (Argyriou, 2016). A key point of such an approach is opening development processes to the private sectors in regard to decision-making and resource management and implementation (i.e. via public-private partnerships). As a consequence, a policy system for developing smart city initiatives emerges, led by political actors (e.g. technocrats, political elites, policy-makers, state-owned enterprises) but leveraged by social stakeholders (e.g. consortiums, supra-national firms, private enterprises), who are able to stimulate both organisational and social capitals. The practices of such openness to the private sectors are demonstrated as *'growth-coalition regime'* (Argyriou, 2016; Douay, 2008). However, such 'regime' only benefits the government to more efficiently manage city administration in order to stimulate economic growth and entrepreneurship. It places less emphasis on the ways in which ubiquitous urban issues that exist in Chinese cities are to be addressed, such as poor urban planning, traffic congestion and air pollution.

In order to overcome these challenges, Chinese cities also make use of a green planning approach to promote sustainable cities from both organizational and political views (Enserink & Koppenjan, 2007; Joss et al., 2013). A key way to do this is to circulate governmental documents, reports and specifications to solidify policy-making and its execution. These policy-related agendas in line with local and wider cooperation partnerships can instrumentally generate many experiments and demonstration projects of smart city initiatives, and expect to be able to steer Chinese cities towards the pathway of sustainability (De Jong et al., 2015; Lindskog, 2004). From the dimensions of organization and policy, this connotes that Chinese cities have been attempting to exert political and legislative influence in conjunction with market-driven organisational dynamics, upon the development of smart city initiatives with the aim to tackle the above-mentioned urban issues.

2.3.2.2 Outer factors

At the outer layer of the smart city initiatives framework lay an additional five factors that might influence the success of smart city initiatives design and implementation. These factors also have interactions with inner factors as a whole, either influencing or being influenced by them at different times and in different conditions (Chourabi et al., 2012). The following content delineates each factor in more detail with regard to how they interact with smart city initiatives.

Human communities

Chourabi et al (2012) argue that smart city initiatives allow citizens to engage in the governance and management of city services in order to be active users, namely the ‘smart citizens’. As an important component of smart city, smart citizens and their associated communities are expected to be endowed with qualities like cultural affinity to smart service provision of the city, social and ethnic plurality, creativity, a sense of globalism and cosmopolitanism, life-long learning, and participation in public services (Nam & Pardo, 2011b). Besides technocratic solutionists who provide efficient and smart innovative solutions to address urban issues, people and wider communities (including social creativity as a whole, grassroot citizen participation, and large-scale cooperation amongst community and between various stakeholders) (Caragliu et al., 2011) are also deemed as an indispensable creative human power in the creation of smart solutions to tackle urban issues. This is what Eger refers to as 'smart community' (Eger, 2009),where networked smartness and intelligence is embedded, and promotion of economic prosperity, the growth of employment opportunities, and improvement of life quality take place. In a nutshell, smart city initiatives need large-scale people and community engagement in governance and collaboration between grassroot citizens and other parties of smart cities.

Governance

Smart city initiatives usually involve multiple stakeholders, e.g. government, public sectors, private sectors, citizens, hence needing better governance to manage the projects and associated services. The ICT-based technologies shift the mode of city governance from digitalisation towards being 'smart'. Smart governance therefore suggests a way in which governments rethink the role they play in a knowledge-based and data-driven society (Bolívar & Meijer, 2016; Giffinger et al., 2007; Giffinger & Pichler-Milanović, 2007). In the particular context of smart city, Meijer and Bolívar (2016) conceptualise smart city governance into four domains: *government of smart city, smart decision-making, smart administration, and smart urban collaboration* (Meijer & Bolívar, 2016). On top of these domains lays the foundation of e-communications between decision-makers and end-users, for instance, *'e-governance practices'* and *'e-democracy'* (Giffinger et al., 2007), which help to promote economic growth and more imperatively make operations and services authentically citizen-centric (Bătăgan, 2011).

The review of smart city governance literature indicates a strong interplay between smart governance and other aspects of smart city initiatives. For example, Meijer and Bolívar (2016) state that smart governance is assumed to be influenced by organisational cultural dynamics, political or demographic figures, technological factors, and so on (Meijer & Bolívar, 2016). Here, the researcher argues that, for a city to be smart, the governance of the city should be focused upon rapid dissemination of information and knowledge, effective information-sharing mechanisms, and high-quality and high-capacity ICTs. As such, the collection and distribution of human resources, technological practices, smart city policies, social norms and codes of ethics would interplay with each other to uphold the whole gamut of smart city governance (Scholl & AlAwadhi, 2016).

Economy

Cities labelled as 'smart' tend to enhance their competitiveness by developing a knowledge-based economy; the term 'smart' indicates both implicit and explicit aspiration to establish cities' socio-economic standards (Giffinger et al., 2010). Economic competitiveness includes several elements such as innovation, entrepreneurship (innovative spirit), productivity, flexibility of the labour market, international embeddedness, etc. (Giffinger et al., 2007; Lazaroiu & Roscia, 2012; Nam & Pardo, 2011a; Neirotti et al., 2014; Raj & Dwivedi, 2017). Such competitiveness within smart city discourse brings about many smart economy facilities and infrastructures for sharing of knowledge, such as research centres, start-up incubators and innovation parks (Appio et al., 2018). These sorts of exercise delineate a smart business system, the capacity of which are reliant on the implementation of ICT by market activities, involving both public and private enterprises.

Vanolo (2014) claims that cities designated as smart tend to develop towards being green or sustainable cities, as well as being informational and technological. Both perceptions interpret the city as a powerful network to activate or stimulate specific rationalities in order to create new economic paradigms, in other words, to bring about new business and possible capital accumulation (Vanolo, 2014). Furthermore, for cities to enhance economic capacity and competitiveness, sustainable organisational structure and strategy and urban socio-cultural dynamics are stated as being imperative, thus needing careful re-configuration and re-generation of smart city agendas (Neirotti et al., 2014). This is particularly important for the Chinese context wherein many potential issues are hidden behind these factors alongside rapid urbanisation and a growing population. Therefore, in order to better deliver successful smart city services, practitioners and policy-makers need to make a concerted effort to create a sustainable environment for the market to enhance ICT capacity and applicability.

Built infrastructure

The design and implementation of ICT and smart governance infrastructures depends upon their availability and operability. Chourabi et al (2012) set out three main dimensions of potential challenges that reside in the built infrastructure of smart city initiatives, which include security, privacy and operational cost. Resonating with this, Kitchin (2019) claims that though smart city technologies and associated infrastructures are advocated as being able to counterattack existing urban risks, they nevertheless create new vulnerabilities, including making themselves and corresponding services insecure, brittle, and open to extended forms of criminal activity (Kitchin & Dodge, 2019). ICT-built infrastructures are classified into wireless infrastructures and service-oriented information systems; both play an important role in creating and provisioning smart services for smarter city governance and higher quality of life of citizens. The capabilities of both need to be carefully examined before implementing new smart city initiatives. Whilst technology and built infrastructure may interplay against each other, their interrelations may impact on the performance of all the other factors demonstrated in the smart city initiatives framework (Alawadhi et al., 2012; Chourabi et al., 2012).

Environment

Since smart city initiatives aim to enhance sustainability of urban networks, it is important to make good use of natural resources to develop essential technologies and infrastructures. This suggests a smart urban resource management for public open space wherein ecology and biodiversity alongside cultural heritage, as a balance, are leveraged for urban residents to work, live and spend leisure time (Govada et al., 2017; Kumar & Dahiya, 2017). This is to say, that the purpose of developing smart city initiatives is not only to give a ‘smartness’ tag to the city but also a label of ‘greenness’, suggesting the potential balance between the implementation of smart city technologies and built infrastructures (e.g. traffic dashboard, sensor networks, urban control room, public means of transports), and the conservation of public smart city services (e.g. citizen awareness, local jurisdiction). Such a label might incur more intensive political constraints to limit business consumption of resources when developing smart city services and more participatory requirements and conditions to enable smart citizens (Anttiroiko et al., 2014).

Drawing upon Chourabi et al.’s (2012) theoretical framework, as a guide, for developing smart city initiatives, this research will explore what the opportunities and challenges for initiating the proposed data-integrated STS initiative in Chinese cities would be, by examining and comparing the factors outlined in the framework with the findings of this study.

It is necessary for the initiation of smart city initiatives to begin with the perspective of citizen end-users. The reason for this is three-fold: first, due to the entrenched purpose of smart city initiatives – to enhance the quality of people’s life; second, due to the explanations given in the Introduction chapter where the researcher argues that there is a lack of focus upon the connections between citizens and commercial enterprises, and between enterprises and government authorities in Chinese cities; and finally, due to one of the main goals of the 'New-Type Urbanisation' plan, in which widespread contending advocacy is in favour of demanding the need to raise grassroots citizens' voice in shaping and participating in the design and implementation of smart city initiatives. The next section will focus on the theoretical framing of citizen participation.

2.4 Citizen participation in smart city initiatives

China has achieved significant progress in terms of economic and social developments within the period of 1978-2011 due to the rapid pace of modernisation, industrialisation and urbanisation; however, this economic reform also has brought many challenges that threaten city governance and the quality of people's lives. Facing these challenges, China's State Council issued a 'New-Type Urbanisation' plan with the aim of achieving smart, green and sustainable cities, stimulating entrepreneurship, enhancing city competitiveness, and significantly improving the inherent quality of urban life (CNDRC, 2014; Huifeng Li & De Jong, 2017).

A number of arguments criticising these objectives have been put forward. A noteworthy stance emphasises that although this plan highlighted *'self-governance by residents'* and *'establishing comprehensive grassroot service management platforms'* (J. K.-S. Chan & Anderson, 2015), smart city initiatives development in China ignores the extent to which, and the ways in which, citizens participate in smart city construction, especially in the co-creation process of emerging initiatives. Instead, smart city practitioners (i.e. commercial enterprises and the government) seem to seek for solutions that, for the most part, are pro-business, open-economic, market-led and entrepreneurial (He & Warren, 2011; Huifeng Li & De Jong, 2017). This results in a situation where citizens are not actively involved in making collective contributions and they wish for the smart solutions developed by those practitioners to not interfere with their everyday life (e.g. NIMBYism – not in my back yard) (Hemment & Townsend, 2013; Hollands, 2015). Chiming with the previously discussed role of human actors within the socio-technical system shaping of smart city initiatives and the citizen-centric goal of the 'New-Type Urbanisation' policy, the following sub-sections will unfold more detail about the characteristics of citizen participation in both the general and Chinese smart city contexts.

2.4.1 Overview of citizen participation in smart city initiatives

Rather than intensively focusing on economic development, which is the main characteristic of the old type of urbanisation, Chapter 19 of the ‘New-Type Urbanisation’ plan draws attention to the human factors and citizen participation, in particular in urban innovation development *(“taking people as basis”)* (M. Chen et al., 2016; CNDRC, 2014; Huifeng Li & De Jong, 2017). In the context of China’s smart city initiatives, this means that development should not only aim to promote sustainable and efficient city administration and economic prosperity, but also address citizen related challenges through citizen-centric or citizen-led innovative solutions, and by leveraging citizens’ voices in a manner of interacting in the co-creation of the smart city initiatives.

Many missions that take into account the roles of citizens in promoting smart city initiatives, on the one hand have been widely complimented, as they have enabled a data-driven, networked urbanism (e.g. Kitchin, 2015) and promoted the sharing economy and commons-based co-production to benefit both the state and citizens (e.g. Hill, 2013; McLaren & Agyeman, 2015; Niaros et al., 2017). However, on the other hand, some of them have been bombarded with critiques in terms of being overly technocratic and top-down in orientation towards the forms of civic paternalism and stewardship in the western context (Cardullo & Kitchin, 2019a), whilst within the Chinese context being hierarchical, top-down in decision- and policy- making, incomplete in public deliberation, and overly reliant upon government, all of which have resulted in ‘government monodrama’ in urban and smart city planning (Huifeng Li & De Jong, 2017; Pieke, 2009). These critiques reflect that citizens need more space and rights to air their views upon actions of initiating smart city innovations, in the smart city era, through ICT-based digital tools and social media; otherwise, these initiatives would serve the interests of government and authorities to a far greater extent than they do citizens.

2.4.2 Theoretical models of citizen participation

There are many theoretical models of citizen participation in urban planning and city entrepreneurship; the most noteworthy and influential of which is the ladder of citizen participation published by Arnstein (1969). She discussed the ways in which citizens are involved in the planning process, wherein she discussed the various extents to which citizens have power in determining the end product, through visualisation of a ladder of participation, for example, non-participation at the lower levels and citizens control at the top. However, when it comes to current smart city discourses, this framework seems not able to fully account for more fine-grained facets of participation, such as the type, role, modality and political framing, etc. As such, Cardullo and Kitchin (2019) reworked and broadened Arnstein's ladder and consequently developed a framework named 'Smart Citizen Participation Scaffold', in order to further unfold these very aspects of citizen participation in smart city initiatives in the context of neo-liberal and entrepreneurial cities (Figure 3). More specifically, the scaffold suggests that citizens' roles vary from being nudged and controlled without participation, acting as consumers with a certain number of choices that are driven by the capitalised market, partially engaging through feedback and suggesting in the decision-making process, right towards being totally inclusive and entitled with citizen power. They argued later that without a sustained foundation of public-based smart city initiatives it is difficult to achieve *"bottom-up, inclusive and empowering"* citizen participation in the urban administrative decision-making process.

<table>
<tr><th colspan="2">Form and Level of Participation</th><th>Role</th><th>Citizen Involvement</th><th>Political discourse/ framing</th><th>Modality</th><th>Dublin Examples</th></tr>
<tr><td rowspan="3">Citizen Power</td><td>Citizen Control</td><td>Leader, Member</td><td rowspan="2">Ideas, Vision, Leadership, Ownership, Create</td><td rowspan="2">Rights, Social/Political Citizenship, Commons</td><td rowspan="3">Inclusive, Bottom-up, Collective, Autonomy, Experimental</td><td>Code for Ireland, Tog</td></tr>
<tr><td>Delegated Power</td><td>Decision-maker, Maker</td><td rowspan="2">Civic Hacking, Hackathons, Living Labs, Dublin Beta</td></tr>
<tr><td>Partnership</td><td>Co-creator</td><td>Negotiate, Produce</td><td rowspan="2">Participation, Co-creation</td></tr>
<tr><td rowspan="3">Tokenism</td><td>Placation</td><td>Proposer</td><td>Suggest</td><td rowspan="7">Top-down, Civic Paternalism, Stewardship, Bound-to-succeed</td><td>Fix-Your-Street, Smart Dublin Advisory Network</td></tr>
<tr><td>Consultation</td><td>Participant, Tester, Player</td><td>Feedback</td><td rowspan="2">Civic Engagement</td><td>CIVIQ, Smart Stadium</td></tr>
<tr><td>Information</td><td>Recipient</td><td rowspan="3">Browse, Consume, Act</td><td>Dublinked, Dublin Dashboard, RTPI</td></tr>
<tr><td rowspan="2">Consumerism</td><td rowspan="2">Choice</td><td rowspan="2">Resident, Consumer</td><td rowspan="2">Capitalism, Market</td><td>Smart building/ Smart district</td></tr>
<tr><td>Smart meters, Mobile/locative media</td></tr>
<tr><td rowspan="2">Non-Participation</td><td>Therapy</td><td rowspan="2">Patient, Learner, User, Product, Data-point</td><td rowspan="2">Steered, Nudged, Controlled</td><td rowspan="2">Stewardship, Technocracy, Paternalism</td><td>Dublin Bikes, Smart Dublin</td></tr>
<tr><td>Manipulation</td><td>Traffic control</td></tr>
</table>

Figure 3: Scaffold of smart citizen participation
(Cardullo & Kitchin, 2019a)

In the context of Chinese cities, Huifeng Li and De Jong (2017) model a theoretical framework (Figure 4) that is based on the combination of Arnstein's (1969) ladder of citizen participation and Fung's (2006) multi-dimensional democracy cube. They claimed that the attributes of citizen participation in China are characterised in the same three dimensions as how Chinese smart cities are governed: *participant selection*, *communication mode*, and *authority and power*. This framework examined the relationships between citizen bottom-up participation and authoritative leadership's policy and decision making in Chinese smart cities. They argue that the extent of citizen participation is limited in the process of initial design process but significantly increased in the stage of implementation; this discrepancy could mark China's current citizen participation mode as *"state-led citizen participation",* suggesting that the Chinese government is not only the initiator but also the dominant coordinator of citizen participation.

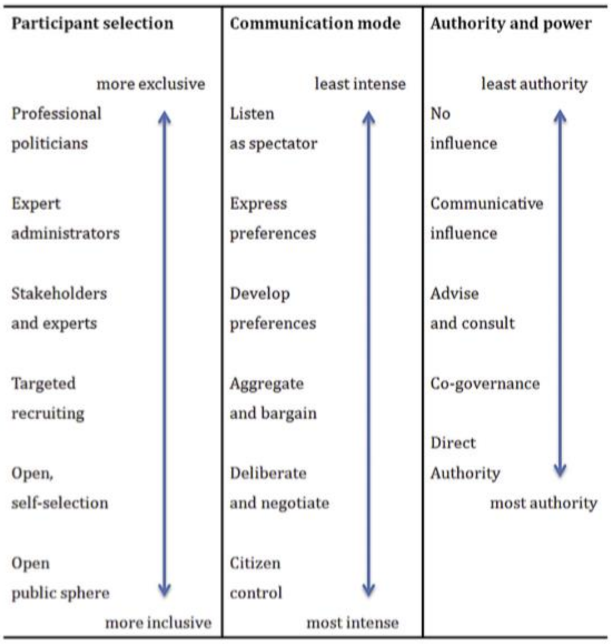


Figure 4: Three-dimensional citizen participation mode
(Huifeng Li & De Jong, 2017)

The modalities of citizen participation presented in Cardullo and Kitchin's (2019a) scaffold suggests a new mode of citizenship in the era of neoliberal urbanism in the western context, where austerity pushes city administrations towards privatisation and marketisation of smart city services and infrastructures. Herein the ways in which citizens participate in smart city initiatives square with instrumentation and heuristics frames of politics; in other words, *'citizens are encouraged to help provide solutions to practical issues, but not to challenge or replace the fundamental political rationalities shaping an issue or plan'* (Cardullo & Kitchin, 2019a). Likewise, in China, citizens participation also conforms to political and social norms. However, the 'New-Type Urbanisation' practices emphasise openness and responsiveness of urban governance in a way that upholds citizen participation in marketisation and public-private partnership forms of economic development (C. Chen et al., 2013). Nevertheless, citizens in this sense have more involvement in the implementation stage than in the design phase of the development of smart city initiatives (Huifeng Li & De Jong, 2017).

However, the public-private partnership and citizens' roles in building market-driven, but citizen-led and grassroot bottom-up solutions (J. K.-S. Chan & Anderson, 2015), require municipal leaders and practitioners to carefully reflect upon what citizens really demand, how their desires for implementing smart city initiatives would correspond to the extent and forms of participation, and the ways in which their participation is meant to be enacted (Vanolo, 2016). These accounts are imperative in order to manage emerging risks that can occur in both the design and implementation phases of smart city initiatives. Regarding this, the 'New-Type Urbanisation' plan states that the new urbanisation encourages *"a favourable interaction between government administration, self-adjustment within society, and self-governance by residents through comprehensive grass-root service management platforms"* (CNDRC, 2014). Such proclamation resonates with Chourabi et al.'s (2012) smart city initiatives (Figure 2) in terms of citizen interactions with involved technologies, organisation and management practices, and political settings. Therefore, this study argues that it is necessary to examine how citizens engage in, and contribute to, the co-creation of a particular smart city initiative at different stages of development (i.e. when it is being designed and implemented), and by what means they interplay with smart city practitioners. As such, the dimension of 'citizens' will be framed as the first theoretical perspective of this research, in order to acquire citizens' desires, understandings and opinions of what a potential data-integrated STS application should look like, before stepping more in-depth to explore the potential challenges and opportunities behind such a proposed solution from the enterprise and government points of view.

2.5 Smart transportation systems

Amongst all Smart City domains, STS makes the greatest contribution to city economic development, has the most complicated issues, and faces the most challenges. STS, therefore, has the most valuable research gap to be filled, which is the focus of this study. The following sub-sections therefore move on from the theoretical framing of the study to discuss STS in China.

2.5.1 Overview of transportation issues in China

The literature review in this section mainly discusses STS issues in China. There are a number of issues in the whole transportation system and this study emphasises the main three, which can be respectively addressed by the implementation of three existing STS applications. The last part of this section focuses on the challenges of current STS applications in China; data integration is the main challenge and is also what this study attempts to address.

In developing countries, particularly in China, tackling traffic issues and solving transportation system problems is one of the guiding principles of the policies and strategies of urban transportation systems, due to the characteristics of the economic and social development, such as overpopulation and poor transportation infrastructure (Biuk-Aghai et al., 2016; Peng, 2005; J. Yan et al., 2018). The current literature which is based on the investigation of traditional transportation systems development in China over the past decade, have suggested that the main issues are related to the demands of urban poor, transportation congestion and bad transportation information transfer. These issues involve both private vehicles and public transports. The existing issues have had a significant influence on Chinese urban development especially the pace of Chinese cities developing and implementing STS initiatives. Taking these into opposite consideration, however, it is obvious that these issues were regarded as the driving force in developing STS initiatives (S. Chen et al., 2014; Ge et al., 2017; Peng, 2005; Pucher et al., 2007; Vasconcellos, 2014; R. Wang, 2010).

2.5.1.1 The demands of urban poor

To clarify how urban poor is defined and why it is seen as one of the main issues of traditional transportation systems in Chinese cities, it is necessary to firstly define the ‘urban population' – which the urban poor are part of. A study conducted by Mathur (2013) for Asian Development Bank (ADB) defined the 'urban population' as the population who are registered as urban residents, namely the people who are not rural residents. In other words, this population live in urban areas; however, a number of them are laid-off, unemployed, retired, disabled or have serious diseases, or who have just moved from rural to urban areas without urban privileges (Cheng et al., 2002; Pucher et al., 2007). This group of people are called urban poor.

The decision-making process by city government in China did not really take the demands of urban poor into consideration. Instead, their focus was mainly on improving the functionality of modernized systems to generally enhance the performance of the urban transportation system. Firstly, the considerable growth of automobile ownership has threatened urban road systems, thus the government expanded the road system through the fast development of motorways in order to relieve traffic congestion. Consequently, the large amount of resources used for road building limit the development of public transportation. Such imbalanced expenditure in motorway building and public transportation initiatives disenabled the accessibility of transportation services for urban poor in their daily lives (Pucher et al., 2007; Vasconcellos, 2014). Secondly, a lot of public transportation services, such as regular bus systems and rapid public transits, cannot really benefit urban poor as a great number of them have mobility problems; in other words, it is inconvenient for them to use the services provided by public transportation. Such services also remain financially unviable for many urban poor.

Both of the aspects discussed above indicate the importance of implementing citizen-centric transportation applications that are embedded in the means of transportation and central transportation control systems, whilst enacting grassroot transportation policies which underpin the design and implementation of new transportation solutions. In terms of the way of participation, such techno-political underpinnings would not only augment the extent to which less privileged or marginalised citizens are empowered with basic rights of smart services in order to be promoted as smart citizens, but also would contribute to those who are already regarded as 'smart' in climbing higher on the ladder of citizen participation in order to have more say in municipal decision-making (Arnstein, 1969; Cardullo & Kitchin, 2019a). Th is very focus would enable public transportation tools to become smarter, which can meet urban poor's demand and minimise the difficulties of their usage of public transportation services (Benevolo et al., 2016; Thomas et al., 2016).

2.5.1.2 Car parking congestion

As a result of increasing economic prosperity and urbanisation process, the vehicle-use intensity in China has grown rapidly over the past ten years (Hao et al., 2017), meaning a growing number of vehicles on the road in cities. The creation of additional traffic has resulted in serious traffic congestion. Amongst many types of urban traffic congestion in Chinese cities, the most remarkable one is car parking congestion, namely the clustering of vehicles surrounding a car park escalating into large-scale traffic congestion. There are many reasons behind this, but the most important ones refer to the proliferation in the number of vehicles on the road and the management of current transportation infrastructure, e.g. car park facilities, an increasing number of which are not able to deal with the influx of cars on the road. For example, research conducted by Karlin-Resnick et al. (2016) suggests that of all types of traffic congestion, the congestion resulting from vehicles searching for parking spaces accounts for more than 30% (Karlin-Resnick et al., 2016).

In addition, the current literature also denotes that the Chinese government have created many solutions in order to alleviate such issues and improve the convenience for daily drivers and travellers. For example, the regular car parking system that has already been widely implemented in Chinese cities can hold availability information of car parks from sensor networks and the cloud data centre and simply provide such information directly to drivers (Kazi et al., 2018; Khanna & Anand, 2016; Zheng et al., 2015). Nevertheless, this type of parking system cannot currently give drivers accurate guidance to the exact parking spot where they wish to park their car. Sometimes the situation is even worse, for example, the information provided for a particular car overlaps that given to another, due to an unreliable and less integrated computational data processing system, with a lack of deeper excavation of data value which may generate more accurate information for the end-users (Camero et al., 2018; Hassoune et al., 2016). It is therefore necessary for the Chinese government to apply a smarter, data- and algorithm- driven, and more integrated parking solution in order to alleviate traffic congestion around such parking areas.

2.5.1.3 Weak transportation information transfer

With regard to the congestion issue stated in the last sub-section, the literature reveals that the non-uniform transportation information transfer is one of the important factors behind causing bad traffic status in most Chinese cities (Peng et al., 2012). In terms of the issue of urban transport has become increasingly prominent and the overall strategy of transportation system development set by the relevant government institutions has been established, many scholars argue that it is necessary to raise the level of transportation systems operation by the use of advanced technologies, e.g. digital communications, vehicle location technologies and cloud computing (Al Nuaimi et al., 2015; Bansal et al., 2016; Guerrero-Ibanez et al., 2015; Hashem et al., 2016). For public transport in particular, they believe that the technologies with regard to improving transportation performance, enable the smart dynamic scheduling and management of the transport, whereas current conventional scheduling is based on normal timetables and experience, which results in 'blindness' and 'lagging'. A number of other public transport system researchers add that transportation scheduling and management should be performed based on real-time information transfer, which means the interrelation between vehicles, users and roads ought to be enhanced (Brakewood et al., 2015; Farkas et al., 2015; Feng et al., 2015; Kwak et al., 2016; Shi & Abdel-Aty, 2015). This means the transport data and information generated from the vehicles in which transportation system applications are installed and roads where the central transportation controlling system update the transport information, can be synthesised and shared amongst all users. This avoids the situation of transportation information being updated only after drivers have left the position where they originally were.

The traditional transportation system technologies are unable to effectively solve the information transfer issue between central control systems and vehicles. It is therefore necessary to further develop and upgrade the technological components behind systems and applications, to cater to the drivers' needs. This not only provides regular urban drivers and public transport users with more efficient journeys, but can also release the transportation pressure within cities.

Overall, the prior studies in terms of existing issues with regard to China's traditional transportation system indicate that within the traditional development environment and under the conventional strategy of transportation, the problems cannot be effectively addressed. The rapid development of smart cities and widespread use of Smart City technologies used for the traditional transportation system, enable it to be increasingly smarter. The developed STS applications are able to solve the issues mentioned in this section, which have not only benefited urban poor as well as wealthier citizens, but also have improved the transportation system performance. The following section focuses on how these applications contribute to tackling the issues of the traditional transportation system discussed above in Chinese cities.

2.5.2 STS application development in China

Solutions to the numerous issues of traditional transportation systems in Chinese cities, as described in the last section, have been sought. With the rapid development in ICT, sensor, control, cloud computing as well as other relevant technologies, the opportunity to improve the current transportation systems exist. The situation where a majority of the decisions made meet the requirements for selecting, developing and implementing the required STS applications as solutions to the needs of the demanded transportation system, necessitates a focus on decision making within emerging software-defined network (Ge et al., 2017; Papa & Lauwers, 2015). However, there are many STS applications available to solve the issues of traditional transportation system in Chinese cities. This study focuses on the following three types of STS application. They are representative solutions that, for the most part, have been considered as helpful in addressing the issues discussed in the last subsection.

2.5.2.1 Smart public journey planner

As discussed in the prior section, in Chinese cities, the government focuses on implementing a lot of transportation infrastructures for private vehicles such as the development and construction of motorways. This does not benefit urban poor and those who tend to choose eco-friendly forms of transports (i.e. public transport). From STS technology perspective, the reason behind this is that the public transport system lacks reliable transportation information, hence an increasing number of commuters opt to use private vehicles (Narboneta & Teknomo, 2014). Narboneta and Teknomo used Shanghai as the case city to conduct their study. They aim to implement the already existing open-source multimodal smart public transportation journey planning system – ‘SmartOpenTripPlanner’, in order to decongest the main roads in the city and to make citizens’ trips more effective and efficient.

Smart public journey planner refers to a transportation system that is able to provide users with reliable traffic information (e.g. the estimated time of the trip and the estimated distance to be travelled) to find out the best route from the origin point to the destination based on the system analysis and calculation (Brennan & Meier, 2007). There are a large number of smart public transportation journey planning applications that have already been developed and implemented in different types of transportation networks across the world. Despite that fact that they were designed based on different frameworks and techniques, they all achieve their purpose which is to provide multimodal public transportation routes to encourage citizens to move away from the primary use of private vehicles to the public transportation tools (Hillsman & Barbeau, 2011). The relevant literature shows that the first generation of journey planner applications were monomodal which focused only on private vehicles, whereas the smart journey planning application takes into account multiple types of transportations and multiple objective conditions such as lowest travel expense, quickest travel time and shortest travel distance (Kumari & Geethanjali, 2010; Jingquan Li et al., 2010; Narboneta & Teknomo, 2014; Peng & Kim, 2008). This generally provides more benefit to urban poor through providing convenient functions and services and accurate information within a low-price range.

Traditional journey planner applications are normally installed in the internal devices embedded in vehicles and the results of which are inadequate and cause user dissatisfaction (Ni et al., 2015). For instance, the fundamental assumption in terms of this is that public transportation modes, e.g. buses, always follow a fixed schedule. Within the actual traffic environment, however, the times that buses arrive and depart are highly dependent on the real-time traffic condition. Different to the traditional journey planners, Xing Wu and Nie (2011) propose an approach that examines the effectiveness of the smart public journey planner on buses, based on the stochastic dominance. The planners are used to explore optimal paths for distinct utility functions, meaning that they create the best scenarios for the users by maximising his/her utility in journey planning. The technologies of smart public journey planners integrate real-time information into routing transportation policies in the stochastic time-dependent networks (S. Gao et al., 2010; C. Wu et al., 2014). Overall, whilst the application used for private vehicles can provide more accurate and reliable transportation information and optimal scheduling solutions to private vehicle owners, it also contributes to enabling urban poor’s accessibility to the transportation services through the smart technologies on public transports.

2.5.2.2 Smart car parking

The increasing number of vehicles on the roads and the rapid growth of the automotive industry - which has led to the severe traffic congestion in urban areas as discussed in the last section - has meant the demand for smart and scientific parking management has grown. Smart car parking system refers to a new and creative parking solution utilising computing technologies, wireless sensor technologies and ICT to facilitate the parking of vehicles effectively and efficiently (Geng & Cassandras, 2011; Idris et al., 2009; Haijian Li et al., 2011; Teodorović & Lučić, 2006).

The investigation of the literature regarding smart car parking applications denotes that wireless sensor networks (WSN) have gained many researchers' attention. This technology can be used in various application domains, such as health monitoring, military surveillance and smart car parking. The typical WSN consists of large amounts of sensor nodes, each equipped with a large range of sensors (Akyildiz et al., 2002). The role of WSN in smart car parking system is to provide drivers with accurate and automatic monitoring and make the information available to them and facility administrators.

The existing solutions of WSN used for smart car parking system focus on the parking place applications that adopt sensor technologies, e.g. magnetometers and video cameras (V. W. S. Tang et al., 2006). However, these two types of sensor technologies have a number of issues. For instance, with '*magnetometers',* WSN cannot ensure accurate detection in the car park since it is very sensitive to environmental factors. *'Video camera'* based WSN technology creates a large amount of data that can be difficult to transmit, and such solutions are generally expensive. Having studied these regular WSN solutions, S. Lee et al. (2008) propose a hybrid approach for the smart car parking system in Chinese cities. Their approach proves such WSN to be not only more accurate and practical but also cost-effective. However, although the number of vehicles in the car park is only counted on each floor by using their proposed approach rather than on each parking place, which does become smarter, it is still difficult to detect many types of vehicles by managing the number of sensor nodes. To tackle this issue, some other researchers have explored solutions. Since different types of vehicles have their own characteristics, e.g. magnetic wave pattern and engine sound pattern, the database of these characteristics for each vehicle can be established enabling the detection algorithm to fit the patterns, so that different kinds of vehicles can be effectively detected (N. Chen et al., 2016; Haijian Li et al., 2011). The car park, therefore, can provide parking information, which includes highly accurate location information, to the users who have the applications able to receive the information installed in their cars.

Overall, through the wide use of smart car parking systems, the transportation congestion can be significantly reduced since the situation where a large number of vehicles are grid-locked on roads whilst searching for a parking place does not exist anymore. However, a drawback that currently resides in Chinese cities is that the coverage of smart car parking is only 7% (2017 figure), which does not match the parking requirements from citizens in general (M. Wang et al., 2017).

2.5.2.3 Smart navigation

The prior section based on the investigation of current literature suggests that one of the most important issues of transportation systems is the non-uniform transportation information transfer between road systems and drivers. In order to solve this issue, over recent years, an increasing number of relevant STS applications have been created. The representative one is the smart navigation system. Smart navigation system refers to a transportation system that adopts wireless communication, location and navigation technologies to lead travellers to the desired destination through real-time location information and navigation (G. Jiang et al., 2006; Salcedo & Battistuti, 2014; Uhlmann et al., 2003; Y. Wang et al., 2008).

Smart navigation system is a highly technical synthetic system in which there is a large number of technologies, such as *'Automatic Vehicle Location (AVL)'*, *'Geographical Information System (GIS)'*, *'Database technology'*, *'Cloud Computing'*, *'Multimedia' and 'ICT'* (Kim et al., 2012). Having tested a variety of smart navigation applications and applied most of them in Chinese cities, G. Jiang et al. (2006) conclude that a good smart navigation system embedded in vehicles should include the following fundamental contents: Real-time location information display that consists of place, direction, time and speed; clear directional patterns on the system (e.g. when the vehicle should change the route, a clear instruction should be shown to the driver); synthetic information service such as an ability to search for a destination; automatic information update (e.g. when a new road is constructed, the system can update this piece of information in time). Huang et al., (2009) emphasise the importance of wireless communication technologies in the system, meaning that different users share the information of their location and roads status to the internet. The formed data can be utilised next time by other users through the cloud computing and wireless communication technologies.

In Chinese cities, especially big cities, smart navigation system applications are needed. The overpopulation, large national territory area and increasing consumption of natural resources accelerate the demand of various modes of transport. The rapid growth of the tourism market makes smart transportation services more urgent. The fast development of smart navigation system has saved resources and time, enabling convenience to travellers within the situation where the basic public transportation infrastructure has not been sophisticated in medium and small sized cities (Xia, 2010). Thus, the personal smart navigation applications on mobile devices or in cars, have become increasingly important to users.

The three existing STS applications discussed in this section have alleviated some of the pressure on transportation in Chinese cities, particularly along with the specific solutions to solve the current major transportation issues. However, STS in China has not existed for a long time and there are a number of challenges it faces, which are discussed in the next section.

2.5.3 Challenges of STS applications in China

The developed STS in Chinese cities have been rapidly growing and improving. Challenges and problems inevitably occur during the process of such systems' implementation. The current literature of previous research suggests that different applications are facing different types of issues but there are a number of common problems that currently exist. Problems that exist in STS applications in large Chinese cities are divided into three distinct facets:

(1) Data collection. The inconsistency of data generated from various sensor-enabled transport infrastructure systems (e.g. sensor-enabled vehicles and roads) cause drivers to be confused about the accuracy of the information from their own application or the road transportation system. (Pelletier et al., 2011; Shao et al., 2018)

(2) Data and information management. Digital transportation information is based on Geographical Information System (GIS). Information such as maximum and minimum speed of the particular vehicles on certain roads, driving direction and maximum allowed height on particular bridges or ducts, etc. are stored in the

digital map. Such information should be updated in time if there are any changes. Out-of-date information decreases the credibility and reliability of the application. (Bohli et al., 2015; Kyriazis et al., 2013)

(3) Data exchange. There are numerous STS applications available for citizens to use. There are many different types of STS users using different modes of daily transportation, who need to share and get access to some amount of information and data from their own applications; the problem is that information and data from one application cannot be exchanged to the other applications. For example, people who installed and are using smart navigation system in their vehicle cannot access the information generated from the smart car parking system. (Bask et al., 2009; Bohli et al., 2013; Theodoridis et al., 2013; Yongjun et al., 2012).

This analysis of the challenges that STS in Chinese cities faces, is based on the data processing and management. Whereas other researchers consider the existing weakness and challenges of current STS more comprehensively involving different aspects of STS, which are as follows:

(1) There are a large number of technologies and techniques used for some specific STS applications enslaved by the inherent production and implementation pattern. These technologies are not generalised and applied to other applications, which results, to some extent, in the loss and waste of labour and material resources. (Fei, 2010; Xiong et al., 2012)
(2) The severe lack of STS experts. STS technology is identified as the combination of conventional transportation technologies and information technologies (IT). China’s development of STS is in urgent demand of experts who not only possess knowledge about transportation technologies but also have the necessary IT skills. This shortage is a challenge to the advanced development of STS. (Krmac & Djordjević, 2018; Y. Yan & Xu, 2013)
(3) The lack of cooperation and data sharing between different STS applications decelerates development of the STS to a further and smarter level. Data should be processed and utilised by more than one application; the re-used data from one application to another then enables multifunctional STS generalisation. (Ge et al., 2017; Qu et al., 2010)

The above analysis and review of the challenges of STS are based on the current literature and prior studies that have been carried out. There are many challenges faced by STS in Chinese cities as transportation systems in China have not been sophisticated enough to enable the whole transportation network to be smart (Ge et al., 2017). A common perspective with regard to the existing challenge from both summaries is that data or information generated from one application cannot be effectively shared to other applications. Therefore, the biggest issues of the current STS are the data integration and data sharing, which is the focus of this study.

2.6 Data integration of STS applications in China

The prior sections of the literature unfolded a theoretical underpinning and framing of this research, including essential concepts and rationales. The next sections of this literature review start looking at issues around STS development in Chinese cities and in particular provides a fine-grained examination and analysis about STS data integration issues.

2.6.1 Conceptualisation of data, datafication and data integration

The current literature contains troves of data-related work associated with both the general context and specific smart city context. Different scholars hold different views of what data mean for a city, how valuable a set of data are in delivering public services to citizens, and for the most part, what profound implications data-driven urbanism, datafication of a networked city, and data integration would have for the smart city development. This section will present an overview of these issues.

A plethora of data science scholars have carried out instructional, heuristic and systematic work around urban data. Amongst them, Rob Kitchin (2014b) published his latest book *The Data Revolution: Big Data, Open Data, Data Infrastructures and Their Consequences* in 2015, within which, the theories and rationales have been substantially cited by many other scholars. With regard to the question of what data are, Kitchin argues that data can never be merely seen as just data; how data are perceived and applied are contingent and variegated across data-holders who capture, analyse and draw values from them (Kitchin, 2014b). Indeed, what data implicates for a particular context with a certain degree of human intervention, often embraces obscured or invisible elements regarding how they are used, damaged and repaired in the contingent processes of development, which is more likely to be the case when data are digitalised (Pink et al., 2018). In the smart city discourse, various smart systems generate a plethora of digital data by deployed sensors and applied big data technologies. From a purely technological perspective, data are perceived to be objective in nature, and situated, conditionalised and relational in application (Bowker & Star, 2000; Kitchin et al., 2015). They should also be conceived as "*framed and framing*" (Gitelman & Jackson, 2013) with accounts of their ethical, political, economic, spatial-temporal, or philosophical bases (Kitchin, 2014b). Embracing these perspectives, it is necessary to take management and governance of data into account when dealing with big data-driven STS issues.

Big data are widely infused into urban smart transportation, wherein the sensors and other data capture tools (e.g. High-definition CCTV cameras, smart phones via embedded GPS, smart card, vehicle tracking through (ANPR) Automatic Number Plate Recognition) used to process large quantities of STS data, are configured in various locations of the city (Kitchin, 2015c). Leszczynski (2017) claims that the big data coming out from these places are circulated in a way of being indiscriminate and all-encompassing (involving all individuals and objects), distributed (emerge across different devices, services and locations), platform independent (data journeys across various sites of data practices, e.g. devices, applications), and continuous (data are generated on a regular and automated basis) (Leszczynski, 2017). These characteristics resonate with the notion of *datafication*, which, from a theory-driven point of view, refers to more aspects of life being quantified in a format that can be tabulated and analysed for certain purposes (Mayer-Schönberger & Cukier, 2013, p. 165), hence requiring real-time monitoring and predictive analysis (Van Dijck, 2014). In this sense, it is argued that, in the context of STS, datafication suggests various kinds of data being created, processed and re-used across different social network sites of data practices in order to mirror how human transportation behaviours are conducted within the data-driven STS, for example, data captured by sensors on public transports can indicate traffic flows.

Data integration is the issue of combining data emerging from different sites of practice and sources and providing the end-users with a unified view of these data (Lenzerini, 2002). More commonly, the practitioners of data integration endeavour to establish data integration systems that access a series of data sources and have the system automatically configure itself so that the integrated system can correctly and efficiently respond to the emerging queries

(Doan et al., 2012). The problem of information systems data integration has become increasingly important and challenging in real-world applications. Again, this is because it is not merely a technical process but also comes alongside social problems, for instance, the way in which data are captured and unitedly coordinated by stakeholders, which might be determined by organisational settings, political legitimacy and local cultural dynamics. Doan, Halevy and Ives (2012) further point out the reasons why information system data integration is challenging include systems, logical, social and administrative elements. Hence, such a process can never be accomplished by only one stakeholder organisation, but instead is reliant on concerted efforts between different types of data holders.

The investigation of the current literature suggests the definition of data integration in STS is that data produced from different STS applications can be shared between each other, in order for the central data platform to be created and in-turn allowing the integration of all datasets as a central STS application (Atia et al., 2014; R. Meier et al., 2005; Z. Zhao et al., 2014). There is a large range of existing studies with regard to both the benefits and challenges of STS data integration. But the focus of these studies is significantly distinct. There are some researches discussing the interactions between applications, the potential effectiveness achieved by STS data integration, as well as the implementation challenges and implications to future practices (Atia et al., 2014; Pan et al., 2014; Z. Zhao et al., 2014). Unlike many others whose work are significantly focused upon the technological layer of how data ought to be integrated, Solecka and Żak (2014) present an overall methodology of assessment of the STS data integration. Their study of the integration solution was conducted with a focus on transportation infrastructure, organisational structure, social economy and informational system, which can obtain a better comprehension of both the benefits and challenges of STS data integration. Drawing upon many prior pieces of research, this study aims to explore STS data integration issues and challenges from various socio-technical dimensions within the backdrop of China's new-type urbanisation policy.

2.6.2 Challenges of data-driven STS in Chinese cities.

In terms of the Chinese government's perspective on STS data sharing, the relevant studies in the current literature vary significantly from the purpose of the research and the methodological consideration. In this sub-section, the issue is discussed according to the following two types of STS data: data generated by the applications and data stored by the government. The former one discusses what and how data sharing of STS applications should be, while the latter one refers to the government's data that is shared with the public.

2.6.2.1 Data generation and sharing

Data generated from STS applications ought to be shared more systematically by the data infrastructure, which can eliminate data distribution limitations through informal means and approaches (W.-H. Lee et al., 2010). This means, STS technologies, in particular, are provided by the networked and federated special data infrastructure, which significantly strengthens data sharing. The government's priority of Smart City development gains the attention of Chinese cities to develop GIS technologies (R. Chen et al., 2012). The spatial data infrastructure, which is always assessed and updated, has been well established and deployed by the government.

STS data sharing is important and has profound implications on the government in a Chinese context. Data sharing is a part of the government's activities, responsibilities and necessities, which arise from data policy issues, personal privileges, and government decision making (F. Harvey & Tulloch, 2006). Since transportation system data is directly correlated to the advancement and innovation of science and technology across the whole country, the value of transportation data is highly corresponded to sharing characteristics in two fundamental respects (Council, 2006). Firstly, smart transportation data sharing, requires the information and knowledge from pertinent disciplines, namely an interdisciplinary approach to achieve data sharing is needed. Secondly, a data-sharing platform is required to facilitate simultaneous and unrestricted copy and use of data, through which data can be entirely shared in order to achieve its maximum value.

However, STS data sharing for the government is not only a technical issue – moving data from one STS application to another. It requires complicated organisational arrangements. The current literature concluded that three factors require the growth of organisations to support data sharing in STS, which are highlighted by government documentation regarding to the technical data sharing issues among enterprises (Clifton et al., 2004; Fan et al., 2014; Hashem et al., 2016; Jing & Pengzhu, 2009). Firstly, due to the diversity and complexity of STS data, data should be well organised and maintained for future data exchange between different applications. Secondly, since data storage built in each application combines different types of data that are shared by other applications a data safety management system should be established and taken into consideration by the application-designers. Finally, all confidential data for each single application should avoid being released or misused. All these factors indicate that data sharing and data protection mechanisms among Chinese enterprises are not currently well developed, and that the government has raised their attention to sharing STS data more efficiently and effectively whilst minimising resource consumption.

2.6.2.2 Surveillance, social control and privacy

Surveillance is a topical issue in the era of smart cities; it is increasingly regarded as an important aspect of data-driven and networked smart urbanism. Galič et al. (2017) claim that surveillance as a scholarly discipline is depicted as an umbrella that involves a variety of topics of social problems (e.g. social control, urban planning, security and privacy). Within the Chinese city context, this study particularly focuses on social control and privacy issues. However, before examining these, this section firstly looks at the interrelations between data and data-driven surveillance, which is identified as crucial in the context of STS.

Kitchin (2014b) summarised that there are three categories of data production (the process of data being generated, processed, shared and analysed): *directed* data (data are generated by conventional forms of surveillance, with data operatives monitoring individuals or particular places), *automated data* (data are generated automatically by a plethora of technologies, with minimal human inventions) *and volunteered data* (data are generated entirely from human activities, such as social media networking, online transactions, wearable/portable smart monitoring devices, crowdsourcing, and community networks) (Kitchin, 2014b). While traditional surveillance may just generate directed data that are used to trace human behaviours and activities, an overflow of various digitalised surveillance technologies has incurred troves of big data that pervade all sorts of data production procedures. In the context of STS, various digital platforms and applications can create automated data from their end-users, such as automatic vehicle identification and automatic smart card fare collection (Jimenez, 2018; Mohamed et al., 2016; Prabha & Kabadi, 2016).

Moreover, data-driven surveillance (also known as 'dataveillance') (Van Dijck, 2014) lay claim to be enablers that contribute to the shape of technocratic and corporate governance (Kitchin, 2014b; Kitchin et al., 2015). Firstly, the vast quantity of data generated from digitalised surveillance infrastructures, such as city dashboards, CCTV cameras, sensor networks, etc., are stored in urban control rooms or command systems owned and managed by government. These infrastructures can zoom, monitor and track individual pedestrians and vehicles, namely that these objects are controlled by surveillance infrastructures. In smart traffic management systems, for example, these data are generated from automatic number plate recognition (ANPR), and are used to track and monitor vehicles and provide implicational inputs and valuable information into the system, whilst also displaying fine-grained algorithmic analysis about the owners of vehicles so as to administer fines and penalties for traffic breaches. This technocratic control and command system centralises governmental administrative and managerial power and decision-making into a set of municipal authorities (e.g. Transportation Bureau) who provide services to civic participants (Janssen & Kuk, 2016; Kitchin, Coletta, & McArdle, 2017).

Secondly, smart city initiatives are being heavily steered by corporate interests who endeavour to stimulate volunteered data that for the most part come from crowdsourcing and social media. These ways of civic participation enable broad cooperative and co-creative forms of governance with the prosperity of large amounts of innovative solutions which aim to achieve a common end (Papadopoulou & Giaoutzi, 2019). While crowdsourcing concentrates on innovativeness wherein externally designated non-professionals engage in a cooperative task without consideration of rewards and compensation (Trottier, 2014), social media-driven volunteered data, similar to living labs, emphasises the interactive, participatory and dynamic integration and inclusion of citizen end-users in the co-creative innovation process (Kitchin, 2014b). In the context of STS, data generated from both types of data platforms are governed by either data-owner STS companies or transportation authorities. In particular, citizen end-users interacting with mobile devices generate data, under surveillance, which are re-used by these organisations to increase commercial value. For example, many smart navigation smartphone apps call for volunteered data collection through citizen end-users reporting and feeding back traffic incidents that are happening, which is acknowledged as an effective way to lower the seriousness of the incidents. Likewise, traffic detection systems rely on constantly capturing vehicle licence plates in order to count dynamic and real-time traffic flows. These data-driven, networked STS solutions are tending to be commercialised, but with some held by the municipality, they actually would like to trade their data into privately owned hands (i.e. marketisation and privatisation) in order to create new models of capital accumulation and corporate form of governance.

However, ICT-enabled STS initiatives could provoke privacy concerns; effective privacy protection mechanisms for urban STS, particularly in Chinese contexts, rarely enters the picture. The issues of STS privacy are scattered around every corner of urban transportation, involving various stakeholders. One of the most overwhelming groups are citizen end-users; issues around what types of privacy they have, how their privacy was invaded and what potential solutions would emerge, have gained increasingly intensive traction among businesses, government and academia. ‘Privacy’ was construed as ‘the right to be left alone’ a hundred years ago by Warren and Brandeis (1890). However this interpretation was rather generic and has been used in myriads of disciplines and social contexts (Warren & Brandeis, 1890). It is difficult to adapt it to surveillance-led STS networks where there are large troves of big data being generated, processed and analysed for public interests. Eckhoff and Wagner (2017) argue that there are five essential types of privacy in smart city context*: ‘privacy of location’, ‘privacy of state of body and mind’, ‘privacy of social life’, ‘privacy of behaviour and action’*, and ‘*privacy of media’* (Eckhoff & Wagner, 2017). Within each of these respects, privacy is compromised by corporate and government surveillance which captures personal information without end-user knowledge. For example, most smartphone apps can trace end-user habits by looking at data embedded in the device (e.g. contacts, photos, locations), which is especially the case in STS-related apps as geo-location service is the primary means by which they access end-user data (Guha et al., 2012).

Furthermore, the issues of privacy usually have close links to the deployment of surveillance-oriented smart system applications. Controversial debates have emerged to the purpose of deploying these applications. Whilst generally surveillance systems are implemented with the purpose of social control wherein population under control are actually being watched and disciplined into certain set of norms and behaviours, they are usually questioned by the population as for whether such control breaks their privacy (Lyon, 2006). For example, in June 2019, a group of masked protesters toppled a couple of smart sensor-packed lamp posts (i.e. smart lampposts), which had recently been deployed by the government in Hong Kong (C. Hu, n.d.). They fought for democracy, claiming their feelings of being watched by *‘tens of thousands of mechanical eyes’*, and therefore the masks they wore suddenly became a symbol of pro-democracy. While protester citizens had concerns over their individual privacy somehow being violated by the urban surveillance system, the Hong Kong government proclaimed that none of these smart lampposts installed facial recognition systems (SIDNEY FUSSELL, n.d.). This conflict suggests that data-driven, ICT-based smart system applications might give rise to public concern, questioning whether the purpose of these initiatives is to simply offer smarter living conditions or to be used as a mechanism for policing and monitoring citizens. In this sense, the government may need to officially stipulate and legalise the use of surveillance-oriented smart system applications.

As for privacy protection, the Chinese government has endeavoured to seek effective leverages to protect citizen end-users' online privacy through legislation and enactment of relevant cybersecurity laws. A few policies have been made, however none of these took into consideration overlapping digital platforms wherein accountability of data flows and ownership are not clearly stipulated (Yang & Xu, 2018). In order to establish a more effective privacy protection mechanism for the sake of legal interests of the public and to promote a healthy and secure environment for social and cyber information sharing, the Chinese government launched the Cybersecurity Law in June 2017 (KPMG, 2017). This policy stipulates clear requirements of the collection and storage of personal data which must be standardised and regulated by relevant internet service providers and the government. This measure aimed to address issues of personal information disclosure, damage and loss, in the process of data transferring or journeying between different sites. Nevertheless, within the current smart city context, complex data-driven, networked assemblages of digital technologies and infrastructures (e.g. CCTV cameras, supervision control and data acquisition systems, telecommunication switches, power grid and smart meters, ETC (Electronic Toll Collection), etc.) from which personal data are generated, are confronting the increasing extent to which they are vulnerable to being hacked in city cyberattacks (Kitchin, 2016a; Kitchin & Dodge, 2019). This means wherever these technologies are implemented, there remain cybersecurity-related privacy concerns (i.e. threats to security of digital information), which the current legal frameworks are not necessarily sufficient to deal with them. A review of the Cybersecurity Law suggests that it seems not strict enough to be able to address such cybersecurity concerns.

Therefore, it is argued that data privacy and security concerns in Chinese cities cannot be addressed merely by a single solution, or what is called the 'one-size-fits-all' instrument that would offer all-encompassing measures for the problems (e.g. enactment and enforcement of a law); but rather, a set of solutions is needed, which are market-oriented, technical in nature, governance-based and more policy, regulatory, and legally concentrated, specially including what Cavoukian et al. (2010) demonstrates as *"privacy by design; law, regulation and* *independent oversight; accountability and transparency; market forces; education and awareness; audit and control; data security; and fair information practices*" (Cavoukian et al., 2010).

2.6.2.3 Data-driven social sorting

As suggested above, surveillance is carried out by both the government and large-scale organisations, but at the same time both have to give consideration and implement policies to protect privacy; therefore, practitioners and researchers need to adopt political-economic, alongside discursive, constructivist and ethnographic approaches. However, privacy breaches and the vulnerabilities of data security are actually deemed as being in relation to what troves of big data are envisioned to achieve. In terms of this, the reviewed literature unfolds that big data have been harnessed by commercial enterprises to predictively profile their potential customer segments by conducting fine-grained, sophisticated, systematic scrutiny and analysis of their geo-demographic and census data (Kitchin, 2014b, p. 176).

For an STS company, for example, such data might be those generated by capturing real-time location and the characteristics of movement of a particular end-user group in a certain locale. These end-users would be profiled to be specific images that can be used to describe user behaviours and patterns of mobility so that the company can create personalised treatment for them. For a commercial enterprise, the purpose of this is to produce their own customised behavioural marketing. More recently, such profiling companies have begun producing individual, rather than collective and aggregated profiles by integrating data that come from a variety of sites of practice (Siegel, 2013). The combination of data from these very sources forms various data assemblages which, for data operatives, are used to comprehensively delineate and predict how individuals behave in their daily lives, what transactions they make, and what kind of objects they socially interact with. This would result in what Kitchin (2014b) identifies as 'social sorting' – namely socially classifying and redlining populations and screening out certain groups to have a preferential status which excludes others (S. D. Graham, 2005; Steve Graham & Marvin, 2002). However, this mechanism of social sorting is greatly controlled by the government, or vendor firms (who own the data) who make data and associated analytics opaque to citizens and consumers. Citizens, as such, have no idea what their customer profiles implicate, on the basis of what kind of sorting that steers or nudges them to be corralled into the brackets of 'heavyweight' or 'lightweight' social groups. The lack of transparency gives rise to long-term and deeply entrenched social discrimination.

Therefore, social sorting needs sophisticated regulatory and legal oversight that can prevent discriminatory practices from happening.

Back to the field of Chinese society, the new-type urbanisation agenda contains a prominent blueprint, named '*Planning Outline for the Construction of a Social Credit System (2014–2020)* (Creemers, 2014)'. As a section of the whole policy agenda, it highlights many of the social problems that exist as a result of the lack of trust and robust regulatory oversight of citizens who break social credit and trust ("Xinyong" in Chinese). Xinyong is gauged by and represented through embedded information encapsulated in national ID cards in which a personal profile photo and a chip are embedded. The government has full control over the use of ID cards, and on many occasions records individual credit changes led by the infringement of rules, regulations and laws, onto the technical system. The fact that such social credit is recorded is referred to as the 'culture of control' (Lyon, 2007). Lyon defined this notion in western terms using western ideas: a *"neoliberal anti-welfare"* political environment, the main characteristics of which are based on the idea of social control rather than social provision. However, in the context of Chinese STS, the nationwide adoption of 'smart card' system (a system that is linked with national ID data) indicates government socially sorting and redlining transportation populations at individual level (C. Liu, 2019; Lyon, 2007),which seems analogous to panoptical surveillance that monitors people and directs the ways in which they interact with urban transportation services. The main characterises of such kind of smart cards suggest that social sorting in China is state-control, and concentrated on individual behavioural patterns (e.g. traffic infringement, penalty points on license).

The big advantage of such initiatives is that municipal authorities can single out the social exceptions by means of reducing their social credits and circumscribing them onto a blacklist (Creemers, 2018). From the social perspective, this means that those who are anti-social, such as transportation transgressors and criminals in general, are excluded or marginalised from society, with the STS services available to them being greatly restricted. Nevertheless, from the technical perspective, as data processing might go wrong, it is likely that people are blacklisted incorrectly. Also, such kind of punishment may backfire, namely that the more marginalised the transgressors become, the more they transgress social norms and expectations. Moreover, such initiatives may limit the extent of citizen participation in smart cities. The 'culture of control' reflects that the Chinese government always acts as the 'patriarch' and 'monopoly' of the statecraft and nationwide socio-spatial initiatives. This can give rise to stewardship, technocracy and civic paternalism of STS initiatives in the smart city context, on the basis of top-down political legitimacy, and which is likely to reduce the power of citizenship in regard to co-designing and co-producing innovative solutions.

The above sub-sections regarding the challenges of data-driven STS initiatives in China critically reviewed key unwieldy issues surrounding the relationship between data and the city. Overall, the researcher argues that, to date, the existing data-driven STS initiatives in Chinese cities aim to create a commonsensical (cities are out there, enacting what they actually are, within widely accepted ideologies, e.g. data generation without interrogation), pragmatic (smart solutions are created with the purpose of efficacy and effectiveness of urban governance, serving the benefits of vested interests and municipal leaders, e.g. anticipatory profiling and social sorting), and politically monopolistic (the government has the whole gamut of power-ship and decision-making rights to control and nudge what and how data are to be used for what purpose, e.g. surveillance) form of urban governance. However, these very aspects of data-driven STS in Chinese cities are, for the most part, focused upon the roll-out of mathematically and algorithmically engineered and computational applications. These applications serve the needs of particular interest groups, rather than factoring the city's socio-material complexities through the use of an integrated and networked frame of reference to carefully examine what would be critical behind an integrated scenario of data applications in STS, within the data-driven urbanism. The next section explores the current data integration issues of STS from various socio-material points of view.

2.6.3 Data integration issues and challenges

Previous sections revealed many conceptual and practical aspects of STS data, which indicated that, in any sense STS data are subjective, situated, contingent, relational, contextually framed and used. High-quality data can be valuable, whereas incorrect and out-of-date data can be misleading or even detrimental to the data practices (Dong & Naumann, 2009). STS data to be integrated echo these characteristics, which further resonates with what Kitchin argues urban data to be: *"never raw but are always already cooked to a particular recipe for a particular purpose"* (Kitchin, 2015a). For the current research, the *'purpose'* means the need for Chinese cities to initiate a more data-integrated STS application where all data are assembled and are converted into all-encompassing STS functionality in order to achieve a smarter, more efficient and more sustainable development of urban transportation.

The '*recipe'* refers to the process in which data are assembled within complex socio-technical assemblages that are shaped and moulded by a series of socio-political, organisational, cultural, and technological forces. The following sub-sections will more closely examine each of these factors respectively.

2.6.3.1 Socio-political factors

A number of aspects of STS in Chinese cities have been changing in recent years (X. Hu et al., 2010) including the use of scientific transportation data, the conditions in which transportation system data are produced, and the role of people (e.g. end-users, system developers and policy makers) in these processes. These changes are a result of the revolution of system capacity and interoperability and development in infrastructure that have promoted data quality and supplied system producers with a significantly growing capability of data collection, analysis and dissemination (Amiri Khorheh et al., 2015). These changes bring about the following socio-political issues (X. Hu et al., 2010): first, the requirement of different types of STS data (generated from various sites of data practice) for particular application development purposes; second, the constitution of widespread data-sharing mechanisms; and third, the integration of existing data with varying data standards and formats to new data sets (Kitchin, 2015a). For the whole of the data integration process, there is a socio-political need for a central integrated data infrastructure and capacity for shared data, for instance, the legitimacy of the corporatisation of governance (e.g. data ownership, data access statutes), and for information management that meets the demand of all relevant stakeholder organisations (Gu et al., 2012). There is now a strong socio-political dimension in terms of this: technology-driven data-integrated STS activities enable monitoring of the environment of the whole smart city construction which can provide society with what it needs, but will only do so if data from different stakeholder sites of practices are shared and integrated properly with legal and legitimate stipulation of what and where data are going to be. In turn, this requires high priority on data policy and the demand of better management of data sets that follow the policy.

There is a large range of definitions of data policy in urban transportation. Welzer et al. (2006) describes this concept in the general smart system context; when applying this concept in urban STS it refers to how STS activity monitoring should be carried out in order to ensure the data produced from users, organisations and governments, are accurate, accessible, consistent and protectable (Y. Liu et al., 2012; Putman, 2013; Welzer et al., 2006). This definition consists of different dimensions of data activities. Urban systems in China have been a big issue in the fields of urban transportation and economic activities (Lao et al., 2016). Comparing these two networks provides new avenues for further developing China's urban network. The law of economic development and information governance by the governmental institutions both play a crucial role in connecting these two networks (Lao et al., 2016). The gap between them can be reduced by relevant transportation system data policy reforms. This in turn, contributes to the STS data integration, whilst the shortened gap between transportation activities and economic activities means that data integration drives urban economic development. Therefore, data policy is a major consideration when integrating STS data sets from the dimension of socio-political factors, which contributes to the balance between transportation networks and economic networks. Therefore, the achievement of STS data integration facilitates city economic development.

2.6.3.2 Organisational and cultural factors

Anumba et al., (2006) suggest that the persistent failure of integrating data of information systems from different organisations is partly because of the impact of organisational and cultural dynamics (Anumba et al., 2006). From the dimension of STS organisations, clear understanding of what STS data integration is for and how it resonates with the core culture and values of the organisation needs careful consideration (Pan, Wang & Yan, 2014). With regards to urban transportation systems as a whole, incorporating ideas of smart corporate forms of governance, overall urban planning, strategic design of urban transportation infrastructure of STS initiatives, and urban culture with local characteristics of entrepreneurship and competitiveness, would help to stimulate successful data-shared transportation systems, wherein data from different systems could be corralled into a central place (Farías & Bender, 2012; Ge et al., 2017; Hollands, 2015; Kitchin, 2014b).

The reviewed literature for the most part has placed particular emphasis upon the role of organisational culture in an STS organisation being able to cope with possible data integration issues. Different types of organisational culture would affect the STS implementation to different degrees. Organisational culture commonly co-exists within different cooperative firms within the context of supply chain integration and is defined as relatively solid beliefs and values that are held within these organisations (Cao et al., 2015). For knowledge management practices, the components and functions of organisational culture is regarded as the reduction of uncertainties, control and coordination, conflict elimination, and competitive edge (Alavi et al., 2005). Within STS and this study's context, a good organisational culture would have a positive influence on an organisation's capability to adapt to changes that take place in the data sharing, transfer and integration process. A solid organisational culture assists goal alignment (Beugelsdijk et al., 2006), in terms of which, there is always an agreement to what type of STS data can be shared and in what way. An effective database sharing mechanism in the STS that highlights involvement, consultation and participation within the scope of application end-users and organisations could contribute to a big change in organisational culture (Braunscheidel et al., 2010). Such change to a large extent means the improvement of application performance. Therefore, it is important for the organisation itself to understand such change (i.e. the current organisational culture), especially in relation to technologies used and the consideration of how the change influences the data integration process.

Many pieces of research focus on a set of complex issues associated with STS development and its implementation, which involves social, technical and organisational factors. But few of them examine data integration issues within the organisational theory domain. A weakness of China's studies on data integration issues of smart application development within smart city context is that the scientists only focus on technological and strategic solutions to business problems (An et al., 2016). A great number of them ignore organisational factors of data integration issues, where there is no attempt to examine the relation between the degree of STS data integration and the degree of success in addressing organisational issues occurring in the data integration process (Gajendran & Brewer, 2007). Organisational issues can be addressed not only by post-implementation evaluation such as appropriate strategic approaches for data integration planning design (Wong et al., 2011), but also pro-actively solved by the evaluation of various models and definitions and better understanding of social, political, and cultural aspects of data integration implementation. Thus, Chinese STS application scientists should take into consideration the basic theories and practice with regard to how data can be effectively integrated, and organisational structure and culture regarding to how the integrated STS adapts to the Chinese market.

2.6.3.3 Technological factors

Technology facilitates socio-environmental performance of data integration (Pardo et al., 2004). In the context of STS, technologies used for data integration can bring the opportunity for new transportation networks which includes basic vehicles and urban transportation infrastructure with completely distinct mechanisms (Clark II & Lund, 2008). Technologies can make a significant difference to STS through the latest up-to-date and smart ICT solutions for smart traffic management (Schünemann, 2011), smart journey planning (L. Yu et al., 2015), and smart noise reduction (Han & Chang, 2013). All of them ought to be upgraded and combined in parallel with the needs and new sustainable demand of the smart technologies. In the case of China, Chinese scientists and professionals by and large have not come up with creative and effective approaches of ICT as well as related STS technologies for data integration, therefore practitioners of different applications do not become involved in adopting advanced solutions. This suggests that, if the approaches provided by the top layer of STS actors, i.e. scientists, within China's socioeconomic environment are not to be innovative enough, the practitioners at the bottom layer, namely the organisations, would not involve in updating the technologies used for data integration.

There is a substantial body of studies that has explored the technological factors related to implementation of integrated STS in which data remained in silos are integrated together. These studies show that social and technological processes should always be considered as a whole in relation to the inter-organisational data integration of STS (Cottrill, 2009; Dueker & Butler, 2000; Tufte et al., 2018). In addition, these two aspects are interacting with each other (Pardo et al., 2004) during the process of data integration. Popovič et al. (2012) propose a model to help system practitioners understand the interrelationships between critical success factors of business intelligence systems. In this model, business maturity, which is identified as one of these significant factors (others include information quality, analytical capabilities and effective use of information for decision-making), is determined by data integration (Popovič et al., 2012). In other words, organisations aiming to effectively evolve their business intelligence system to higher levels of business maturity would need to implement advanced data integration mechanism in order to assure data can be well integrated across the organisation. In the context of Chinese STS data integration issues, the model demonstrates how a particular smart data-driven technology, which relies on the advancement of urban informatics and urban science (Kitchin, 2015a), mutually connects and interacts with relevant organisational or business processes. These two processes (i.e. Technology solutions and organisational/business processes) are shaped as two elements of the inter-organisational setting (resource sharing and trust) (J. Wang et al., 2011). For example, one company can produce more than one application and any two of them can share resources for each of their own purpose, e.g. 'Baidu', 'Google'. The outer context of the model is the policy and social environment, meaning that all of the data integration processes always follow the same data policy (for example, incorporate available information into decision-making process) within the same social environment. In China a large number of STS resources are handled by the government, all of which are represented as special data sets that follow the consistent data policy (Lin, 2012). Above all, in such a situation, STS data integration technologies always interact with organisational and business processes within the socio-political environment, no matter how the technologies are updated.

Overall, the current literature regarding the technological factors of STS data integration suggest that the data integration process is highly associated with business-driven, organisational and innovative thinking from the top layer (e.g. technocrats, STS practitioners, policy-makers) within the data integration context. In addition, the technological process of data integration issues is in high interaction with socio-political processes. The updating processes of technologies must be under the same socio-political condition and within the same data management environment.

2.7 Summary

Whilst the study is particularly focused upon the data integration of urban smart transportation systems, the reviewed literature firstly provided rudimentary rationales of the term ‘smart’ anchored into the urban context and key theoretical framings of smart city initiatives. As a crucial smart city domain system, the literature of STS was subsequently reviewed with a focus on its application in Chinese cities and main challenges. The chapter then unravelled key concepts surrounding ‘data’ before concentrating on what makes sense of data integration of the STS within Chinese cities.

Prior studies have placed significant attention on the practical issues of Chinese STS from a range of perspectives, such as infrastructural design, policy making, technical deployments, human factors, and so on (Ge et al., 2017; Lingli, 2015; J. Yan et al., 2018). Driven by the objectives of the STS per se – convenience, sustainability and instantaneous communications, as suggested by its definition, endeavours have been made on the basis of existing city transformation agendas through promoting ICT-enabled systems and applications (e.g. city dashboards, traffic control rooms, smartphone transport apps, sensor networks, smart navigation systems).

However, wicked urban issues still exist, such as increasingly serious traffic congestions, unsustainable development, information asymmetry, and the ‘information island’. One possible cause of these problems is that those smart transportation systems and applications are technically and functionally independent, leading to weak capabilities of data transfer across different places. Prior studies have explored data integration issues in the context of the Chinese smart city in general terms and with a focus simply on non-functional and technical requirements, such as the building of open standard systems (An et al., 2016), the embedding of IoT networks (Alam et al., 2017), and information sharing protocols between organisations (Raghavan et al., 2020). However, ambiguities remain, firstly as to what data integration would be for urban STS in particular; secondly, what broader social and political factors would impact on shaping the integration process; and thirdly, whether this integration would be able to respond to the wicked issues that widely exist in cities. This research was proposed to explore these controversies.

To be specific, this study does not aim to actually design and implement a data-integrated STS, nor does it intend to examine its issues, driving forces, or constitutive factors from simply the technical point of view as the above-mentioned studies have done. Drawing on Chourabi et al.’s (2012) theoretical framing of critical factors leading to the success of smart city initiatives, the thesis identified a significant gap in understanding the socio-technical dynamics related to STS data integration within the context of Chinese smart cities. Furthermore, citizen participation is an important angle of exploration of the contemporary smart city efforts argued by many smart city thinkers, like Rob Kitchin, Anthony Townsend, and Dan Hill. This, in practice, resonates with one of the objectives of the New-Type Urbanisation agenda – being citizen-focused. Despite a few studies that touch upon citizen roles in extending the Chinese new urbanism (e.g. J. K.-S. Chan & Anderson, 2015; Cheshmehzangi, 2016) and Huifeng Li and De Jong's (2017) study on the characteristics of citizen participation in Chinese eco-city projects, there is a lack of emphasis on the way in which, and the extent to which, citizens participate in smart cities and the STS in particular, and this is also significantly neglected in Chourabi et al.’s (2012) framing of success. In this study, the citizens’ angle is considered prominent in unravelling social challenges, risks and unintended consequences that may emerge from the data integration process.

Above all, this literature review set out to combine the socio-technical vision and rationales of citizen participation as the theoretical lens of this study, followed by unfolding existing socio-technical issues around data in Chinese smart cities and the STS. The thesis, as such, will close the gap by incorporating the problems of how citizens participate and interact with firms and the government, into the socio-technical framing. This thesis, which is aimed at exploring the question '***What would be the potential challenges and opportunities for initiating a data-integrated STS application in China's new-type urbanisation from a socio-technical perspective?',*** will address the gaps identified above, and in order to address this question a more inductive approach is required. The Methodology Chapter will elaborate on the philosophical and methodological defining of this inductive study in more depth. It will outline the research strategy, data collection approaches, and the data analysis approach used to undertake the empirical research.

Chapter 3: Methodology

3.1 Introduction

Research methodology refers to a series of systematic procedures by which the researcher conducts the research to describe, explain, explore, and address a specific problem within a particular context (Kothari, 2004). It is interpreted as the science of exploring how a piece of academic research is scientifically conducted. The building of the methodology of this study was based upon the research aim – ***to explore the potential challenges and opportunities for initiating a data-integrated STS application in China's new urbanism from a socio-technical system perspective.*** The chapter is primarily focused upon the discussion of the methodology that is used in this study. It illustrates the philosophical paradigms, and presents the research design with an overview of the methods and approaches adopted for data collection and data analysis. It also provides an explanation of the reasons behind the choices made to achieve the research aim.

Both theories and practices are crucial to a successful research project. Hence, this chapter will discuss the methodology of this study from both its rationale and applications. By doing so, the chapter is divided into the following sections: First, the orientation of the philosophy of this research is discussed, which includes epistemological and ontological assumptions, inductive and deductive research theories, and qualitative and quantitative research approaches. The second section provides a comparison of different research strategies. The third section discusses the selected research method – i.e. single case study – with its rationale and application. Next, specific data collection and data analysis approaches are respectively presented in the fourth and fifth sections, followed by the last section – ethical concerns.

3.2 Research philosophy

The term 'research philosophy' refers to "*a system of beliefs and assumptions about the development of knowledge*" (Saunders et al., 2016, p. 124). When this definition is interpreted in a more comprehensible way, it is said that the research philosophy is like the 'rudder' of the research, which states when the research will start. The purpose of carrying out research is to "*develop knowledge in a particular field*" (Saunders et al., 2016, p. 124), so the role of research philosophy is to orient and guide the research direction (Crotty, 1998). The research philosophy allows the researcher to make certain types of assumption at each stage of the research (Bryman, 2016), such as epistemological and ontological assumptions, which are discussed in more detail in the following sub-sections. The discussion of research philosophy also refers to identifying the research to be either inductive or deductive, whilst using a qualitative, quantitative or mixed-method approach.

3.2.1 Research philosophical considerations – epistemology and ontology

Research philosophy with its essential components is depicted by Easterby-Smith et al. (2015) as a tree trunk; its cross-section represents the four primary features of a research's philosophy – from the 'heartwood' to the 'bark', i.e. ontology and epistemology, methodology, and methods and techniques (Easterby-Smith et al., 2015).

Ontology refers to the root of philosophical assumptions that the researcher makes about the nature of reality (Saunders et al., 2016). Issues that are usually being investigated are built upon the questions of "what is the reality" and "in what way the researcher sees and shapes the choices of what to study in order to 'unbox' the nature of such reality" (Easterby-Smith et al., 2015; Saunders et al., 2016). The literature of social research philosophy in general demonstrates that ontology is usually composed of several positions which are situated on a continuum, and the two remarkable positions are internal-realism and nominalism. Easterby-Smith et al. (2015) argue that it is more likely that research defined as nominalism-oriented in philosophical nature applies a qualitative research approach, and conversely, a rather quantitative study design is usually produced by an internal-realist ontology, despite possibilities that some research are apparently characterised in a blurred line of combining both two streams of ontological assumptions, such as 'relativism' (Collins, 1983).

Internal realism emphasises that rather than being real and totally independent (characterised as 'purely realism', which is usually considered in the field of natural sciences), the world and its reality are causally independent of the human mind. There is no direct means to gain access to the nature of that reality, however it is possible to collect indirect evidence with regard to what is happening in fundamental physical processes (Bryman, 2016; Easterby-Smith et al., 2015). For example, in the context of this study (i.e. the STS), while the traffic status can be measured through a set of solid parameters, such as the speed of vehicles, wind velocity, the timing of traffic lights, (which is usually what natural scientists take interest in), an internal realism places attention upon the causally related factors that determine the traffic status in a specific locale, such as the performance of the equipment used to detect those parameters (e.g. road cameras, sensor-enabled road infrastructures) and road network characteristics. In a nutshell, this position underlines ‘accuracy’, in a way of identifying any distinctive physical characteristics of a particular reality within a particular context (Easterby-Smith et al., 2015).

Nominalism emphasises that reality is created by human beings and therefore never exists independently of human perceptions (Saunders et al., 2016). In other words, how reality is being sensed depends on how human beings view it in the real world, and on the truths human beings create to interpret it in a given situation. Thus, there is no underlying reality to the world beyond what people attribute to it, and the upshot as such may vary amongst different people as they have different experience and interpretation of reality (Burell & Morgan, 1979). This research, for example, resonates with a nominalist position, wherein social actors represent the main force that could direct the initiation of the proposed data-integrated STS solutions, and their perceptions of the potential challenges and opportunities really matter in the proposed future STS scenario. In addition, different types of social actors (i.e. citizen end-users, STS enterprises, government agencies) may have different insights, which embodies their own view to the ‘reality’ being discovered.

Different from ontology, which is focused on the nature of the reality, epistemology is the study of the ways to inquire the nature, usually with attention placed upon questions such as “what is knowledge”, “how is knowledge acquired”, and “how is the acquired knowledge interpreted to other bodies” (Bryman, 2016; Easterby-Smith et al., 2015). Within epistemology, two different traditions of philosophical position exist – positivism and constructivism. The distinction between these two stances concerns more about different legitimate knowledge types. These types of knowledge usually range from scientific explanation of quantifiable, graphical and numerable data that are all based upon empirical facts (i.e. positivist position), towards interpretation of qualitative, textual, conversational and even fictional data (i.e. constructivist position) (Saunders et al., 2016; Tuli, 2010).

Different to positivism, social constructivism is considered as a valid vantage point to understand a particular social phenomenon and its human activities therein in real-world situations (Mead et al., 1967). Such 'understanding' is conducted by occupying the frame of reference of social actors in practical actions with their subjective rather than objective views (Burell & Morgan, 1979). The view of reality is hence shaped by the daily interactions amongst people through knowledge and experience sharing with each other via the medium of language. According to the rationales of social constructivism vis-à-vis positivism as basic epistemological positions of social science research, it is remarkable that social scientists should not pay attention only to gathering the facts and measuring the frequency of patterns of particular social behaviours (Easterby-Smith et al., 2015). Rather, they should give priority to untangling and assessing the different potential meanings and constructions that social actors would have upon their experience and knowledge. This research was conducted by gaining the perceptions of how the new concept of STS and its proposed data-integrated scenarios would be formulated from different layers in the current social system, namely citizens, companies and smart government. Their opinions, with regard to the dynamics of integrating data from different applications into a central one through which the data can be effectively shared, would have profound implications upon the findings of this research. Therefore, the social constructivism is applied as the epistemological position of this study.

3.2.2 Research theory – deduction and induction

Whilst the ontological and epistemological positions lay the philosophical foundations of research, the relationship between research and theory is another issue to be resolved i.e. whether a research is identified as a deduction-based study or an induction-based study.

Deductive theory begins with a social theory that examines its implications with data. On the basis of what is known, the deductive research in a specific research domain firstly theorises or hypothesises from a general level of focus, then the hypotheses deduced are translated into operational terms, meaning that research observations are collected in order to address the hypothesis in turn (Thorne, 2000). Therefore, the hypotheses that emerged from the theory are ultimately tested by focusing on a pin-point detail. Sometimes in social sciences, deductive theory is informally called a 'top-down' approach (Bryman, 2016; Hyde, 2000). Conversely, in an inductive research, theories are the outcome of research, meaning that the inductive research involves drawing broader generalisations and theories out of specific observations (Bryman, 2016; Thomas, 2006). It starts with particular observations and measures, then formulates hypotheses that are ready to be explored, and eventually generates research theories. This logic of inductive analysis resonates with what Corbin and Strauss (2014) think: the heart of 'induction' is – *"deriving concepts, their properties, and dimensions from data"* (pp. 56). In contrast to deductive theory, inductive theory is defined as a 'bottom-up' approach (Bryman, 2016; Saunders et al., 2016).

Some scholars, e.g. Bendassolli (2013), argue that an induction-based study may either develop new theories or theoretical considerations or refine existing theoretical standpoints about particular social realities. Whichever way is chosen, there is at least something new about the theory emerging from the data. For this study, the research aim is to explore the potential challenges and opportunities of initiating the proposed data-integrated STS application from a socio-technical system perspective. In order to achieve this aim, the Smart City Initiatives Framework developed by Chourabi et al. (2012) was initially referred to as a theoretical lens for this study. Secondly, citizen participation rationales developed based on its socio-political shaping in both the neoliberal and the Chinese contexts as a frame of reference of the ways in which citizens are included in initiating the proposed data-integrated solution. Thirdly, a couple of existing issues in relation to the STS and data integration in the wider literature are examined, providing a vantage point to the study for further exploration within the current societal context. However, rather than to test whether these factors are applicable and transferable to developing the proposed data-integrated STS application, the current study instead purports to unravel in more depth, and discover new dynamics of, the socio-technical factors leading to the opportunities and challenges of such a proposed solution. A theoretical framework is expected to be developed by the end of the study based on the research outcome. In other words, this study follows an inductive theory, which is more suitable to the research setting.

3.2.3 Research approaches – qualitative and quantitative

The distinction between induction and deduction is closely associated with the identification of the approach adopted for the research, namely quantitative, qualitative or mixed-method approach. To differentiate qualitative and quantitative research approaches, a microscopic and quick way is to compare the research data. Quantitative data is usually in numeric form (e.g. numbers, graphs); the research usually examines the relationships between variables which are measured by various types of graphical or statistical instruments (Amaratunga et al., 2002). In contrast, qualitative data is presented in non-numeric form such as words, images and video clips; the research typically explores participants' ideas and finds out relationships between them (Saunders et al., 2016).

In a macro and generalised way of distinguishing these two research approaches, quantitative research is generally associated with ontologically nominalist and epistemologically positivist positions of philosophy, particularly when the study is built upon highly-structured and pre-conditioned empirical facts (Easterby-Smith et al., 2015), because the key purpose of the study is discovering the facts and truths in an objective manner. Whereas qualitative research is typically associated with ontologically nominalist and epistemologically social-constructivist positions. Qualitative studies in this sense are usually interpretive since researchers tend to disentangle the subjective and socially constructed meanings through the sense-making and understanding of different social actors on the basis of their own social observation (Bryman, 2016; Saunders et al., 2016).

From a more practical data collection point of view, the way to distinguish between quantitative and qualitative research approaches is that the former approach usually adopts a standardised technique (with set rules of data collection techniques), while the latter approach normally employs a non-standardised method for data collection so that the questions and procedures emerge and can be altered during a data collection process (Mugenda, 1999; Saunders et al., 2016).

This study places focus upon participants' perceptions on the research topic, where what they know about the existing STS development and its applications and how they perceive the data integration scenario, is what the data collection and the ensuing analysis aim to explore. In order to gain high-quality empirical data, the participants are expected to provide their opinions on the basis of their own knowledge, experience and skills; these insights, therefore, are expected to be as in-depth, flexible and narrated as possible, which only a qualitative research approach can achieve. Therefore, this research is identified as a qualitative study.

3.3 Research strategy

The study has explored and identified the research philosophy, which is considered to be ontological nominalism, epistemological social constructivism, inductive and qualitative research. The most appropriate research strategy needs to be selected from a range of qualitative social research strategies. Research strategy - in this sense as a concept of methodology - refers to a range of research methods, techniques and courses of actions for the generation and analysis of research material, and to the way in which the researcher designs the research according to the research reality and conceptuality (Saunders et al., 2016; Verschuren, 2003). It is hence regarded as a plan that a researcher will follow in order to respond to the pre-set research questions. This section begins with a brief discussion of selecting research strategies, before shifting the focus towards the case study strategy chosen for the research. It then discusses and clarifies the rationale for the case study strategy as well as its practical applications in this research project.

3.3.1 Selecting a research strategy

Saunders et al. (2016) concludes that social sciences research consists of the following strategies: experiment, survey, action research, grounded theory, ethnography, archival research and case study. All of these research strategies, except experiments and surveys, are usually adopted by qualitative social researches. As aforementioned in the prior sections, this research project is identified as a qualitative study, so experiments and surveys are not discussed in this section. Moreover, Easterby-Smith et al. (2015) argue that the selection of a particular research strategy is determined by the underlying orientation of the researcher; in a word, what philosophical positions is it that usher the research towards successful accomplishment. To be more specific, what distinguishes different research strategies and which of them would be adopted as the methodology of the research require an evaluation and analysis of three conditions (Yin, 2017): first, the type of research questions to be identified; second the researcher's control over behavioural events when the research is being conducted; and third, the research's focus on either contemporary or historical phenomenon.

Case Study as a research strategy facilitates in-depth exploration of a contextual social phenomenon (Bryman, 2016). Many scholars have clarified the situations where case study is adopted as the research strategy. Yin (2009) states that researchers using a case study method usually aim to explore and explain the 'what' or 'how' issues of the current social settings. Case study strategy has become increasingly popular with social scientists because it is deemed as useful to tackle the limitations of quantitative methods in gaining in-depth and holistic explanations of the social, individual and community-based problems (Zainal, 2007).

Furthermore, a remarkable feature of case study research strategy is the exploration of diverse perceptions of a particular social phenomenon within a specific geographical context. These perceptions might be derived from various types of research fields wherein participants of the research are engaged in expressing different perspectives upon the issue being investigated (Ritchie et al., 2013). In addition, case study as a research methodology is adopted in various situations where the researchers' knowledge at individual, group and organisational levels and of political, social and cultural dynamics, is accumulated (Yin, 2017). The researcher of this study would like to understand a holistic and meaningful real-life STS issue in much depth within the Chinese context; this understanding may involve both commonalities and contingencies amongst different contextual conditions. In addition, as Chapter 2 suggested, different perspectives upon the proposed data-integrated STS will be explored, by collecting data from different groups of stakeholder participants. Further, as the research aim implies, the researcher can identify, and gain relevant knowledge of, various socio-technical issues that are considered as crucial in order to initiate the proposed data-integrated STS application. For the above reasons, it is argued that case study is applicable and appropriate to this study, and it is hence selected as the main research strategy in order to achieve the research aim.

3.3.2 Case Study rationale and application

This section further elaborates how case study research strategy guides the methodological shaping of this study in more depth by firstly illustrating basic conceptions and rationales, and secondly explaining how it is designed and applied.

3.3.2.1 Case study rationale

Amongst many case study researchers, Yin (2017) provides an authoritative definition that points out all key components of the case study as a research strategy:

> *"A case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-world context when the boundaries between phenomenon and context are not clearly evident. … and when it relies on multiple source of evidence"* (Yin, 2017, p. 16)

Given the research aim of this study, the definition is exactly applicable and suitable. Firstly, 'empirical inquiry refers to the nature of qualitative study – i.e. exploration of people's perspectives. Secondly, the topic of this study is the STS which is considered as a contemporary phenomenon that has not long existed. Thirdly, the study is set in the real-world context of Chinese cities. Fourthly, few studies exploring the potential challenges and opportunities for initiating STS data integration solutions have placed a focus upon the context of Chinese cities. Finally, this study investigates different groups of stakeholder participants in order to achieve an in-depth and holistic understanding of the issue.

Easterby-Smith et al. (2015) argue that there are three types of social science research: exploratory, descriptive, and explanatory. Thus, case study method is correspondingly divided into exploratory, descriptive and explanatory case studies (Yin, 2017; Zainal, 2007), only one of which is inductive, i.e. exploratory case study (Piekkari & Welch, 2018). First, case studies with an exploratory purpose usually adopt qualitative approaches to collect data. When the researcher enters the field, the questions asked by him or her involve both general questions which are open for further explanation by participants, and follow-up questions for additional information. In this sense, exploratory studies are designed particularly for discovering relevant constructs in the field where theory is built, participants' experiences and context of procedures are prominent, and as aforementioned, the 'how' and 'why' of a phenomenon is the purpose of investigation (i.e. discovering and understanding the complex system and deeply entrenched reasoning behind the scene) rather than simply understanding 'what' the problem is (Bhattacherjee, 2012; Yin, 2017; Zainal, 2007).

Descriptive case studies set out to describe a certain phenomenon which takes places in the data in question. Researchers who conduct descriptive case studies usually start with a descriptive theory in order to effectively describe the phenomenon; as Zainal (2007) argues, *'the goal set by the researcher is to describe the data as they occur'* (Zainal, 2007, p. 3). So general descriptive case studies are conducted in a narrative way examining the scope of the case. Thus, descriptive case study method is typically used in political science and sociology with the use of a set of experiments or survey data collection methods to reflect the 'how' of a situation (Yin, 2017).

In order to explain a social phenomenon, explanatory case studies focus on data at both a surface and deep level. Researchers who conduct explanatory case studies might generate a theory during the study and then test the theory later (McDonough & McDonough, 2014). Yin and Moore (1987) identified three different types of theory – "*knowledge-driven", "problem-*

solving" and "social-interaction" (referred to by Zainal (2007)). Similar to exploratory case study, the explanatory study also deals with 'how' and 'why' issues; however, the difference is that the outcome is derived from external materials rather than from research data, namely something that already exists helps to shape the research outcome. Moreover, both descriptive and explanatory case studies usually need propositions (Rowley, 2002), meaning that the researcher needs to speculate what the research findings might be, based upon the literature and previous evidence of the issue being investigated. This study is defined as an exploratory case study because firstly, the expected findings were purely created from the research data; secondly, the findings reflected the outcome of an exploration of a proposed novelty from various perspectives; and thirdly, the study relied on participants' in-depth understanding and knowledge of the issue being studied.

Having clarified that the case study strategy being applied in this study is exploration-driven, the focus now moves to defining of the case. Yin (2017) states that a case can be an individual person (who is recognised as the primary unit of the analysis), an event or entity (e.g. small groups, communities, programs and institutional change, and specific organisational events), or a geographical area (such as a region, a city or a nation). Bryman (2016) argues that however the case is defined, the research aim and objectives need to be taken into consideration from the start. This is because the research aim usually suggests and hence determines the type of case that Yin argues above; also the questions being explored during the data collection process, which will be developed by the research aim and questions, will be asked within the boundary of the case unit. The purpose of the case study strategy for this research was to explore the development of STS initiatives within Chinese smart cities, hence defining 'city' as the case unit of this research. The next problem is identifying the quantity of cases that need to be involved within this study.

3.3.2.2 Case study methodological decision

Case Study rationales discussed above help to make the methodological decisions for the case study carried out in this research. The design of the study is built upon the idea of incorporating distinctive social constructs that work to shape the proposed data-integrated STS – citizens as end-users, STS enterprises as system developers and government agencies as transportation policy makers. This sub-section illustrates the methodological decision behind the case study of this research.

This study will take into account, in a sequential order, the perspectives of the following three groups: citizen end-users, STS enterprises and government agencies. The reasons for this are two-fold. **Firstly, on the side of academic research**, many smart city studies have evidenced the need to incorporate general public, commercial businesses and government agencies as rudimentary constructs of particular smart city initiatives. However, there is a lack of research focusing on the connections between citizens and commercial enterprises and between the commercial enterprises and government agencies, especially within the context of Chinese cities in the field of smart transportation initiatives.

For example, Giffinger and Pichler-Milanović (2007) rank European smart cities based on six indicators, one of which is 'smart people'; it is concerned not only with individual citizens, but also social groups, such as enterprises and government. Many studies thereafter claim that 'smart people' are the key players in the development of smart cities (e.g. Shen et al., 2018). However, these studies did not take into account how these various smart people interplay with each other to co-create value for future smart city initiatives, particularly in the field of STS. Moreover, Finger and Razaghi (2017) conceptualise the smart city by suggesting a three-layer model that digitalised urban systems are built upon; these layers include: urban infrastructure, data and social. Based on these, they propose a promotional concept of the digitalisation of smart cities to better understand various interests in promoting smart city initiatives. They particularly emphasise upon the last perspective – citizens, civil society and the government – which was depicted as a 'big circle' that intertwines and interacts with the previous five somewhat commercial-driven perspectives (i.e. hardware vendors, telecommunications operators, digital platform operators, data analytics companies, and urban utilities), but they claim that such intertwining and interacting relations remain undeveloped. This suggests that hardly any research, in this sense, has explored issues around how, and the way in which commercial enterprises transform urban transportation services through data analytics tools and relevant computational and digital technologies, on the basis of their citizen end-users' needs and desires and through interaction with the government's political regime. The current study therefore, also focused on these three perspectives, but further explored how they interplay to produce a synthesised view and holistic understanding of the issue being studied.

Secondly, on the side of empirical practices, smart city initiatives in China are developed on the basis of stakeholder collaborations that necessitate a close-knit but top-down concerted effort, which is propelled by enablers (i.e. city representatives, such as government agencies, strategic committees), executed by providers and utilisers (i.e. private sectors and knowledge backbones, such as ICT companies and professionals), and eventually used by the general end-users (i.e. citizens) (Mayangsari & Novani, 2015). Such sequential logic indicates that citizen end-users' rudimentary understanding and expectations of building a particular smart city initiative would need to be captured by system providers and utilisers who actually take basic end-user demands into account for their system development. Furthermore, both citizen end-users' insights and system providers' perceptions on developing initiatives would need to be referred to the local government in order to unfold a high-level and all-inclusive view of initiating smart city solutions (Cardullo & Kitchin, 2019a; Castelnovo, 2016; Granier & Kudo, 2016; Vácha et al., 2016). In this study, citizen participants as the representatives of STS end-users were expected to provide their potential desires for, and their understanding of possible benefits and challenges related to, implementing the proposed data-integrated STS application from the implementation point of view. STS enterprise and government participants' perspectives were also investigated with a focus on exploring more constructive and configurational factors that may influence the successful initiation process from both the design and implementation points of view. The three intertwined perspectives were finally synthesised in order to gain a more holistic understanding of the potential challenges and opportunities for initiating a data-integrated STS application in Chinese cities.

3.3.2.3 Case study design

The design of case study research strategy can be classified as either single-case or multi-case design (Yin, 2017). Multiple-Case Study design is applied when the same social phenomenon is deemed to exist in various situations, whereas single-case study design is adopted when such phenomenon may exist in many places but the case selected is a representative that contains all essential components (Yin, 1981, 2017). Research that adopts multiple-case studies is normally regarded as being more robust. On the contrary, single-case study design requires careful investigation within a specific research context. What should be noticed is that the both single- and multiple-case study design may involve a variety of units at the same level, meaning that there is likely to be a range of separate sections that are analytically compared as the means to acquire knowledge about the research case, such as an organisation (Verschuren, 2003). This is known as an embedded case (Yin, 2017). The differences of the embedded case design between single-case study and multiple-case study are demonstrated in Figure 5.

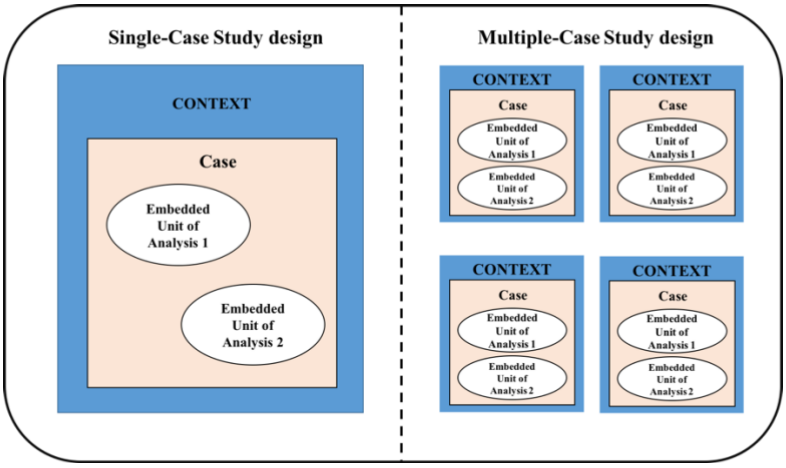


Figure 5: Embedded case study design
(Modified from Yin, 2017, p. 50)

As such, this research project adopts embedded single-case study design. The study was conducted in Shijiazhuang, Hebei Province, China; it is considered as the ‘case’ of this research. The study aimed to investigate each of the perspectives of the citizen end-users, STS enterprises and government agencies. Each of these three groups of participants was identified as the embedded unit of the case. The left part of Figure 5 can be further dissected in more detail within the context of this study, as shown in Figure 6.

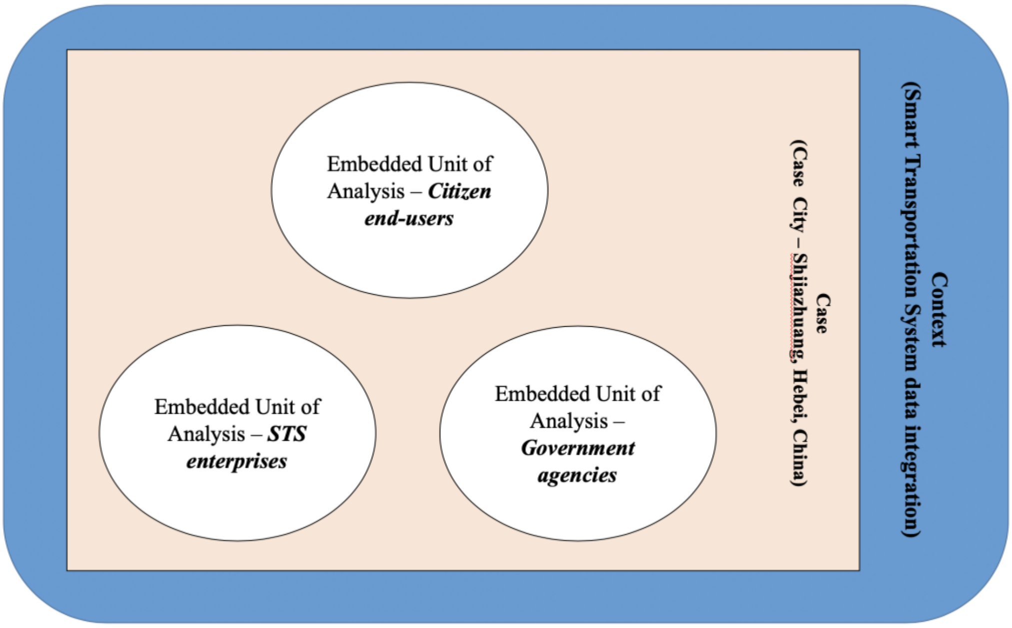


Figure 6: Embedded single-case study design of this research

3.4 Data collection

The next step of the single-case study in this research was to make a decision regarding what data collection approaches were adopted, at which sites the fieldwork was carried out at, who were the potential participants, and how to approach them.

3.4.1 Data collection approaches

According to Ritchie et al. (2013), qualitative research data are typically classified as '*naturally occurring data'* and '*generated'* data (pp. 56); while the data collection approaches of the former types of data include observation, archival/documentary analysis, conversation analysis and discourse analysis, those for the latter are in-depth interviews and group discussion. According to previously stated philosophical assumptions, the research objectives of this study are best met by some form of interpretation from potential participants, including their views of the existing STS initiatives and perceptions of possible future solutions. This means that verbal recounting could be the best way to obtain a more context-specific and in-depth understanding of the issue being studied; this further suggests that research data are embedded in (or generated from) participants real-time interaction with the researcher. Therefore, the expected research data of this study are generated data, and thus in-depth interviews and focus group discussions are applied as the main data collection approaches.

Many scholars have claimed that semi-structured interviews and focus groups are the two most representative qualitative approaches to collect generated data (e.g. Bryman, 2016; Easterby-Smith et al., 2015; Ritchie et al., 2013; Saunders et al., 2016). However, they serve distinct roles and selecting between them both turns on the following factors. Firstly, the nature of the study group. Ritchie et al. (2013) argue that a key feature of in-depth, semi-structured interviews is their depth of concentration upon the individual. Researchers who use this approach expect participants to provide detailed information from their own perspective and personal context (e.g. personal history, understanding, knowledge, etc) regarding anything in relation to the discussion (Bryman, 2016; Ritchie et al., 2013). In contrast, focus group emphasises upon interactions between group members regarding the question asked, with less chances for the detailed production of individual accounts. Also, the researcher adopting this approach often expects to see discrepancies between participants about a specific point of discussion (Bloor, 2001; Kitzinger, 1995; Silverman, 2016) because the purpose of the study could be to acquire a general understanding of what the multitudes view is, or perhaps their envisioning of a particular social phenomenon.

As prior chapters suggest, the citizens end-user perspective was going to be the first phase of the data collection process within this study; focus group was identified as the ideal data collection approach for investigating citizen end-users. The reasons for this are two-fold. Firstly, citizen end-users as the participants in the context of this study referred to groups of citizens (see Section 3.4.3.3 for sampling strategy) in the case city who use STS applications. They had certain experiences and basic understanding of existing STS applications; however, they were not knowledgeable in initiating STS applications from more professional and technical points of view. This is to say, the investigation of citizen end-user perspective was an exploration of their insights and thoughts on the current STS and its associated transportation issues (e.g. privacy, infrastructure, security etc.), their perceived advantages and disadvantages of the existing STS applications, and their perceptions of what could be the potential impact of STS data integration. Focus group discussions allowed comparisons and interactions across the group to occur, so that a large range of ideas, opinions and perceptions emerged from the conversations. Secondly, in terms of research design, the reasoning for such a ‘citizen-first’ arrangement was that the nature of the study necessitated understanding how citizens as consumers and end-users of STS initiatives would perceive the data-integrated scenario from a very rudimentary but rather user-centric point of view, before untangling more in-depth and expertise-driven insights of such a proposed solution with STS enterprises and government officials. The role of focus group discussions herein was that basic and general insights across distinct types of participants provided evidence that embodied citizen end-user interests of expanding a designated citizen-centric STS initiative by STS practitioners.

Having investigated the citizen end-user perspective of initiating the proposed data-integrated STS application, the study shifted its focus towards STS enterprises, from which in-depth, semi-structured interview data were collected. The reason why STS enterprises were the second targeted unit of participants was that they were the on-the-ground designers, implementers and developers of STS applications, who should have interactions with citizen end-users. In other words, the citizen end-user perspective of developing a particular STS initiative would be significant to the STS enterprises who convert their perspectives into practical solutions. As such, the citizen end-user perspective was provided to enterprise participants for discussion. Hence, the data collected from STS enterprises were expected to be rather in-depth, expertise-driven and knowledge-based. The conversations with potential participants were expected to concentrate upon their perceived advantages, disadvantages, difficulties and opportunities of both the existing STS applications and the proposed data-integrated STS application. Likewise, the third stage of the data collection process set a focus upon government transportation agencies who were considered as the policy makers and regulators of urban STS development. The data collection procedure undertaken with this unit of participants placed more attention upon socio-political-economic dynamics from government, society, the market and political points of view. The collected data were also expected to be in-depth and more holistic, with considerations of both citizen end-user and STS enterprise perspectives. To conclude, semi-structured interviews were applied to investigate both STS enterprises and government officials' perspectives. The application of all three phases of the data collection process is discussed in the following sections.

3.4.2 Case background

As revealed before, Shijiazhuang – the capital city of Hebei Province, China – is defined as the case city of this study. This is because Shijiazhuang is one of the primary transportation network hubs in China; transportation system plays a pivotal role in city development. However, the system has shown unbalanced development between rural and urban areas. Whilst rural transportation has been advancing towards being sustainable and environmentally-friendly, urban transportation is facing many problems with congestion, air pollution and unsystematic planning (W. Wu, 2017). It is worth investigating the development of STS initiatives that are expanded for improving urban transportation.

Another reason for choosing this city as the case city is that Shijiazhuang is one of the Tier-2 cities in China and also the capital city of Hebei Province. According to Shijiazhuang's local government annual report (accessed from http://jtt.hebei.gov.cn/), huge financial investment has been made in initiating STS services and integrating transportation resources - a high priority of local government administration. Also, the provincial government gives priority to developing Shijiazhuang's STS initiatives amongst many other cities in Hebei Province, which lays a good foundation for expanding innovative STS solutions (Shijiazhuang Municipal People's Government, n.d.)

The third reason for the choice of case city is Shijiazhuang, as a Tier-2 city, has many entrepreneurial opportunities; despite there not being as many as Tier-1 cities like Beijing, Shanghai and Guangzhou, Shijiazhuang is considered as one of the most attractive locations for entrepreneurs to create business due to its superior transportation conditions and unique local characteristics, including cultural tolerance, complex living conditions and myriads of untapped markets.

Lastly, as the capital city in the province, Shijiazhuang's STS development mode would be referred to by lower-tier cities in Hebei. Such a 'bond' between the urban development of Shijiazhuang and other cities could stimulate economic prosperity for the whole province.

3.4.3 Focus Groups

The third research objective was to explore the citizen end-user participants' desires for, and their understanding of possible benefits and challenges related to, the implementation of the proposed data-integrated STS initiative in the context of Chinese cities. Research focus groups were a primary mode of data collection in achieving this objective. This section is focused upon the rationales of focus group discussions (Section 3.4.3.1), group size, composition and categorisation (Section 3.4.3.2) and the sampling procedures (Section 3.4.3.3) in the context of this study.

3.4.3.1 Rationale of focus groups

Focus Groups derived from social scientists working in both applied and academic research settings (Jenner et al., 2004). Ritchie et al. (2013) state that what should be particularly taken into consideration before the group discussions actually start are the size and composition of the groups, the physical research environment and the arrangement and organisation. As afore-mentioned, consistent interactions from which research data are generated are the main feature that makes focus groups different from other approaches. Whilst one participant in the group expresses his or her own perception, other group members are allowed to interrupt and add their own viewpoints which can in turn illuminate that participant's perception (Bloor, 2001). The entire process is built upon both individual brainstorm and interactions between group members. Figure 7 demonstrates in more detail the steps of undertaking focus groups by referring to Bryman (2016), Ritchie et al. (2013) and Saunders et al. (2016).

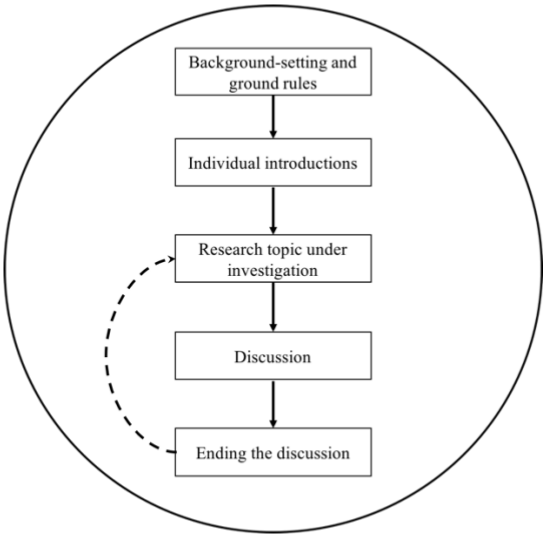


Figure 7: Steps of focus group discussion

In the first stage, the researcher makes a formal start of the focus group session, introduces himself/herself and the background of the study, and outlines the topics that will be discussed in the session. Particularly, issues pertaining to confidentiality, sensitivity and participant consent are addressed. In the second stage, the participants introduce themselves one by one and give details about their social background, occupation, and the most importantly, their general experience in relation to the topic being discussed. Meanwhile, the researcher links individual introductions to the topic and starts to set the tone of an in-depth discussion. Thirdly, the general questions are given, prior to which the researcher begins a more specific discussion, wherein some definitional and conceptual terms and issues are highlighted. Next, the formal discussion is carried out within the group. The researcher listens to the terms and words used by participants and disentangles their insights in order to formulate comments or further questions. Finally, when the main body of discussion has completed, it is advisable for the researcher to end the discussion by, for instance, discussing the profound implications and recommendations of the topic being studied. Noticeably, there might be a circuit of the phases of focus group discussion particularly when the study involves more than one topic to be explored. When the first topic has completed, the second topic will start from the beginning of the third stage.

Whilst the rationales in relation to the focus group steps are actually applicable to most of the social research topics, the next sub-section takes a close look at how focus groups were applied in this study, in terms of the definition of potential participants and the sampling procedures thereof.

3.4.3.2 Focus groups size, composition and categorisation

Ritchie et al. (2013) argue that appropriate size and composition of a focus group is critical to shape the group dynamic and determine the quality of discussion. Chiming with Bryman (2016), they claim that a good focus group should be composed of about 4-10 participants, with a point of balance between the two extremes of heterogeneity (i.e. diversity of participants types) and homogeneity (i.e. resemblance of characteristics between participants) both within one group and across different groups. In other words, some diversity in the composition of the groups will bring about greater perspective, innovation and interaction, but too much can result in difficulties of future analysis for teasing out interconnections between viewpoints of different participants. In addition, a certain extent of resemblance will encourage more disclosure of information, especially those sensitive to participants; however, too much would make the discussion less dynamic so that the researcher would struggle to find comparable ideas and perceptions to the topic being studied.

The weighing-up between heterogeneity and homogeneity of the groups in this study hinted that it was necessary to appropriately categorise participants within a group and classify participants into different groups. The study had six focus groups, and the participants for each group were recruited from the case city – i.e. Shijiazhuang. Considerations of **categorising participants within one group** are shown as below:

- Categorisation: The means of transport that participants frequently use.
- Group size: five participants per group
- Composition: two car-users (CAR), one public transport users (BUS), one non-motor vehicle users (NMV), and one walker (WALK)

In the context of Shijiazhuang transportation system in general, the above demonstrated means of transport were able to cover scenes of transportation from the citizen (as end-users) point of view. There had been a plethora of existing STS applications that were popular and commonly used by citizen end-users with different preferable means of transport they often used. For example, AutoNavi as a smart mapper and navigator is widely used by both car-users and walkers. SmartBuser as an application of real-time bus tracking is used by those who always takes public transports. DiDi as a car-sharing and car-pooling application are mostly used by people who neither would like to drive nor take public transports. OFO as a bike-sharing company provides thousands of non-motor vehicles for people who commute short distances. The participants were targeted based on those who had knowledge and experience of using these applications.

Moreover, the category of car-users involved two participants per group. This is because firstly, most traffic congestion in Shijiazhuang is fundamentally driven by the growing number of vehicles of which personal cars account for the most (Sina Hebei, 2017). Secondly, most of the application-based STS services that are widely used serve private cars owners. This means that people who often drive or take taxis are the main end-users of STS applications. It was thus expected that car-user participants would be able to provide more useful information to the discussion as they were relatively more familiar with the urban transportation settings, policy, regulations and environment in Shijiazhuang, and more knowledgeable of the role of technological initiatives in developing STS. Thirdly, people who drive also use other means of transports (but not necessarily the other way about) because driving requires certain skills and official certification. Thus, car-user participants would be able to provide more comprehensive ideas about the issue being investigated.

This line of reasoning above also led to **the classification of participants into different groups**: four groups of participants (Groups 1-4) were created with each group containing various social experience and backgrounds; each group contained people from a specific age range, and two extra groups of car-user participants (Group 5-6) were created, with the aim to further explore more citizen end-user perspective of STS data integration from the car-user point of view. The settings of the groups are shown as below:

- Group 1: university student participants who were aged 20-25. They were considered as less socially experienced and financially independent but rather keen to learn about innovative STS initiatives.
- Group 2: participants who were aged 26-35. They were considered as the end-users of STS applications who had accumulated a certain extent of social experience and financial independence over a few years, and were keen to use innovative STS initiatives.

- Group 3: participants who were aged 36-60. They were considered as highly socially experienced, and relatively less enthusiastic about exploring STS initiatives.
- Group 4: participants who were aged 60+. They were considered as the most socially experienced, but the least enthusiastic, and some are weak in interacting with STS initiatives (i.e. urban poor).

The purpose of such classification was not to gauge the extent to which participants were socially experienced, financially independent and enthusiastic about exploring STS initiatives (e.g. applications). Rather, the intent was firstly, to explore whether these characteristics of participants would result in different outcomes of the data analysis and secondly, to gain a broader and more general understanding of the citizen end-user perspective of implementing the proposed data-integrated STS application based upon large-scale demographic variables.

3.4.3.3 Focus groups sampling strategy

Sampling strategies for social research are generally divided into probability sampling and non-probability sampling (Ritchie et al., 2013). Whilst probability sampling is considered as the most rigorous approach used for statistical research, it is also considerably claimed as being an inappropriate sampling approach for qualitative research. In contrast, non-probability sampling approaches are widely used in qualitative studies to examine particular features and characteristics of groups within the sampled population. This sampling strategy is hence especially applicable to research like the current study where the case unit was of a small-scale while the investigation was in-depth. Saunders et al. (2016) list a variety of non-probability sampling methods – "*quota sampling", "purposive sampling", "volunteer sampling"*, and "*haphazard sampling"* (pp. 298). Quota sampling is typically used for structured interviews which is the data collection method of quantitative studies. It has similar criteria for sample size with probability sampling strategy. Haphazard sampling takes place when the sample population is easily approachable and available. Participants are randomly selected; hence, participants may have little relevance to the research aim and findings extracted from the data often have little credibility. Overall, quota sampling and haphazard sampling strategies were inappropriate for this study.

Purposive sampling was considered as one of the sampling strategies for this research. It is often used when the cases are small and when the researcher wishes to select samples that are especially informative. The researcher needs to be cautious when making a decision of defining the case units and selecting samples that fall into the criteria; in other words, the conduct of purposive sampling is directed by the pre-set research questions and objectives which the researcher keeps in mind throughout the sampling and data collection processes (Neuman, 2007). As the last subsection suggests, criteria to approach potential participants are set before the fieldwork is carried out. Participants of each single focus group should conform to the requirements (i.e. the categorisation and classification of participants). In a word, participants are purposively selected.

It was not difficult to recruit participants for the first focus group; the researcher relied on his personal social networks (i.e. 'guanxi'[1]in Chinese). However, there are challenges to sample for the following groups due to limited approachability. As such, another type of sampling strategy that Saunders et al. (2016) propose – i.e. volunteer sampling – is applied. Snowball sampling (also known as Chain-Referral Sampling) is one of the most commonly used volunteer sampling strategies that are applied in qualitative research (Bryman, 2016), and it is a non-random sampling method (Atkinson & Flint, 2001) that attempts to sample hard-to-reach populations (Noy, 2008). Generally the researcher who adopts snowball sampling initially approach a small number of participants who correspond to the criteria of participation, and these people in turn help the researcher recruit other participants who fall into the criteria as well; these participants will then suggest further participants, and so on (Bryman, 2016; Handcock & Gile, 2011). In this study, the recruiting process for the next group was reliant upon participants in the last group volunteering to approach potential participants they had access to through 'guanxi' relationships. The criteria of approaching these participants were exactly the same as those applied to the volunteering participants. In a nutshell, snowball sampling strategy was applied alongside purposive sampling strategy in this study. The procedures of snowball sampling are described as the Figure 8 below:

[1] Guanxi' is widely understood as personal connections and relationships. It is a concept that is deeply anchored in Chinese culture at many levels of social networking, e.g. individual, groups, and organisational. Zhan et al. (2018) that 'guanxi' plays a pivotal role in both individual social networks and organisational administration in terms of both inter-organisational and inter-personal dynamics, which hence has influence on the resources available to individuals and organisations.

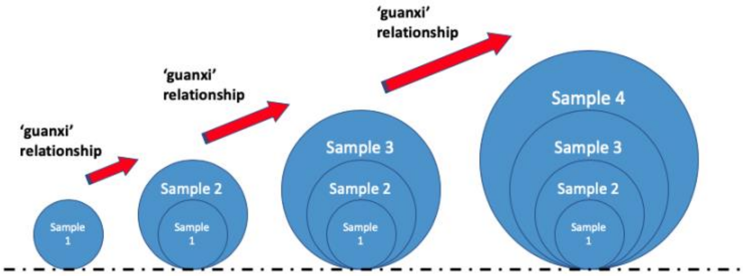


Figure 8: Snowball sampling process

3.4.3.4 Focus group questions

The questions for the focus group discussions were designed in three sections: Shijiazhuang's transportation system in general, issues of the current Shijiazhuang's STS and its applications, and the proposed idea of STS data integration. Participants were asked about their opinions of Shijiazhuang's transportation system and the road network in general terms, and about their knowledge and understanding of the causes of the negative aspect of the current system. These points of discussion were considered as the opening gambit and directed the conversation to be increasingly in-depth towards STS and the core issue of the data integration scenario. Next, the discussion of the current STS in Shijiazhuang and its applications help the participants brainstorm about the potential to implement a data-integrated STS application; their understanding of the current applications was expected to provoke their perceived ideas of initiating an integrated application. Finally, the discussion about data integration contains multiple aspects; therefore a set of open-ended questions were referred to, including participants' possible and ideal forms of the solution, their imagined scenarios of transportation where the proposed integrated solution can be applied, and the potential enablers to develop such a solution, and so on.

Noticeably, as citizen participants were not technical STS experts nor did they possess an in-depth knowledge about urban political conditions for initiating STS solutions, the focus group discussions were only focused on their perspective on implementing the proposed data-integrated application without looking at how the application could be designed. Moreover, as they represent the end-user voice of STS initiatives, it was necessary to firstly investigate what their desires are in terms of implementing the proposed data-integrated application before further exploring their understanding of possible benefits and challenges.

3.4.4 Semi-structured interviews

Research objectives 4 and 5 were to respectively explore the STS enterprise and government perspectives of the potential challenges and opportunities for designing and implementing the proposed data-integrated STS application in the context of Chinese cities. The semi-structured and in-depth interviews were a primary mode of data collection in achieving these objectives. Similar to the focus group approach, this section firstly demonstrates the rationales of the semi-structured interviews (Subsection 3.4.4.1) and secondly, illustrates how the semi-structured interviews are applied in this research, including the background of both case units, demographic features of the participants, and the design of interview questions.

3.4.4.1 Rationale of Semi-structured and in-depth interviews

The term 'semi-structured' when associated with qualitative interviews means '*non-standardised'* (Bryman, 2016); typically however, a list of themes and some core questions regarding the topic are provided (Saunders et al., 2016). The concept of 'in-depth' is usually considered as a form of conversation between the participant and the researcher, wherein deeper inquiries are disentangled with often complicated, holistic and sometimes multi-dimensional answers unfolded (Ritchie et al., 2013). Most qualitative interviews involve both of these two visions; how these two characteristics stand out in the interviewing process is argued by Rubin and Rubin (2011):

> *"The research is looking for rich and detailed information, not for yes-or-no, agree-or-disagree responses. He or she is looking for examples, for experiences, for narratives and stories. ... the questions are open-ended, meaning that the interviewees can respond any way he or she chooses, ... the interviewer ... can change wording or skip questions if they don't make sense at the time ... can pose a separate set of questions to different interviewees."*

Such definition of semi-structured and in-depth interviews approach social research from an interpretivist and constructivist perspective (Kvale & Brinkmann, 2009), and thus fits within the nature of the topic being investigated in this study. Therein, the initiation of the proposed technological innovation is grounded in practitioners' expertise, skills and knowledge, as well as their existing empirical, theoretical and practical understanding of the initiating process.

Interview participants who were sampled according to these traits could be rather flexible in managing the questions posed by the researcher in their own way, as long as they were able to offer in-depth insights for each single question. Thus, interview questions in this data collection were adjusted from time to time according to the participant's responses. The more open-ended and in-depth the participants' perceptions tend to be, the more likely the data would be useful in achieving the research objectives.

3.4.4.2 Demographics of participants

Same as the focus groups, the sampling procedure of the interviews with both enterprise and government participants applied purposive sampling strategy as well. The interview participants of the case are sampled according to certain criteria that are based upon the initial research objectives (Mason, 2017; Patton, 2014). In this study, the selected participants for each case unit had similar demographic features regarding the nature of their occupation, with discrepancy in organisation, position and role. These variables enabled all-encompassing research data, and thus allowed the issue being studied to be explored from various socio-technical points of view - shaped and guided by the Smart City Initiatives Framework that Chourabi et al. (2012) propose.

STS enterprise participants

STS enterprise participants were sampled from three local transportation firms in Shijiazhuang that specialise in STS and mobility initiatives (names of the firms and participants anonymised). Five participants from each firm with a total number of 15 participants were sampled. Moreover, the participants from each firm have different roles, working in different positions.

- **Project managers**. The previous section stressed that each case firm has developed different applications for citizen end-users who can use them to efficiently interact with urban transportation. Within each firm, there were project teams working on a particular application. Project managers played a role in managing and supervising the project on a macro scale. They were considered as knowledgeable in both technical and social aspects of developing STS applications, especially those in relation to their own organisational context. Provided that technical staff within each firm were considered as a type of participant with professional technical expertise, the interviews with project managers involved questions with regard to the more non-technical side of the issue (i.e. 'social' aspect of the socio-technical system view; see Section 2.3.1) which can be associated with some factors outlined in Chourabi et al.'s (2012) framework, influencing or being influenced by one another.

- **Strategy director**. Strategy directors were specialised in top-level design and overall planning of project implementation. They usually had strong connections with government officials. They were familiar with STS-related policies and had critical insights of STS market and socio-economic drivers of developing STS innovations. Thus, strategy directors were considered in this study as important participants who were expected to provide useful information of more general innovation dynamics both inside and outside of the organisational context.
- **Data technician**. Data technicians selected were technical skeleton staff in each case firm. They were rather specialised in technical configuration of the application design and implementation, especially the processes in relation to data processing and computing. As such, they played an important role in the technical side of application development throughout the project cycle. Hence, the interviews with these participants mainly focused upon questions in regard to their analysis of the existing STS applications and perceptions of the technical imperatives of the data integration scenario.

Government agencies

Government participants were sampled from two government transportation agencies: *Shijiazhuang Transportation Bureau* (*STB* hereafter in this chapter), and *Shijiazhuang Traffic Management Bureau* in *Department of Public Security of Hebei Province* (*STMB* hereafter in this chapter). STB takes responsibility for managing all kinds of transportation resources and governing both intra- and inter-city communications. STMB is specialised in managing urban traffic, monitoring the public and various means of transport through high technology, and administrating urban traffic data and information. Three participants from STB and two participants from STMB were sampled (names of the participants anonymised). In addition, these participants had different roles working in different positions.

- **Deputy director**: Deputy director is a member of the top management in both bureaus. They were responsible for general coordination of transportation resources, overall planning and policy-making. They had strong expertise and skills in transportation and traffic management and had a holistic view of ICT-driven STS development in the particular Shijiazhuang transportation context from a socio-political point of view.

They had particular insights of the role of STS initiatives not only in terms of citizens' lives but also business development of commercial enterprise. Hence, interviews with deputy directors were mainly concerned with the managerial, political and organisational dynamics of data integration issues from across the entire network of STS development, including their connections with enterprises and citizens.

- Division director of publicity: This person is the head of the department of publicity, who is responsible for promoting and publicising government decisions concerning urban transportation. Participants of this type were knowledgeable in both on-the-ground execution, (how would government policies effectively interact with citizenry, for instance) and the top-level decision-making process of government administration. Interviews with this type of participant particularly focused upon issues of data sharing and data transmission across different sites from the legal and political point of view.
- Data technicians. Data technician participants of the government site were specialised in government data gathering, processing, storing and maintaining. They were professional data scientists who dealt with all technical issues of managing government data and making computing and algorithmic solutions to address transportation-related data issues. Therefore, interviews with data technicians concentrated upon technical side of the socio-technical system view of this study.

Table 1 demonstrates demographic information of interview participants involved in both stages of data collection in more detail.

Name of Organisation	Professional Position	Years of Experience	Gender of Participant	Participant ID
Data collection: STS enterprises				
Company 1	Project Manager	12	Male	C1-PM
	Data Technician	5	Male	C1-TS1
		18	Female	C1-TS2
		7	Male	C1-TS3
		6	Female	C1-TS4
Company 2	Strategy Director	17	Male	C2-SD
	Project Manager	20	Male	C2-PM
	Data Technician	7	Male	C2-TS1
		6	Female	C2-TS2
		11	Male	C2-TS3

Company 3	Strategy Director	25	Male	C3-SD
	Project Manager	22	Male	C3-PM
	Data Technician	8	Male	C3-TS1
		4	Male	C3-TS2
		10	Male	C3-TS3
Data collection: Government agencies				
STB	Deputy Director	33	Male	GP1
	Data Technician	15	Male	GP2
		12	Female	GP3
STMB	Deputy Director	35	Male	GP4
	Division Director of Publicity	36	Male	GP5

Table 1: Interview participants in the research

Overall, each of the three stages of the data collection process were specifically focused upon one particular STS stakeholder perspective. The prior theoretically framed socio-technical system vision of smart city initiatives and citizen participation theories that were used as a theoretical lens helped to shape the design of data collection process. The former, which is based upon Chourabi et al.'s (2012) framework, guided the setting and interview questions of all three phases of data collection towards being socio-technical, grounded with a holistic view of both the social and technical systems of the proposed data integrated solution. Citizen participation as another theory involved in the literature of this study allowed the design of all three phases of the data collection to explore the 'citizen end-user' side of initiating the proposed data-integrated solution, with different social constructs expressed for each of their own stances. These various stances, in terms of citizen participation, were synthesised and holistically demonstrated in later stages of this study.

3.5 Data analysis

Data analysis is not an independent procedure of the whole research project. Research procedures from data collection to data analysis are actually interconnected and interactive (Saunders et al., 2016). For inductive studies in particular, the initial data analysis allows the researcher to recognise crucial patterns as well as their inter-relations from the collected data, and to further explore sub-level patterns (i.e. themes, sub-themes and codes) which can be reported as the final results (Bryman, 2016; Miles & Huberman, 1984). In this study, Thematic Analysis was applied to analysing data from both focus groups and semi-structured and in-depth interviews. Braun and Clarke (2012) claim that thematic analysis is a growingly popular and predominant method used in qualitative data analysis, as it offers the qualitative researcher a systematic and rudimentary view of data analysis and a foundation of skills needed for other qualitative analysis approaches.

Thematic analysis is defined as a method to systematically identify, organise and build insight into themes across the collected dataset based upon meanings both explicitly and implicitly embedded in the data (Braun & Clarke, 2012). The idea behind thematic analysis is *"theoretical propositions"* (Yin, 2017. pp. 243), wherein the analysis of focus groups and interviews in this study, for instance, rested upon theoretically informed interpretations extracted from the research data. The focus group and interviews data formulated a set of interpretations of socio-technical themes, sub-themes and codes. The purpose of this was to explore the interrelations between them, and how they relate to, or reflect, the 'theoretical propositions' of this study – i.e. the contextualised socio-technical vision of smart city initiatives and citizen participation within the particular context of the Chinese STS, rather than to fully test or evaluate the validity of any existing theories (Boyatzis, 1998; Guest et al., 2011). The following subsections illustrate the five main steps of thematic analysis used in qualitative studies, and how these steps were carried out in this study.

3.5.1 Familiarising with data

The analysis procedure began with the researcher familiarising himself with the collected data sets. The first step of familiarisation is usually the transcribing of focus group and interview recordings; the transcribing process was carried out using NVivo (i.e. a coding software). Whilst this process generally is considered as rather tedious and laborious as the researcher needs to recursively read and re-read the data, persistent notetaking (Braun & Clarke, 2012; Ritchie et al., 2013), such as memos on Microsoft Word and annotations on NVivo, was a particularly helpful means to facilitate the analysis for the consideration of accuracy and avoidance of omissions and repetitions. The aim of this was to immerse in the collected data to help start thinking about what the data possibly mean and how they relate to the research questions, and to create initial thoughts of possible patterns as a frame of reference for the further steps.

There was a noticeable but uncommon issue with the process of familiarisation in this study. For whatever reason (e.g. poor quality of the voice recordings, noise in background etc.), there might be a need at some point to re-visit participants to gain clarification about something they said. As such, the researcher of this study attempted to double check with several participants in order to make sure the key points pertaining to the discussion were accurately transcribed and interpreted.

3.5.2 Coding

Coding is a process of abstraction that reduces the amount of original data sets to that which relates to the research aim and objectives, disentangles the data into various analytical sections, and aids the researcher in converting the raw data into higher-level insights or abstractions that are further formulated as themes (Maguire & Delahunt, 2017; Tuckett, 2005; Vaismoradi et al., 2016). Coding is a critical process of data management; in the later stages of the analysis the researcher can rearrange or retrieve the data under relevant themes and codes. Hence, an inappropriate coding strategy might result in the researcher struggling to comprehend the meanings and hidden insights of the data sets. A coded extract of data is referred to as a *'unit of data'*, which can be a set of words and sentences, a whole paragraph or even a visual diagram or image (Saunders et al., 2016, p. 580). The coding process requires the researcher to connect these units of data which are referring to the same meaning. For inductive studies in particular, the researcher is very likely to code all relevant data involved in order to discover both explicit and implicit meanings from the original data sets (Tuckett, 2005). This study was identified as an inductive and exploratory case study, so all potential meanings relevant to the issue being studied – i.e. the potential of initiating a data-integrated STS solution – were abstracted as conceptual units of data, including those which involved indirect reflection of the topic, such as discussion around the advantages and disadvantages of existing STS applications. The image below presents an example of using NVivo for the coding process of the 2nd stage of data analysis in this study.

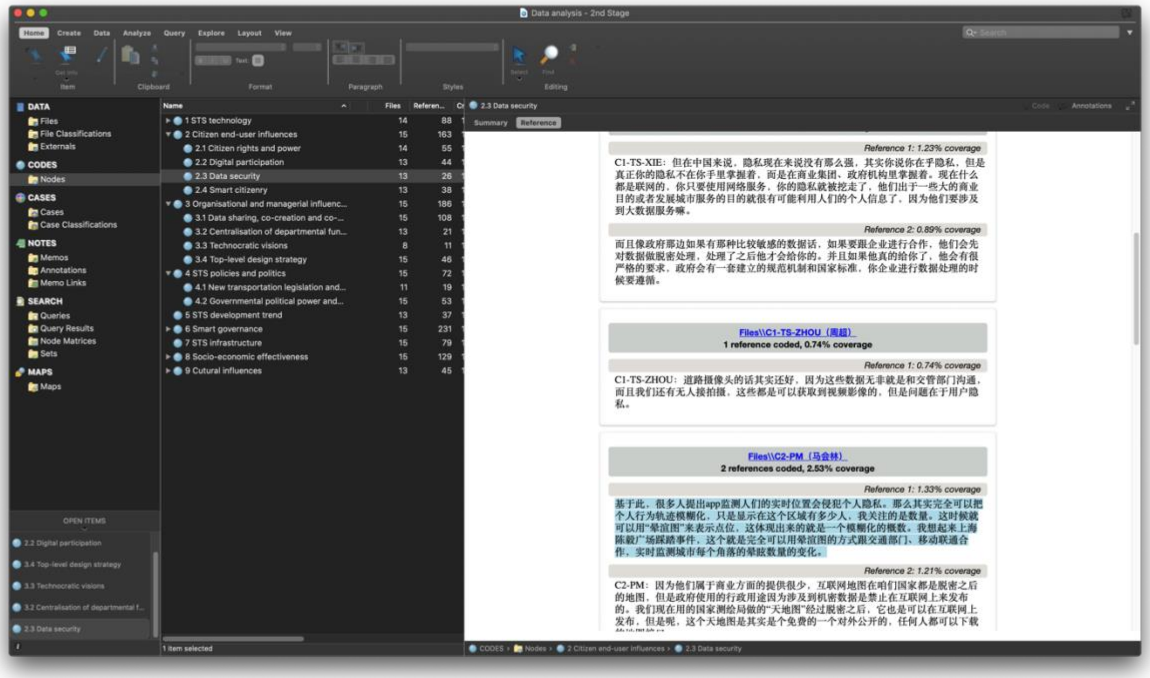
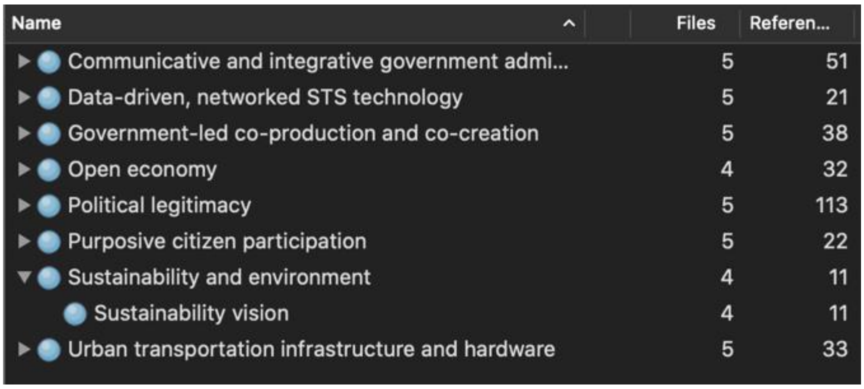


Figure 9: Example of using NVivo to code

3.5.3 Searching for themes

Whilst the coding process exists to organise units of data, searching for themes is a process to sort and collate the coded data extracts into a broader level of potential themes (Braun & Clarke, 2012). There is not an advised quantity of codes within a particular theme; rather, the quantity is closely related to the nature of the research, the methodology adopted and the degree to which the generated codes are relevant to the meanings of the issue being explored (Guest et al., 2011). A list of potential themes is created after the patterns of data extracts are discovered and the codes are clustered into different groups.

A particular theme often includes several codes which relate to each other with the same meaning; however, themes with only a single code may also exist (Braun & Clarke, 2012). In this circumstance the single code is assumed to be irrelated to all the other codes but still crucial to reflect the potential of achieving the research aim. In this study, the data analysis process that drew upon Chourabi et al.'s (2012) socio-technical understanding of smart city initiatives framing facilitated the coding process in extracting a large range of codes into various socio-technical themes that were particularly rooted in the context of this study. However, when the themes were being created, some codes were independently extracted without any potential relations to other codes and therefore were identified as a theme. The image below is a screenshot of the coding process in the 3rd stage of data analysis that shows an example of a theme with a single code.



Name	Files	Referen...
Communicative and integrative government admi...	5	51
Data-driven, networked STS technology	5	21
Government-led co-production and co-creation	5	38
Open economy	4	32
Political legitimacy	5	113
Purposive citizen participation	5	22
Sustainability and environment	4	11
Sustainability vision	4	11
Urban transportation infrastructure and hardware	5	33

Figure 10: Example of the theme with a single code

3.5.4 Reviewing themes

Reviewing themes typically begins when the list of candidate themes has been devised. It involves the refinement of these themes according to whether they are relevant to the original aim of the study (Braun & Clarke, 2006). The purpose of this step is to establish a coherent set of themes that helps to shape an analytical framework as further evidence of the potential contribution of the study (Vaismoradi et al., 2016). At any point during this stage and when necessary, some initially defined themes need to be merged, or re-grouped into new themes; this requires the researcher to go back to stage 1, re-read the transcript and re-untangle the meanings and interrelations of the affected codes (Saunders et al., 2016). A noticeable concern regarding this step is that it is a quite common requirement for the entire coding process to start over from the beginning if the reviewing process cannot address the issues, such as *"what is the quality of this theme (does it tell something useful about the data set and research question?"*, *"Are the data too diverse and wide ranging (does the theme lack coherence)?",* and *"Are there enough (meaningful) data to support this theme (is the theme thin or thick)?"* (Braun & Clarke, 2012, p. 65). A concept map is recommended by many qualitative researchers who often apply thematic analysis (e.g. Braun & Clarke, 2012; Castleberry & Nolen, 2018; Javadi & Zarea, 2016); it is claimed to be useful in facilitating the reviewing process by visualising the procedures of defining codes and themes and establishing correlations. The image below is the concept map of the developed themes and codes of the 3rd stage of data analysis. Such visual representation of the raw data sets helped the researcher to finalise the findings.

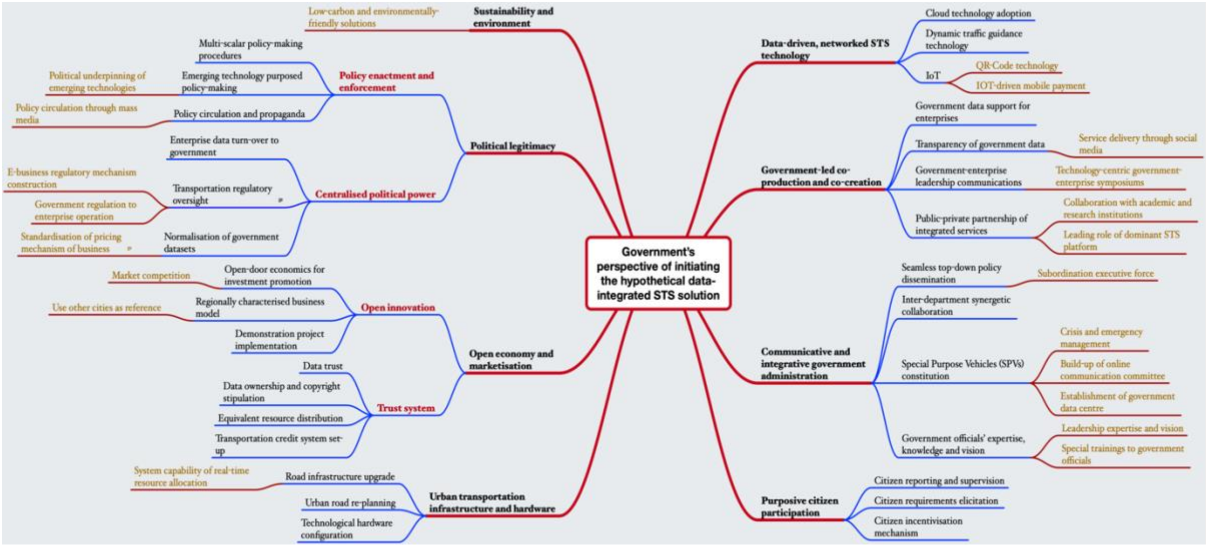


Figure 11: Example of concept map

3.5.5 Naming the themes and reporting

When the concept map has been developed, the researcher needs to re-think about the 'essence' of the themes, namely what each single theme is actually talking about, and give a proper name that represents such 'essence' (Guest et al., 2011). On many occasions where a theme may incorporate many codes, it is necessary to go back to the collated units of data within each theme to make sure the way in which the theme is named does not sound complicated or diverse (Braun & Clarke, 2006). Vaismoradi et al. (2016) claim that an important step of theme development in thematic analysis is 'rectification', wherein the coded data and themes need to relate back to the reviewed literature, from which the theoretical lens is shaped, in order to examine whether the named themes are truly suggesting the theoretical propositions. This is often facilitated with a stabilising procedure in which the named themes and codes are described in a few sentences with key ideas outlined for each, where possible, in order to develop the entire storyline (Maguire & Delahunt, 2017). Finally, the developed storyline is converted into a formal chapter of findings with more details revealed. Relevant quotations, description of the original context of data, and other supporting materials need to be incorporated into the report for the consideration of transparency, credibility and transferability of the study. Further detail of the quality of research design is presented in the following section.

3.6 Overall procedure of the research design

The previous two sections illustrated how data were collected using different approaches for different groups of participants and how the collected data were analysed by applying

Thematic Analysis. The overall procedure of data collection was divided into three consecutive stages; this division was based upon the nature of each perspective of the research participants. It is important to stress that rather than completing all three stages of the data collection process before beginning the analysis, data collected at each stage were instead analysed independently and only when the analysis was complete did the next stage of data collection begin. In other words, the research data were successively collected and analysed.

The reason for this was due to the logic of the interpretive and socially constructive nature of the epistemological assumption. Instead of comparing one perspective to another, the purpose of this study was to explore each of the three perspectives and systematically examine the interplays between them. Since different groups of participants were cast as different social actors with distinct roles within the initiating process of the proposed STS data integration solution, a logical sequence of exploration of such a phenomenon was formed on the basis of end-user (bottom-end view) to system developer (executive view) to policy maker (high-level view) perspectives. Put another way, the analysed data with their initial key ideas that emerged from citizen end-user perspective were referred to as critical concerns involved in the data collection design for the stage of STS enterprises; the same procedure was also applied to the last stage of data collection.

Further, the analysed data of each stage were reported as the corresponding findings as presented in the following three chapters. Once the writing-up of all the data collection, data analysis and findings were completed, all findings of this research were synthesised and discussed with a final visualisation of the theoretical framing of this study in Chapter 7. The figure below demonstrates the overall procedures of this research starting from data collection.

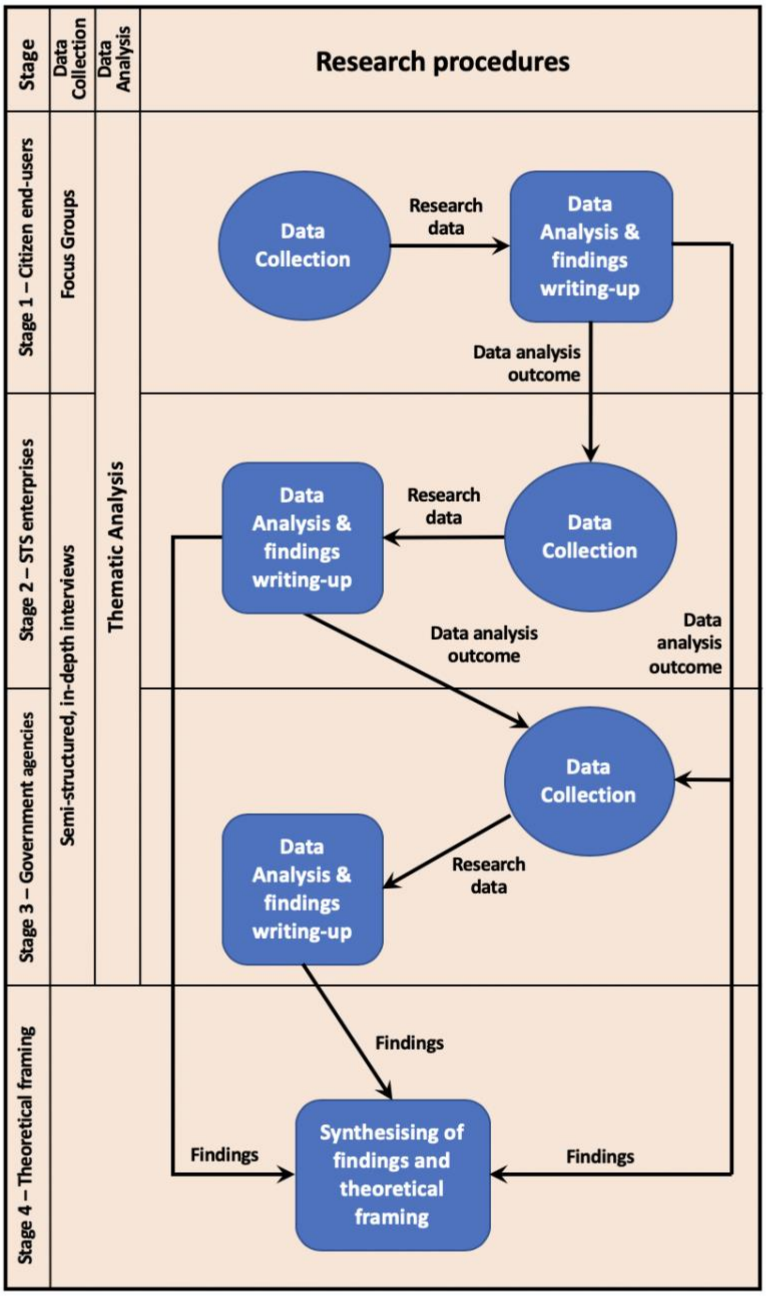


Figure 12: Summary of Research Data Collection and Data Analysis Procedures

3.7 Research design quality

This section raises the issues concerned with the quality of research design. Guba and Lincoln (1981) argue that all research must have its 'truth value', which varies from positivist quantitative studies to socially constructed qualitative studies in terms of paradigm-specific criteria that are set for ensuring trustworthiness (Morse et al., 2002). Corresponding to Guba and Lincoln's (1981) proposed criteria used within qualitative paradigm, many other scholars also have highlighted the significance of examining research *credibility*, *validity (i.e. transferability)* and *reliability* (e.g. Bryman, 2016; Leung, 2015; Mason, 2017; Rubin & Rubin, 2011; Yin, 2017). This section takes a close look at each of these criteria to test the quality of this study's research design.

Credibility

There are many elements that the quality test can draw upon to examine its credibility. In general, credibility refers to whether the research findings genuinely reflect what is being studied rather than rely on the researcher's subjective assumptions and opinions (Yin, 2017). To a large extent, such genuine reflection is dependent upon the data collection, including the design strategy, consistency throughout the research and the performance of the actual interviews. Firstly, a common technique of the data collection strategy designed to achieve credibility is data triangulation. This entails using multiple methods or sources of data in investigating the social phenomenon (Bryman, 2016), which leads to greater confidence in the findings of the research (Webb et al., 1999), as what Saunders et al. (2016) claim, the findings are *"telling you what you think they are telling you"*. In this study, multiple qualitative data collection methods were applied, including focus groups with citizen end-user participants and semi-structured interviews with STS enterprise and government participants. The final contribution of this study drew upon the combination of all these sources.

Secondly, more than one researcher being involved in the research project provides a greater sense of consistency; everyone agrees with one another regarding how the final report of the study will be presented, based upon what they have all seen and learned from the evidence. The researcher of this study regularly met with supervisors who are indigenous English speakers, which, as a useful technique that Lincoln and Guba (1986) propose, enabled balanced and appropriate data interpretation in a sense that the issues with language and cultural barriers were maximally mitigated.

Finally, the success of the data collection process is to a large extent determined by how well informed the participants actually are – whether they talk from their first-hand experience, whether they clearly and accurately reflect the events they are being asked about, and whether they objectively reveal what is being discussed in relation to their organisation or past actions, rather than hedging the stories by always emphasising the positive side (Rubin & Rubin, 2011). During the interviewing process with both STS enterprise and government participants, the researcher of this study carefully phrased the questions and follow-up statements to avoid formalistic response so that the participants were able to provide indirect answers and dodge responsibility. Whenever statements were found to be not clear enough to be presented as constructed findings during the coding process, the researcher approached the relevant participants again to confirm what they initially said.

Validity

Validity of the research design is rigorously divided into internal validity and external validity. Internal validity exists when the research is looking for causal relationships, which is not what the current study is doing. As such, external validity is relevant to the research design. It refers to the extent to which the study can be analytically transferred to other relevant cases towards a broader theory. Tracy (2010) states that a detailed and rich description of the research context, strategy, data collection, data analysis, and assumptions, can help the potential of transferability. Resonating with what other scholars claim regarding the significance of fully describing the case(s) alongside the use of theories where possible (e.g. Bryman, 2016; Yin, 2017), the detailed information of the case city Shijiazhuang and its embedded units as well as the theoretical framing drawn from both socio-technical system vision of smart city initiatives and citizen participation literature, contributed to the identification of participants, data collection procedures and the presentation of the findings. In particular, both of these theories that the design of this study drew upon, were used as a theoretical lens in the particular research context – i.e. STS data integration in a Chinese city of Shijiazhuang; likewise, the theoretical outcome of the research can in turn be transferred to a broader context (e.g. other Chinese cities with similar socio-political-economic characteristics) and settings (e.g. smart manufacturing, smart healthcare).

Reliability

Reliability refers to the extent to which a study, and its results, can later be replicated by another researcher. This is considered as a challenging criterion in qualitative studies (Saunders et al., 2016), in the sense that the applied methodology used in one research would yield data that are ontologically similar in another, yet with discrepancies in the ways in which the data are interpreted on their own epistemological basis (Leung, 2015). Nevertheless, strategies to tackle these issues exist. A typical measure against possible inconsistent interpretation is the constant comparison of the analysed data with the raw data (Patton, 1999); this comparison can be carried out by the researcher but with the support of advisers (e.g. other researchers, supervisor etc.). In this study, the design of the focus groups and interview questions was completed by the researcher but under the supervision of his supervisors who provided consistent support throughout the research project. The actual interviewing process was regularly reported to the supervision team in order to reach consensus on any point of the data collection procedure. Both the researcher and his supervisors constantly checked the accuracy and appropriateness of the codes and themes that emerged from the analytical process. These actions ensured both consistency and reliability.

Another dimension of reliability is thorough demonstration of the research methods adopted, including the arguments of why the selected strategies and methods are more appropriate and applicable than others, the protocol of the case study (i.e. details of the case units, especially the participants) and the intricacies of the data collection design process (Saunders et al., 2016; Yin, 2017). As outlined in this chapter, rationales of the selected research methods and a comparison with other possible methods were presented. Additionally, the data collection design process was subsequently unfolded in detail. A later investigator can take a look at these intricacies and these would help him or her to gain the same results. In other words, it can be said that the design and findings of this study are reliable to some extent.

3.8 Ethical issues

Research ethics refers to *"the standards of behaviour that guide your conduct in relation to the rights of those who become the subject of your work, or are affected by it"* (Saunders et al., 2016, p. 239). Typically, ethical concerns take place when the study is being designed, including the ways data are collected and analysed, and the interpretation of the findings. More concerns, however, emerge as the researcher is undertaking the fieldwork. Diener and Crandall (1978) define four types of ethical concerns regarding social research: threats to research participants, informed consent, violation of privacy, and transparency. Based upon this, Bryman (2016) and Saunders et al. (2016) both highlight that formal ethics approval from the university, participants' consent and privacy protection and confidentiality, are more common ethical issues associated with contemporary social research. This section provides a reflection of each these issues.

Ethics approval

The research obtained ethics approval in June 2017, a month before the fieldwork for the citizen end-user stage of the study. Relevant documents, such as an application form and participant consent form, were submitted to the University of Sheffield's Information School Research Ethics Committee. The planned research design strategy, data collection and analysis approaches, and the case study protocol, were clearly stipulated in the application form. The researcher confirmed that no actions would commence before the application was approved by the university. Further information about the ethics application form and participant consent form can be found in the appendix.

Informed consent and privacy protection

Considering the nature of snowball sampling (i.e. some participants are not directly recruited by the researcher), it is therefore rather prominent to ensure the all participants are happy to volunteer and participate in the research. In order to avoid any issues in relation to consent, all focus group discussions and interviews were conducted face-to-face, with an explanation of the background and purpose of the research, and a copy of the statement of research ethics provided to the participants. The approved consent form was also signed by the participants before the focus groups and interviews began. Furthermore, the conversations between the researcher and research participants did not delve into private or sensitive realms, such as income, political stances, religious or sexual orientation. As the last section suggested, research questions were designed by the researcher with oversight from his supervisors, so participants did not face any questions which they may interpret as being inappropriate.

Confidentiality

Confidentiality is often referred to as data and anonymity of participants (Saunders et al., 2016). All the raw data (i.e. voice recordings and transcripts) collected in this research were properly and securely saved by the researcher and were only accessible to himself and his supervisors. Requested by the participants, interview materials of STS enterprises were anonymised, including information like the name of the firms and participants. Participants of the other two types (i.e. citizen and government participants) also requested to be anonymised in the study by being replaced with a unique ID.

3.9 Summary

Whist Chapter 1 introduced the research background, research aim and objectives, and Chapter 2 revealed the existing body of literature for shaping the theoretical foundation of this study, this chapter stepped into its philosophical and methodological thinking in regard to how the study was designed and conducted in a certain context.

The philosophical foundations defined the study as an inductive and qualitative study, based on which various research strategies were discussed and single-case study was identified as the methodology applied in this research. As such, the chapter then introduced the case study protocol, including the background of the case and case units, before illustrating the rationales of the selected data collection methods and their application in the practice of this research. Involving three groups of participants representing three different social roles in the reality of the developing of STS initiatives, this study applied focus group discussions with citizen end-user participants, and semi-structured interviews with STS enterprise and government participants. A thematic analysis was adopted to analyse these data.

Finally, the chapter presented an overall procedure of the research design, stressing its consecutive nature of the logical sequence of data collection and analysis for the three stages. Research design quality and ethical concerns were lastly discussed for the consideration of producing high-quality research.

Chapter 4: The perspective of citizen end-users

This findings chapter illustrates a discussion of citizen end-user participants' (citizen participants hereafter) desires for, and their understanding of possible benefits and challenges related to, the implementation of the proposed data-integrated STS application in Chinese cities. The findings in general suggest that firstly, whilst citizen participants had little knowledge about technical requirements of implementing the proposed data-integrated application, they expressed their opinions about the current state of play of Shijiazhuang's transportation system and their understanding of what an STS initiative, and potentially a data-integrated STS scenario, is supposed to be. Secondly, citizen participants revealed issues surrounding the end services they have direct interaction with, even though they acknowledged that there might be a plethora of more in-depth social, organisational and/or other aspects of issues as well.

As suggested in prior chapter, citizens provided useful insights on implementing the proposed data-integrated STS application; these insights represent for the end-user voice of STS initiatives. As such, the findings are categorised into their desires for, and their understanding of possible benefits and challenges related to, the implementation of the proposed data-integrated STS application, which will be presented respectively in the following sections. Within each section, themes and codes emerged from the thematic analysis process.

4.1 Citizen end-user desires for implementing the proposed data-integrated STS application

This section illustrates citizen participants' desires for the implementation of the proposed data-integrated STS application; more specifically, these desires relate to what kind of services, functionalities and considerations citizen participants wished to be implemented in the proposed integrated application. The analysis of participants' desires signifies grassroot citizen's voice and insights of making STS initiatives truly citizen centric and user-oriented.

The desires came not simply from participants' direct envisioning of what the proposed data-integrated STS application should look like, but also from their opinions on the advantages and disadvantages of the existing STS applications. The analytical output of these disadvantages has been identified as a set of elements indicating possible achievements of desired service and functionality on the proposed integrated application. These disadvantages include poor human- application, vehicle-application and road-application interactions, defective custom-built services and the lack of unique user recommendations. Overall, citizen end-user desires based on these analyses are divided into two different dimensions: social and user effects, and technical and functional improvements. Table 2 below, shows specific codes that have been defined in each dimension of end-user desires.

Theme	Code
Social and user effects	Customised and user-recommendation service
	Environmentally-friendly development
Technical and functional improvements	Indoor positioning
	Real-time vehicle-application interaction

Table 2: Citizen end-user desires for the implementation of the proposed data-integrated STS application

4.1.1 Social and user effects

In this sub-section, the analysis of end-user desires is focused on the user effects of implementing the proposed data-integrated application and its social conditions. Amongst many of the desires that participants mentioned or hinted about in the focus group discussions, two of the most dominant types which were identified based upon the frequency of reference, were: developing customised and user-recommendation services, and sustaining environmentally-friendly modes of transportation development. However, although participants' desires were drawn upon their perceived opportunities and benefits of future STS initiatives, these desires might not be practically realisable. Whilst the later phases of investigation into STS enterprises and government officials' perspectives will reveal more in-depth and practical insights of these issues, it is still useful in this finding to demonstrate insights upon citizens' perceived desires and how they see STS developing in the future.

4.1.1.1 Customised and user-recommendation service

This identified desire responded to the participants' opinions on the disadvantages of the existing STS application regarding the weak human-application interaction mechanism. On the one hand, the growing development of customised services would enable diverse modes of human-application interaction. Participants described a custom-built integrated application as a ‘robot’ (Focus group: G2-CAR2), ‘secretary’ (Focus group: G2-PT) or ‘personal assistant’ (Focus group: G3-CAR1) that always offer users with unique and customised services and functions in different scenarios. This desired interaction aims to achieve awakening and switchover of services based on the big data analysis of end-user real-time location (Focus groups: G1-CAR1, G4-PT, G5-CAR1, G5-CAR3). Consequently, the proposed application would be able to provide users with better decision-making scenarios. For example, the application could automatically offer users who are driving, a detailed journey plan including any route changes whilst providing users who are passengers in a taxi with suggestions of choosing other means of transport in order to avoid traffic congestion. Both circumstances are enabled by data analytical results of user’s real-time locations.

On the other hand, the findings suggested that the diversity of traffic status in different areas in a city necessitates high-quality application data acquisition as well as its data processing capability. This aims to not only realise customisation under different end-user transportation scenarios, but also to provide end-users with user recommendation services. This type of human-application interaction means pre-departure recommendable journey plans that are more suitable to the end-users. To realise user-recommendations, the computing system of the application should be able to analyse end-user traffic habits and preferences (Focus groups: G3-NMV, G5-CAR2, G6-CAR4), such as regular driving speed on both urban roads and motorways, a selection of constantly preferable means of transport, and frequent locations (Focus group: G6-CAR4).

> *“Some mapping apps actually have already achieved the analysis of frequent locations. For example, they can show your home location if you type ‘home’ on the map based on your daily commuting. However, these apps cannot provide more comprehensive recommendation services to the users to plan a better user-oriented journey.”* (G6-CAR4)

The achievement of these pre-departure recommendation services would enable different types of user to be offered with different journey recommendations. Participants implied that, for example, the recommendations to old people would be focused more on time-saving, whilst to students, they would be more focused on cost-saving (Focus groups: G1-WALK, G4-NMV). As a result, people with different purposes and preferences of mobility patterns would distinctly benefit from the user-recommendation services. Overall, the enhanced human-application interaction embodies the achievement of both user-oriented customised services and user-recommendation services.

4.1.1.2 Environmentally-friendly development

The second desire in this theme is environmentally-friendly development. It is notable that only participants in senior groups expressed a desire for future STS initiatives and the proposed data-integrated application in specific to be environmentally-friendly. It is also noteworthy to point out that participants perceived that an environmentally-friendly mode of development would benefit not merely the end-user side but also the sustainability of all urban transportation. What participants referred to as being environmentally-friendly is green commuting solutions which involve government policy-making as well as its specific actions. In terms of these actions, senior participants emphasised the importance of urban landscaping by planting trees on both sides of the roads. In particular, G4-CAR2 believed that urban landscaping can reduce the air pollution caused by exhaust emissions. Participants in Group 3 highlighted the positive effects of low-carbon transportation, such as metros and the use of bikes and electric cars. As for the role of government and their policy-making, the participants hinted that these solutions actually rely on government propaganda in terms of encouraging citizens to reduce their carbon footprint in their daily life and supporting commercial organisations to develop their business using low-carbon public transportation, e.g. bike sharing and smart buses (Focus groups: G3-PT, G3-NMV). Above all, participants in senior groups maintained that the government plays an important role in green transportation development. The implementation of the proposed data-integrated application should be seen as a solution that would need to respond to such a green ethos.

4.2.2 Technical and functional improvements

This sub-section demonstrates participant desires with regard to the implementation of the proposed integrated application in terms of its technical and functional features. These specific features were identified as the services that the participants wish the application to have, including indoor positioning, real-time traffic offence reminding, and real-time road-application interaction.

4.2.2.1 Indoor positioning.

Many participants resonated on advancing indoor-positioning technologies for future STS initiatives. Although this might not be a technological imperative from an STS expert point of view, it is useful to see what technologies citizens are really concerned about. This code emerged from their insights into the current state-of-play of indoor positioning functions embedded in the existing STS applications and their perceptions of the profound influence that indoor positioning technologies have upon their mobility. To be more specific, according to participants' experience, the growing tendency of clustered organisations to be located in one building has made indoor positioning an imperative instrument to seamlessly bridge between urban transportation and indoor mobility. The specific location information of these clustered organisations is accessible but rather inaccurate on the existing mapping applications (Focus group: G2-CAR2), thus resulting in end-user demand for the further indoor-positioning development via technical promotion and commercial cooperation, such as obtaining internal structure plans of the building (Focus group: G2-CAR1). To his knowledge, G5-CAR5 expressed that the technology used for outdoor positioning is different to that for indoor positioning where the latter involves Bluetooth and WiFi technologies. This means that all Bluetooth and WiFi signals available in the building should be captured to connect to a GPS signal (Focus group: G5-CAR5). However, the challenge of this type of cooperation is specialised as it involves large-scale data collection and signal capture from all data-openable public buildings. Overall, participants expressed that effective indoor positioning technologies embedded in STS applications would allow them to more accurately locate indoor places - and as accurately as they do outdoor locations. Above all, the findings suggested that citizen participants' desires to achieve widespread indoor positioning on the proposed application is also a potential challenge to its configuration and deployment.

4.2.2.2 Real-time vehicle-application interaction.

This type of interaction refers to the connection between applications installed in mobile devices and the central control system embedded in the vehicle. Car-user participants in particular expressed their desire for the development of a vehicle version of the proposed data-integrated application, or for the capability for the application on a mobile device to be able to connect to the vehicle central control system. This solution is desired on the basis of enhancing vehicle-application interaction, which aims to stop users from using mobile devices when driving which can result in car accidents.

> *"As a car user, I think, really, smart applications should be able to enhance vehicle-application interaction, [e.g.] voice control, in a way that we do not rely on interacting with the application while driving, but [rather] the vehicle directly meets our demand. I believe this should be achieved by the integration of applications with vehicles. [In other words], the [integrated] [transportation] service should be everywhere, and the [integrated] [transportation] information should be delivered to users anywhere"* (G2-CAR2)

G2-CAR2 implied that such a type of vehicle-application interaction could be a potential development direction of the proposed integrated application from the technical point of view – user-friendly and roadworthy. This suggests that although the integrated solution requires data to be integrated from various sub-STSs, these data should be converted to services that are easily controlled by the end-users. Participants' resonation of this point indicates a technical desire of more user-centric and demand-driven service delivery.

4.2 Citizen end-user perspective of the potential benefits of implementing the proposed data-integrated STS application

This section presents citizen participants' perceived benefits of implementing the proposed data-integrated STS application in STS. Not only did the findings emerge from the focus group questions that were directly related to the 'benefits', but were also extracted from the responses of general questions in terms of the current weaknesses of Shijiazhuang's transportation that would need to be tackled in the future. Apart from the fact that these weaknesses pose a threat to the general urban transportation management, the overall analysis in this section suggested that they also have direct influence on citizen mobility. As such, citizen participants expressed that a centralised application that integrates various STS data resources with all-encompassing services and functionalities, might be one of the possible solutions to tackle these issues in order to benefit both urban transportation and citizens. Such the proposed data-integrated STS solution was hence what citizen participants envisioned a data integration scenario could be. Although participants across groups had different opinions of 'benefits' from various dimensions, factors relating to both general urban transportation management and citizen mobility were explored, as they both could potentially benefit from the potential STS data integration scenario.

Table 2 provides an overview of two themes that have been identified as being related to the benefits. The first theme 'efficient transportation management' focuses on urban transportation in general, in which the potential STS data integration scenario would benefit relevant transportation stakeholders to better manage urban transportation. The second theme is directly related to the benefits to citizen end-users: the transparency of transportation information refers to dynamic and accessible information being delivered to them in real time. The following subsections provide a detailed report of the findings in relation to each of these themes.

Theme	Code
Efficient transportation management	Reduction of road capacity pressure
	Unification of transportation information
Information transparency	Easy-to-access transportation information
	Abundance of transportation information
	Information security

Table 3: Citizen end-user perspective of the potential benefits of implementing the proposed data-integrated STS application

4.2.1 Efficient transportation management

The findings revealed that for citizens, transportation management refers to the improvement of urban transportation management at both a macro and general city-level. The existing mode of urban transportation management has not been able to tackle the weaknesses of Shijiazhuang's transportation that were mentioned by the participants in the focus groups, e.g. heavy traffic congestion and poor transportation information circulation. According to their opinions, the proposed integrated STS application would have a positive influence on addressing these issues. From their point of view, the proposed integrated application may enable multiple ways for the public to access urban transportation information and relevant services, which would further lead to more efficient urban transportation management by relevant government agencies. In other words, such an integrated application could be expected to be a solution to improve traffic conditions and unify transportation resources in one place, in order for a unified transportation management mechanism. Within this theme two codes emerged from the analysis: reduction of traffic pressure, and unification of transportation information, which are discussed in the following sub-sections.

4.2.1.1 Reduction of road capacity pressure

Road capacity pressure refers to a high density of vehicles on a given section of road resulting in a significantly below average speed of movement (Tan et al., 2014; T. Q. Tang et al., 2013). The increasing number of vehicles disables the role that the current STS applications play on improving traffic conditions in the city. Non-motor vehicle (NMV)-type end-user participants complained that the current transportation system in Shijiazhuang has been in an awkward situation where non-motor vehicles are sometimes a better choice than motor vehicles to travel in the city with regard to the overall amount of time spent on the road. They further claim this is due to the lack of a mechanism that covers different types of information that is generated during different transportation scenarios. At this point, G1-NMV suggested that an integrated application could be considered as this kind of mechanism, providing multiple services and traffic information, and potentially offering end-users better planning of their proceeding actions in traffic. He explained that the large number of existing applications that provide different functions and services leads to the fact that transportation information is not shared effectively between them. Hence, it could be predicted that the entire road capacity pressure in the city could be reduced if every single user could plan their travel route in advance via the accessible integrated transportation information on the application, as G1-NMV stated:

> *"Traffic congestion always takes place near the public car parks … if the integrated application covers different functions, the traffic pressure would to some extent be reduced. For example, everyone in the city can use the smart navigation service on the app to better plan our routes and accurately navigate ourselves to the destination. So, before we start going, we could have already reserved a place in the car park using the smart car parking service on the [integrated] app…"* (G1 - NMV)

In particular, participants believed that the proposed integrated application could integrate information from public transportation stops or stations into the application. Through this integration, they perceived that the integrated application could be able to benefit the traffic condition at these places. On the one hand, end-users who are taxi drivers are able to acquire the timetable of trains through the application so that they can effectively make decisions and plan their services. On the other hand, passengers on the trains are able to book a taxi via the app before they arrive. In this case, the road capacity pressure around the train station would be reduced due to the "point-to-point" service. By achieving this, both taxi drivers and passengers would potentially be able to save time.

> *"I think if the proposed integrated application covers the train or flight schedules on the app, taxi drivers would not have to be waiting in a long queue. They can better manage their time by checking the time of arrivals every now and then and the reservation notification made from a particular passenger. ... Then we would hardly see traffic jams around these places."*
> *(Group 2 - CAR)*

4.2.1.2 Unification of transportation information

Compared to the reduction of traffic pressure, a majority of participants believed that unification of transportation information would be a more significant benefit of the integrated STS application. People using multiple applications results in a situation where the transportation information that is held by different people varies. For example, a participant who usually used route planning applications strongly complained that the congestion level shown on AutoNavi and Baidu were sometimes completely different (as shown in Figure 13). The image is a comparison between AutoNavi (on the left) and Baidu (on the right) in terms of the real-time road traffic status; at a particular location AutoNavi suggested little-to-no congestion which was marked green while Baidu indicated heavy congestion which was marked red and yellow. This contradictory information led users to question the application reliability and wish for an integrated platform in future.

Figure 13: Discrepant information shown on AutoNavi and Baidu Map

(Real-time screenshot for AutoNavi and Baidu Map on the same section of a route at 11:33am)

G6-CAR2 in particular shared his experience of the issue of contradictory information he encountered whilst using different applications:

> *"Once I was driving with two friends of mine to the airport to pick up another friend. We drove fast because there were only 40 mins left from now on till the plane arrived, and usually it at least takes 30 mins to get there. … We were all using navigation but just on different apps. What was annoying was that all of our apps were directing us towards different routes with also different remaining time. … I decided to rely on my experience and read the road guide boards to figure out the quickest way to get there."* (G6-CAR2)

The findings suggested that such discrepancy not only impact on car users but also on all other types of end-users. They expressed a high expectation on the reduction of discrepant transportation information by unifying information in one place. Participants were unanimous in the view that the unified information would be able to eliminate their concern about inconvenience and time wasting.

When asked further about the possible implications of unifying information, more than half of the participants stated that the scenario where everyone could receive exactly the same information (as information from different data producers is unified), could allow relevant government organisations to more effectively manage transportation resources and release transportation information without concerns about information inconsistency between different stakeholders.

> *"… the use of the proposed integrated app could benefit urban transportation as a whole; traffic could be easily regulated and controlled by the government. For example, [whilst] there are myriads of commercial STS companies providing online taxi services, such as DiDi and Yidao, unified information [embedded] in one place for all citizens could allow government to monitor, manage and even control real-time traffic status and people's traffic behaviours" (Group 2-NMV)*

Overall, the conducted focus groups suggested that transportation information being unified would enable the delivery of more transparent transportation services to the public. The next section, therefore, is focused on the benefit of the proposed integrated STS application to citizen end-users regarding information transparency respectively.

4.2.2 Information transparency

Information transparency is identified to be the second theme within the scope of benefits that the proposed integrated application could provide to citizen end-users. The general feeling of participants, when being asked about their opinions on the current transportation system, was that large amounts of transportation information was currently invisible. They wished for more information that was held by relevant stakeholders to be disclosed to the public. In order to achieve the forms of "visibility", it was vital for information providers to remove barriers of access to transportation information and create opportunities for open information. More specifically, the findings suggested that a potential data integration solution of STS could contribute to a more transparent transportation system. Participants implied that this was determined by amount, availability and accessibility of the transportation data gathered from different data sites. These data, moving from different sources into one application, would make users step into an open-information-driven transportation environment.

There are three codes identified within the theme “information transparency”. The first sub-section below is focused on transportation information which would become easy-to-access for citizen end-users of the data-integrated application. The second sub-section reveals the benefit surrounding abundance of transportation information. The final sub-section is focused on a secure information environment.

4.2.2.1 Easy-to-access transportation information.

The openness of transportation related data at different sites enables comprehensiveness and accessibility of transportation information presented on the proposed integrated application. The findings indicated that citizens face challenges in accessing different transportation information in different ways, and most of this information is difficult to access. In other words, there is not currently a single platform with an efficient information-gathering mechanism for citizens to garner various types of useful transportation information. The integration of transportation data from different places into an integrated platform would therefore enable citizens to easily gather the information they demand by using the application (Focus groups: G2-WALK, G3-PT).

This dimension of benefit was explored from the perspectives of participants in all groups. The university student group, who may travel across the university city and home city, expressed their opinions on the benefit to the easy-to-access information of external traffic communication, such as timetables of trains and aeroplanes. G1-PT in particular claimed that there are various transportation-related applications installed on his mobile phone providing different types of transportation services; he always uses multiple applications when he travels between two cities in order to smoothly connect between inter-city and intra-city transportation.

> *“Before I head to city of my university, the first thing I do is using an app to buy train tickets. Then I use Didi to call a taxi to send me to the train station. On the way when stuck in a traffic jam I use Baidu Map to check how long I can get through… The problem here is not really the trouble with using multiple apps, but [rather] that I could not really access the information I need in one go regarding the journey from where I set off to the destination.” (G1-PT)*

His opinion was echoed by other student participants in the group i.e. this issue could be solved by using the integrated application – easy-to-access information of both intra- and inter-city transportation is integrated into the application. Participants in other groups, especially those who were senior citizens were concerned with the administration of government decision-making which may not be known by the public through STS applications. For example, the existing smart navigation system is able to detect that a particular part of the road is congested, but users may not be informed that the congestion is being caused by government road engineering in a nearby place; this is especially the case for car users. Not acknowledging what is happening ahead and what might be the cause of the congestion would lead to less effective decision-making and traffic strategy adjustment on the car drivers' side, as they may have no idea how the congestion will impact on the rest of their journey (Focus group: G4-CAR2). From the point of view of senior citizens, such easy-to-access transportation information should not only be achieved through mobile services like smartphone applications, but also through traffic information guidance systems embedded in urban traffic infrastructures. The diversity of information and services on the proposed integrated initiative also contributes to the second dimension of information transparency to citizen end-users – abundance of transportation information – which is discussed in next sub-section.

4.2.2.2 Abundance of transportation information

Apart from the diverse service range on the integrated application, transportation data sharing between different data providers is also an important factor that contributes to an abundance of transportation information that can be utilised by citizen end-users. This means that cooperation across different sites and the support from relevant organisations will enhance both quantity and quality of transportation information to the end-user side. Participants, especially those who typically used smart navigation applications, e.g. Baidu Map, AutoNavi, commented on the potential benefit of the proposed integrated application in addressing an issue emerging from existing applications with regards to the amount of transportation information.

The findings revealed many insights about participants' perceived benefits of the proposed data-integrated solution in relation to the unification and integration of data coming from various places. Whilst previous sections (i.e. Section 4.1.1) placed an emphasis upon the unification of data generated from different end-user applications, this section stressed the potential opportunity that the proposed integrated scenario could unify, and somehow link, data generated from urban transportation infrastructures and the information displayed in end-user applications. This is to say, participants perceived that the proposed data integration solution should accurately reflect what urban transportation infrastructures display to their end-user applications; and if this becomes a reality, they suggested that large amounts of transportation information and associated services could be delivered to them. Participants complained that the information end-users acquire from their STS applications does not usually reflect what is actually happening on the roadways. A car-user participant in Group 6 complained about the inaccurate speed limit reminder on his application:

> *"… I was sticking to the application voice reminder, so I did not draw my attention to the signpost at all. The speed limit on that bridge was actually 60km/h whereas my app was saying 80km/h. … The consequence is I was fined ¥300 [(≈£27)] and three points on my licence."* (G6-CAR1)

When asked about the cause of such contradiction, some participants commented that the likely possibility is the weak information sharing between transportation data providers and practitioners:

> *"[IT] companies prove that they are quite strong in making technological progress. However, I think… a lack of two-way data sharing and integration [practices] between relevant infrastructure vendors and themselves may lead to the situation where the data resources held in different sites are different without a sort of unified mechanism to ..." (G6-CAR3)*

In general, from the car-user participant perspective, data sharing and information delivery between relevant stakeholder organisations would enable the elimination of information asymmetry. The openness of data at different sites is therefore imperative to facilitate data sharing. Moreover, the integration of various data into one application would increase the amount of transportation information, which at last would contribute to the accuracy and quality of application services. Besides, the integration of data would not only enable an abundance of transportation information, but would also improve information security, which is discussed in next sub-section.

4.2.2.3 Information security

When transportation information from various sources are shared and integrated into one application, another issue emerged from the debate in terms of whether end-user information has become securer. This information includes both personal information such as name, address, telephone number etc., and financial information such as bank account or third-party payment platform. When people register to use current STS applications for the first time, they are often required to provide their personal information in detail and sometimes to link their payment method with the application, e.g. bank account. For example, by using taxi booking applications, customers do not pay the bill at the end of the journey; the pre-condition is that a payment method is linked with the application with customers' personal information. Despite the fact that the large range of STS applications provide people with more convenience in traffic, people are concerned about their personal and financial information which is likely to be released or falsified. As such, senior participants in particular had strong feelings about the importance of information security mechanisms being built into applications due to their experience of using the current STS applications, as they resonated:

> *"I have removed all my [binding] third-party payment accounts from mobile apps after once a large amount of money was taken from her account following the use of a taxi booking application."* (G4-PT)

> *"I never let the amount of money in his binding payment account exceed ¥100 [(≈£9)] just because, to my knowledge, I believe the online business environment is not safe."* (G5-CAR3)

> *"I would stop using the application if I was asked to bind my payment account before I use it."* (G4-CAR)

> *"I felt uncomfortable with the fact that I often receives phone calls from different business companies for the promotion of their products, which was attributed to the disclosure of his personal information when registering with the company."* (G4-WALK)

However, when it comes to the proposed integrated application, participants believed there could be a positive effect in terms of information security. They envisioned that the proposed data-integrated application, as an initiative, would need to be run by government, or dominant or monopolistic corporations who take charge of data management in one place; therefore, the application would reduce the risk of end-user personal information being disclosed without awareness of the business and commercial purposes.

> *"I would say when all information and service come to one application, even though I have my payment account linked with it, I would not worry about information security issue. Similar to Alipay which plays a dominant role in online business transaction, nearly 70% Chinese people are using Alipay to make payments, but we hardly hear any information security issue with it."* (G4-WALK)

What G4-WALK reflected here is not merely an indication of centralised data management in one site of authority, but also a hint at the issue with online surveillance systems and privacy concerns. Although the proposed data-integrated solution might be able to eliminate citizen end-user concerns about information disclosure to various entities, they expressed that it might also lead to a stronger, more centralised, and more politically-driven surveillance system that is embedded in the application, controlling and detecting citizens' movements and online business activities. In a nutshell, whilst this could be a good way for authorities to leverage surveillance to *"know"* people (other than *"know about"* people) (Galič et al., 2017; Norris, 2005), participants stated that they would feel uncomfortable being "*straitjacketed*" (Focus group: G2-WALK) without knowing for what specific purposes they are constantly being monitored. Car-user participants in particular echoed this point by referring to their negative feelings regarding the status of current CCTV cameras capturing their real-time mobility; herein, every single vehicle is considered as a data point which contains myriads of driver information, such as licence number, home address, contact details and vehicle information. They perceived that the proposed integrated application could make such surveillance leverage even stronger, as G5-CAR2 implied:

> *"… the problem is we do not know when, where and how our information is captured, for what purpose. I am not saying relevant authorities shouldn't do this, but instead my feeling is I think we need to be known that this sort of*

information, or at least the intention, ought to be transparent [to citizens].” (G5-CAR2)

4.3 Citizen end-user perspective of the potential challenges of implementing the proposed data-integrated STS application

Whilst the last section illustrated how citizen participants perceived the proposed data-integrated STS application would benefit both people and urban transportation systems in general, this section presents citizen participants’ perceived challenges that stand in the way of integrating data from various STS applications. As far as citizen participants understood the current state-of-play of STSs, a set of socio-technical challenges may hinder such an integration process. The findings were drawn from the focus group investigation of citizen participants’ insights of the disadvantages of Shijiazhuang’s urban transportation network and its development in general, and discussion of their experience and knowledge of the existing STS applications they used, transportation policies they encountered, and socio-cultural dynamics they are involved in regarding the potential of data being shared and integrated on a large scale.

In more detail, participants claimed that the current issues of urban transportation in Shijiazhuang mainly consist of low capacity of emergency command, poor configuration of traffic infrastructures, ineffective government policy administration, deficiency of ICTs deployment and poor citizen traffic behaviour (e.g. speeding). They also stressed that the disadvantages of the existing applications refer to the low quality of data, poor user-side effectiveness and issues of market competition. This means that, the weak performance of existing urban transportation systems and the shortcomings of the current applications are yet to be improved in order to implement the proposed integrated application. In company with the direct questions asked to participants about the potential challenges, these explorations helped in formalising the categories of potential challenges in this sub-section, as shown in Table 3.

Theme	Code
Data processing issues	Data processing issues
Citizen end-user effectiveness and	User-side acceptance

participation	User-side operability
	Smart city awareness
Socio-economic performance	Promotion and circulation
	Market competition
	Government support
	Cooperation among relevant organisations
	Technological and social investment

Table 4: Citizen end-user perspective of the potential challenges for implementing the proposed data-integrated STS application

4.3.1 Data processing issues

This sub-section reveals participants' perceived challenges of integrating various types of data from a technical point of view. Whilst participants in all groups reflected the challenges based upon their own understanding and experience, a noticeable issue that raised their attention was data processing barriers that may stand in the way of data integration solutions. Moreover, the overall analysis indicated that young participants and car users in particular, provided the most comments on this dimension as they seemed relatively more knowledgeable and experienced in interacting with existing smart applications compared to other groups. Referring to the existing applications under the current development of urban transportation systems, they acknowledged that the main technical challenges of the proposed integrated application contains the quality of datasets, functionality of each service and technical upgrading.

Participants in each focus group stressed on numerous occasions that data generated from myriads of places, and being collated in one place, is what they perceived a data integration scenario to be. Processing these complex datasets was as such identified as a challenge within this theme; it refers to the difficulty of achieving data accuracy, from data being collected, analysed and converted to user-side information. In terms of data collection, the low capacity of existing data-collection tools might lead to the inaccuracy of terminated services on the end-user side. For example, data on the existing applications are more accurate in urban areas especially in city centres and less so in the outskirts of cities and rural areas (G6-CAR5); car-users in focus groups had strong feelings about this when they were using GPS services.

> *"Once before I was driving in the outskirt of the city while I was using GPS to direct … The system asked me to turn right at a crossroad first and then keep going straight on. A few minutes later, I realised I was driving towards a dead end, but the application was still directing me to carry on…"* (G1-CAR1)

G1-CAR2 in the group speculated that this was due to the limitation of data acquisition. He maintained that most applications prioritise cities in terms of service coverage, followed by towns and countryside. Traditional data acquisition tools, e.g. data acquisition vehicles, are mainly used in city centres but rarely in the outskirts or peripheral areas of cities, resulting in data accuracy gaps between different geographical service areas. In this sense, car users as a whole maintained that the proposed integrated application could face some challenges to overcome such data acquisition limitation issues. This is because the integrated service is focused on massive datasets from various data sources; the majority of potential end-users of the application are located in downtowns. Therefore, participants believed that the classification and priority of the geographical service area would become crucial for the development of the application (Focus group: G5-CAR1). Moreover, participants who usually take taxis pointed out the technical issue of the updating of real-time data especially in the taxi-hailing applications. He (G5-CAR1) speculated that this might be because of a poor algorithmic system for cloud computing behind the application.

> *"I really do not trust the remaining time shown on the car-hailing application when I was waiting for the taxi coming. Once I called a taxi and the application displayed 5 mins away from the taxi's arrival. After a while the remaining time turned to be 2 minutes and the real-time location of the taxi showed that it was near to where I was. [However], the taxi driver called me, saying he was stuck in a tailback and would get to me in about 15 minutes long, so he suggested me cancelling the order if I was in a rush."* (G2-CAR1).

This failure to update real-time data resulted in unsatisfactory service on the user side. The cause of the failure was speculated to be inaccurate cloud computing particularly in a situation where many users use the application on the road (G2-NMV; G2-CAR2). Another case as regards the issue with the updating of real-time data is related to voice prompt on the existing applications, particularly when driving at relatively high speed. Some car users in the car-user groups suggested that most traffic accidents were caused by motorists looking at their mobile phones, and thus the technology of voice prompt enhanced driving safety to a large extent. However, some cases of delayed information delivery on the current smart navigation applications led to user dissatisfaction.

> *"The application directed me to convert into the left-turn lane after I actually had passed the crossroad already. ... The delayed information would lead to motorists going towards a wrong way, or in the worst-case scenarios, breaking the traffic rules at some point ..."* (G5-CAR1)

The findings revealed that the issue with the updating of real-time data may also exist with the proposed integrated application (if the current data processing tools were not to be upgraded), as the volume of data would be much bigger. This potential challenge would give rise to the unsatisfactory effectiveness of each single service on the proposed integrated application, which will be discussed in the following sub-section.

4.3.2 Citizen end-user effectiveness and participation

The analysis of challenges related to data processing led users to be concerned with a further set of potential challenges in terms of the end-user effectiveness of the proposed data-integrated solution. The analysis revealed that this effectiveness relates to user-side acceptance and user-side operability (which are mainly concerned with the technical performance of the application), and smart city awareness (which is focused upon a broader environment of smart citizen participation). User-side acceptance refers to application credibility and the intention of users to use the application, while user-side operability suggests how good the performance of the application would be and what users' feelings would be regarding using the application. These two dimensions of analysis match the findings that car users have more reflections compared to the other types of participants. This is because there is a wider range of STS applications for car users, so their experiences with these applications aroused their critical thinking with regard to their overall effectiveness (Focus groups: G1-CAR2, G2-CAR1, G3-CAR1, G4-CAR1). Smart city awareness implies that citizen traffic behaviour plays an important role in shaping citizen participation in building smart transportation environments. It is interesting to reveal that older participants who have more social experience expressed comparatively more perceptions about the significance of citizens having smart city awareness compared to younger participants.

4.3.2.1 User-side acceptance

The first aspect of this theme is related to the intention of potential users to use the application. Older participants suggested that middle-aged and older people have already formed user habits and dependence on the existing applications as well as those who are not sensitive to new technologies. This fixed habit and dependence would impact on their willingness to attempt to use the new applications. This means that, the proposed data-integrated STS application should be able to change users' current habits and usage pattern to enable themselves to more quickly become involved in the services provided by the application. However, purely from the end-user interaction perspective, user involvement was identified as being related to the uniqueness of the application. This relationship was mainly underlined by participants from Group 3 and Group 4 who on the whole denoted a characteristic of unwillingness in accepting new technology. They explained that a crucial factor in determining whether or not they would tend to use the proposed integrated application would be how distinctive it is compared to the existing STS solutions.

> *"I am not a technology savvy that would like to try innovative products unless everyone says they are good. And I think ... in general whether everyone would say a particular innovation is good is determined by how distinctive it is from the actually existing STS solutions and the extent to which it delivers value to us."* (G3-PT)

> *"From my point of view, I believe that if a technology product is aimed at being ground-breaking innovation, it has to be really addressing people's demand. ... In the case of data integration, I think it should be distinct from all current integrated applications [used in other fields], like Alipay and WeChat. I believe only with these conditions would people would like to be widely involved."* (G4-WALK).

However, the findings suggest that although the uniqueness of the application would bring increasing number of users, the abandonment of the application would appear after it has been used for a while, particularly if the application is not as trustworthy as users expected it to be. Many participants mentioned that, for instance, AutoNavi successfully attracted many users who used to use other applications by diversifying its voice prompt service with various accents. However, it is interesting to note that the accuracy of smart navigation function become lower if users switch to the personalised accent, resulting in the wide range of abandonment of the application (Focus group: G5-CAR5). In a nutshell, participants' opinions upon the disadvantages of existing applications regarding end-user acceptance make them perceive potential difficulties in addressing these issues when implementing the proposed data-integrated solution. Apart from user acceptance, the overall analysis found that user-side operability was also a challenge with regard to eventually implementing the proposed integrated application.

4.3.2.2 User-side operability

The findings showed that user-side operability indicated a visual impression of the application; an easy-to-handle application is more highly praised by users. It is notable in focus groups that older participants do not bother to use complicated technology products. They were concerned more about user-side operability than younger participants. Operability was thus deemed to be a challenge to implementing the proposed data-integrated solution due to the contradiction between multi-functionality service and user-friendly control. This implies that a comprehensively integrated application, with multiple functions, may not be able to quickly direct users to use a particular service on the application.

> *"[For example], I do not really use the mini programmes and related services on Alipay as each is not as good as existing apps that specialise in a particular service. Also, these services are completely independent from each other; there are no interaction between them. I have to quit a service if I want to use another."*
> (G4-CAR1)

Though Alipay is not a transportation application, G4-CAR1's story implied that the proposed integrated application should not mechanically integrate all services. Instead, these services are expected to effectively switch over as required by the end-user. Furthermore, participants in all groups placed an emphasis on the simplicity of the application end-user interface, indicating that information shown ought to be easily and quickly accessed by users. Apart from the effectiveness of the application on the user side, participants also suggested some potential challenges in relation to its risk assessment in society. This is discussed in the next sub-section.

4.3.2.3 Smart city awareness

The theme of "smart city awareness" emerged from the analysis of what citizens perceived as a potential challenge in regard to the extent to which citizens are aware of the importance of being 'smart'. The findings on this point are two-fold. Firstly, citizen traffic behaviour. Participants claimed that good traffic behaviours and their active participation in smart city technologies would play an important role in initiating emerging smart city solutions. Although municipal governments in China have taken drastic measures to promote smart city initiatives under the banner of "New-Type Urbanisation" policy (J. K.-S. Chan & Anderson, 2015), almost all participants highlighted that poor citizen traffic behaviour is always a barrier to developing STS technologies. They further stressed that for more integrated solutions to be widely rolled out in cities, citizen traffic behaviour would need to be improved. For example, many people are familiar with the location of road surveillance systems which capture most traffic violation in the city, resulting in many citizens who are guilty of such offence, escaping without punishment. This would easily provoke traffic accidents, the subsequent effect of which would be a spell of disorder at certain points on the road. Furthermore, the findings suggested that poor traffic behaviour in general also poses a threat to pedestrians, especially disadvantaged groups of people such as old people and children (Focus group: G1-WALK). Participants who always walk had more experience in this sense than those who use other forms of transportation as they often encounter the situation where their travelling was impacted by reckless motorists. In the context of data integration, such kind of messy condition in urban traffic is magnified because of multiple data sources and highly integrated STS services.

> *"I always walk, and I really feel unsafe when I walk across a road. A lot reckless drivers just only care about themselves; they have no awareness to give way to pedestrians at all. Low citizen quality is really a big threat to developing smarter and sustainable transportation from citizen rights point of view." (G1-WALK)*

Moreover, to be more specific about the traffic conditions in Shijiazhuang, participants stated that poor citizen traffic behaviour also indicates motorists changing traffic lanes without indication; this change threatens the vehicles behind with potential and unpredictable traffic accidents (Focus groups: G4-CAR1, G5-CAR2, G6-CAR4). To conclude, only when significant improvement of traffic behaviour has been achieved would the functionality of the proposed data-integrated application perform more effectively for its end-users (Focus groups: G1-CAR1, G2-PT).

Secondly, top-down form of citizen participation. This has been explored as the second dimension of challenges within this theme in initiating the proposed integrated application. The diverseness of smart city initiatives may lead to multiple forms of citizen participation, wherein smart citizens or smart citizenship usually performs within the boundaries of expected and acceptable behaviours (Cardullo & Kitchin, 2019a). Further to this point, the findings suggested that the increasing transformation from traditional manual work to algorithm-driven and automated practices (e.g. sensor-based car parks) would need widespread public engagement because data that these technology solutions rely on are stemmed from citizen end-users (Focus group: G3-WALK). Nevertheless, the challenge was explored as the issues of whether this kind of top-down decision-making of smart initiatives is what citizens demand, and the extent to which they are likely to participate in using the initiatives. The evolution of the way in which people participate in these initiatives aims to create a ‘smart environment’ (Focus group: G6-CAR5) where everyone is encouraged to access, and make use of, smart technologies in their daily STS activities:

> *“Since early this year, the car park of Wanda Plaza (one of the main business centres in Shijiazhuang) has only accepted WeChat Pay and Alipay for the payment of parking fees. To enhance the operating efficiency of the car park, customers are encouraged to scan their QR code on either WeChat Pay or Alipay to make the payment in advance.”* (G6-CAR5)

Wanda car park was the pilot project of car park payment system reformation, due to the fact that 80% of consumers in Wanda Plaza are young people (this demographic accounts for the largest proportion of WeChat and Alipay users) (Focus group: G6-CAR5). However, senior citizens in particular, stated that the execution of the new payment system needs authoritative decision-making regarding the issues with the locality, geographic characteristics, and technological underpinnings of the site of practice, and corresponding government policy-making, in order to make sure it is legitimately achieved.

4.3.3 Socio-economic performance

Whilst previous themes of the findings respectively focused on essential technical issues of data processing and end-user effectiveness of the proposed data-integrated STS application, the participants also indicated some challenges that potentially influence its socio-economic performance. These challenges include promotion and diffusion, market competition, government resource management and support, cooperation among relevant organisations, technological and social investment, and duty allocation among stakeholders. This dimension of challenges has been analysed to be the main concern that citizen end-user participants have about the implementation of the proposed data-integrated application. The analysis indicated that participants from different groups all shared many of their insights related to socio-economic performance.

4.2.3.1 Promotion and diffusion

Promotion in this sense is interpreted as relevant stakeholder organisations (e.g. application developers, government agencies) publicising the application towards the civic society with the aim of quick public familiarisation at the initial stage of implementation. Diffusion suggests the generation of widespread use of the application following its implementation. However, participants suggested many barriers in promoting and diffusing the proposed data-integrated application. The overall analysis indicated the issue of cost, where many participants perceived that the application would need large amounts of capital input for its promotion and diffusion (Focus groups: G4-NMV, G5-CAR3, G6-CAR1), and that such capital input would be a continuous process (Focus group: G4-NMV). In addition, G4-WALK claimed that capital input requires various channels to enhance the effectiveness of promotion and diffusion:

> *"Capital input is rather important, and it needs mass media as channel to publicise and promote a particular initiative to the public."* (G4-WALK)

The mass media play an important role in publicity. However, the difficulty in maintaining a relationship with them, and the amount of capital input required would exist throughout the lifecycle of the proposed integrated application. The comprehensiveness of the application suggests challenges in opening various cooperation channels with the mass media, namely that a concerted effort amongst STS practitioners and the mass media would be needed.

Moreover, another dimension of challenge with regards to promotion and diffusion which emerged from the analysis is related to the potential crisis of the labour market, potentially caused by the shift of production from manual work towards being data-driven, algorithm-based and automated, that the proposed data-integrated application would create. The integration of a large range of social resources and widespread tendency of using the integrated smart application would dismiss some unnecessary employees whose work is of a manual nature.

> *"…what about those who used to work in the car park as a conductor? They would be facing with a challenge that they are not needed anymore due to the development of sensor-based technologies and infrastructures."* (G3-NMV)

The successive re-disposition of employment in the labour market (Focus groups: G3-WALK, G3-CAR2) was therefore identified to be a difficulty in regard to promotion and diffusion. This potential challenge stems from, and is based on, government policy making towards smart city development (Focus groups: G3-CAR1, G3-CAR2). This means that the smart city development agenda requires the government to promote and circulate all types of smart city technologies and re-allocate potentially impacted labour resources.

4.3.3.2 Market competition

Market competition in the context of this finding means that on the one hand, various STS enterprises compete to be the core innovation actor in the process of implementing the proposed data-integrated STS application, and on the other, such integrated application may face long-standing competition from existing commercial STS solutions. For the first dimension, market competition is a crucial condition that exerts influences on the interplay between strategic alliances amongst relevant organisations and organisational product innovation (J. Wu, 2012). In this sense, participants resonated that the initiation of new innovative solutions would rely on the climate of market competition which could impact the existing mode of collaboration between stakeholder organisations. This indicated that the initiation of the proposed data-integrated application may need stakeholder organisations to refashion their strategic alliances. The failure to do so might lead to the chance that many existing applications with a specialised service range, in a particular STS area, are more trustworthy and acceptable than the proposed integrated application (Focus groups: G1-

CAR1, G2-CAR1, G3-WALK, G5-CAR1). In a nutshell, as G1-CAR1 commented, *“where there is market competition, there is collaboration, and where there is collaboration, there are innovations”*.

For the second aspect, existing applications with consolidated data and resources embedded, threaten the data acquisition and data reliability of the proposed data-integrated application. For example, threats would exist in the competition against existing smart navigation applications which have been playing a dominant role in the smart navigation market through possessing increasing amounts of data and resources. This would lead to difficulties for the proposed integrated application in terms of matching the data quality and quantity of the existing smart navigation applications. This indicates that such difficulties would be enlarged when integrating all types of services to the proposed integrated application, resulting in low trustworthiness of the end-users (Focus groups: G1-CAR2, G2-CAR1).

> *“I cannot imagine how much effort that the developers of the proposed integrated app would make in order to compete with all existing successful apps in regard to having the same level of data quality and quantity of each of them on the proposed integrated app.”* (G1-CAR2)

G1-CAR2’s statement suggested that high quality data resources are the core of developing an STS application. In other words, G1-CAR2 believed that many STS enterprises placed much attention on their data resources in order to be competitive.

Except for the above two aspects of market competition, the findings also revealed that the successful implementation of innovative STS applications by particular developers would lead to large-scale competition from other commercial enterprises. The latter would develop their own applications which have similar or further ameliorated functions or services; market research and product investigation into the former application would become an advantage in the process of developing their own.

> *“When a new product comes to our life, many other commercial companies tend to design their own products with similar functionalities but further develop more attractive services on top of these functionalities to earn more users.*

Consequently, the latter applications would have increasing number of users and dominate the market." (G4-NMV)

G4-NMV's view suggested that the competition would take place in amelioration rather than innovation of particular innovative solutions, and such competition was identified as a potential challenge that occurs after the implementation; in contrast, competition against existing applications would take place before the implementation. The next two sub-sections will reveal more information about what participants perceived as potential challenges in regard to government support in coordinating data resources and the mode of cooperation between relevant stakeholder organisations.

4.3.3.3 Government support

Participants acknowledged that government is the policy maker and coordinator of urban transportation data resources that guides the direction of transportation-related business prosperity. G5-CAR1 in particular, according to his own knowledge, pointed out that government possesses the most essential traffic data which are inaccessible to commercial enterprises without approved legal authority. In order for commercial STS enterprises to co-create an integrated STS application, government support would be needed in terms of the sharing of the essential traffic data with commercial enterprises and traffic resource management and allocation. The challenges hidden in sharing government data are two-fold. The first dimension is the capture of traffic resources which cover the entire urban transportation network, such as data produced from traffic surveillance (Focus group: G5-CAR1) and road-embedded thermodynamic sensors (Focus groups: G2-CAR2, G6-CAR2). In order to provide end-users with an integrated service, participants claimed that it is necessary to utilise the data generated from urban road infrastructures managed by government (Focus group: G5-CAR5). The failure of integrating government data resources might lead to less comprehensive and accurate transportation information for citizen end-users.

The second dimension of the challenge in government data support suggests that the implementation of the proposed data-integrated application would need more flexible policy making. First, the implementation of taxi-hailing applications has been hindered by the government not allowing them to compete against traditional taxies around public transport stations, e.g. train stations and airports. As such, Uber taxies for example, regard themselves as social cars. This is caused by government policy with regard to preserving state-owned taxi-fleets (Focus group: G3-CAR1). Policy making regarding public transportation also suggests the connection between the proposed data-integrated application and data produced from public transport stations (Focus group: G1-PT). In particular, to better alleviate the traffic congestion and enhance traffic efficiency around public transport stations, a policy making mechanism would need to support the sharing of data such as real-time train schedules with commercial transportation applications (Focus groups: G2-PT, G3-PT).

> *"As I said earlier, legally speaking, specific information should be captured from train and bus stations, then the application would help users more efficiently arrange their journeys in advance."* (G2-PT)

This statement suggests that firstly, data of public transportation are actually managed by government, and secondly, data sharing means cooperation between commercial companies and the government. Applications that currently exist regarding data sharing with public transport stations only provide information about the mode of transport from the station in question, i.e. no other service such as maps, or route planning developed by commercial STS enterprises is provided. The potential challenge herein that participants identified refers to the legality of integrating data produced from public transport stations with data from other places.

In addition to the challenges hidden in sharing government data, the analysis also identified the challenges of government support regarding government transportation resource management and allocation, based upon the fact that unfixed and spoilt traffic infrastructures on the roads pose a threat to road capacity and traffic efficiency (Focus group: G4-CAR1). STS application efficiency is impacted by these infrastructures not being fixed in a timely manner. This implies that the proposed integrated application, which would have integrated services, would also be impacted by such traffic paralysis caused by poor infrastructure management.

> *"Apart from those caused by human factors, many traffic issues are triggered by inappropriate management of traffic infrastructures. For example, the malfunction of traffic lights which are not fixed in real-time would easily result in traffic disorder in road junctions. The case would become even more serious during rush hours."* (G4-CAR1)

Spoilt infrastructures not being fixed is only one case of ineffective government resource management and allocation. The cause of this was identified, particularly by the participants from senior groups, as the issues with duty allocation among relevant departments. Uncleared duty allocation and the lack of executive leadership may lead to the situation where problems were not addressed in a timely manner. To amplify this issue in terms of implementing a data-integrated STS application, duty allocation refers to all government agencies strictly fulfilling their responsibilities in supporting the development of the proposed application (Focus groups: G4-CAR1, G4-CAR2, G4-WALK, G5-CAR3).

> *"Well I think... government should not [merely] manage transportation infrastructures, but also carefully monitor every single process of the application development. [To achieve this], government should stipulate clear departmental responsibility, namely which department should take what sort of problems in responsibility." (G4-CAR1)*

G4-CAR1's opinion indicates that government duty allocation is fractionised into specific departments which perform their own duties. They play different roles in providing support to the application developers. This means that problems existing at any particular site of allocated duties may hinder the development of STS initiatives (Focus groups: G4-WALK, G5-CAR3).

4.3.3.4 Cooperation among relevant organisations

In addition to government support, the findings revealed that data sharing involved in implementing a data-integrated STS application also refers to the cooperation among relevant commercial organisations. In this sense, such cooperation means core data sharing among STS companies and additional data sharing between STS companies and non-STS social and public service organisations. Different STS companies have their own technological resources and data. For example, companies who provide tailored taxi services have a large user dataset, e.g. taxi driver information and passenger user records; bus applications have a full schedule of bus routes and times; and smart navigation applications have their own map and positioning technologies. Data sharing that takes place amongst these current applications means data produced by one company are adapted by others and then used as their own data. For example, Chinese Uber uses map data from Baidu Map, and Baidu Map has a service connector to Uber taxi to help their users directly call Uber from Baidu Map. As implied by participants, the proposed integrated application aims to achieve the integration of data from all types of transportation services. The cooperation between different STS applications is hence crucial to realising essential data sharing.

> *"This project really needs cooperation between different STS enterprises. ... The obstacles of data and resource sharing lead to the situation where the integration of all sorts of transportation services is difficult to achieve by one organisation. This would turn out to be a sort of large-scale alliances of the entire STS market."* (G6-CAR3)

However, data sharing in this context is not only limited to STS companies, but also non-STS social and public service providers. These organisations have supportive resources that are converted to data; these data can be re-used and adapted to the proposed integrated application. For example, the internal structure plan of a shopping mall with detailed shop information is needed to achieve indoor location queries; and the connector to a broadcasting station can achieve up-to-the-minute traffic reports by converting broadcast information into application data, as G4-WALK stated:

> *"Many people tend to listen to the broadcasts to capture real-time traffic status. These traffic information from broadcasting station is actually from the public constantly reporting the traffic condition they encountered. ... The integrated application would be facing the challenge in regard to establishing connection to broadcasting stations."* (G4-WALK)

The purpose of this type of cooperation is to enrich datasets from public platforms. The challenge involved in cooperation with social and public organisations was explored as data processing from a large range of datasets that originate from different public places. However, the diversity of public resource acquisition needs large investment in both technical and social terms.

4.3.3.5 Technical and social investment

This dimension of challenges is identified as being related to the previous challenges. This means that both market competition and cooperation amongst stakeholder organisations are built upon a large amount of investment. As far as technical investment is concerned, the proposed data-integrated application aims to make high-quality functionality on each single service outdo each of existing applications. However, the achievement of this goal would require substantial technical input which is a requirement (Focus group: G1-CAR2) at all stages of application development, i.e. from the design towards implementation (Focus group: G2-PT). Furthermore, up-to-date data are crucial in providing end-users with the latest information and integrated service; the cost of the update of the application and involved data would be high due to its variety of service and functionality (Focus groups: G1-CAR2; G6-CAR5).

> *"Different to those with focus on only a few services, this [proposed data-integrated] application should do its best on every single service. So technical requirement would be the priority, followed by substantial technical investment."* (G1-CAR2)

> *"This [integrated] application should involve have a large number of data. Once the application needs data updating, the cost would be considerably a lot. Despite of this, real-time data updating is absolutely needed [in order to] provide users the latest and accurate information and service."* (G6-CAR5)

In addition to technical investment, social investment is also identified to be a potential challenge. Previous sub-sections of the findings highlighted that government and different types of enterprises are all important data resources, and the cooperation between these organisations means data sharing. Many cases of data sharing are dependent on regular data business where particular data produced from each place are required by others through business transactions (Focus groups: G3-NMV, G4-CAR2). The integration of data that are acquired from different organisations are therefore driven by capital input.

> *"As far as I know, government will never offer you resources free of charge; you should buy data from government. Likewise, the cooperation amongst commercial STS companies in terms of data sharing is also built on data transaction."* (G3-NMV)

G3-NMV's view suggested that the identified challenge from the social investment point of view is correlated with that from the dimension of cooperation amongst relevant organisations which was discussed in the last sub-section. The latter challenge highlights the difficulty in successfully achieving the cooperation with various organisations, while the former challenge is particularly focused on the capital investment that lays the foundation for the cooperation. Overall, the findings suggested that both technical and social investment were deemed necessary but face difficulty in the whole process of initiating the proposed data-integrated application. The continuity of these investments is an important factor in maintaining the provision of high-quality services to the end-users (Focus group: G5-CAR3).

4.4 Summary

This chapter illustrated the findings drawn upon from the focus group discussions amongst citizen end-user participants. It aimed to explore their desires for, and their understanding of possible benefits and challenges related to, the implementation of the proposed data-integrated STS application. Ideas of their perceptions came from their understanding, experience and knowledge of the current state of play of STS development and their envisioning of potential data integration practices. The findings revealed both commonalities and differences of participant perceptions between different groups. In general, younger participants were concerned more about the technical aspects of the proposed integrated application, including specific technologies and end-user interaction effectiveness, whereas senior participants revealed more insights of socio-cultural dynamics and challenges.

Reflecting upon the disadvantages of the current STS applications, participants firstly expressed their desires for the implementation, and desired services and functionalities, of the proposed data-integrated application. Next, they pointed out that the proposed application should be able to benefit both urban transportation management in general in order to be efficient, and citizen end-users for interacting with more transparent STS information and services. Nevertheless, they believed that there could also be challenges that stand in the way of integrating data and implementing such a data-integrated application. These challenges were discussed respectively from technology, user-side and socio-economy points of view. Key points of these dimensions were their perceived difficulties of data processing practices for the integration process, user-side performance, the potential of smart citizenship, collaboration between various stakeholder organisations, and the role of market competition.

Although all citizen participants' perceptions might not be practically realisable, some are still useful to STS practitioners as the basis of initiating more citizen-centric and citizen-oriented STS applications. The issues of their potential desires for, and their understanding of possible benefits and challenges were referred to the STS enterprise participants who further revealed some key issues of STS data integration, which are presented in the next chapter.

Chapter 5: The perspective of STS enterprises

In the phase of data collection from STS enterprises, more in-depth investigation was conducted in regard to STS experts' point of view of designing and implementing STS initiatives. Based upon the results of citizen end-user perspective regarding their potential desires for, and their understanding of possible benefits and challenges related to, implementing the proposed data integration solution on STS applications, the interview questions in this stage were developed to focus on three aspects. First, participants' story telling about their STS applications that were developed in the past and those currently being developed. Second, discussion surrounding the role of data in developing STS applications. Third, in-depth reflection on socio-technical considerations of data integration solutions on STS applications. Different from the investigation into citizens' perspective where the researcher acquired a basic understanding of citizens' perceptions, the interviews with STS enterprises revealed significant expertise of key issues and factors that STS experts would need to consider in both the initial design and implementation stages of the initiating of the proposed data-integrated STS application that citizen participants perceived.

This chapter revealed detailed qualitative findings that emerged from the fifteen interviews conducted with Project Managers, Strategic Directors and technician participants who take different responsibilities from three case STS firms in Shijiazhuang. The Thematic Analysis approach adopted in this study directed the analysis of interview data, which were finally grouped into nine different categories.

Table 5 provides an overview of the nine crucial thematic factors that enterprise participants deemed as important to STS application data integration solution. Within each of these themes, corresponding sub-factors (i.e. codes) have been explored as more solid and fine-grained theoretical underpinnings. According to participants' perception, these nine factors were thematically identified on a basis of the logical extent to which the factors were perceived to be indispensable and influential to designing and implementing the proposed data-integrated STS initiatives in Chinese cities. More specifically, STS technology was positioned in the first place as technology that was perceived to be the technological underpinning that undergirds the development of a data-integration solution. Following technology, essential urban transportation infrastructural fabric lays the technical foundation of the running of STS initiatives. These technological and infrastructural basics necessitate stakeholder-related dynamics in the play of directing the success of the proposed integration solution, with focuses on citizen end-user, organisational and managerial dynamics, government-related issues of policy and politics and overall smart governance concerns, respectively. Furthermore, the findings revealed global and social issues concerning the trends of STS development, socio-economic influences and cultural influences.

Theme	**Code**
STS technology	Information architecture of the integrated information system
	Data mining and fusion
	Big data analytics
	AI-based technology
STS infrastructure and hardware	STS infrastructure and hardware
Citizen end-user effects	The rights and power of citizens
	Digital participation
	Information security
	Smart citizenry
Organisational and managerial dynamics	Data sharing, co-production and co-creation
	Centralisation of departmental functions
	Technocratic visions
	Top-level design strategy
STS policy and politics	Transportation legislation and regulation
	Government political power and orientation
Smart governance	Data governance
	Real-time transportation management
Global STS development trends	Global STS development trends
Socio-economic influences	Social evaluation of potential transportation issues
	Structural change of human capital
	Market research
Cultural influences	City competitiveness
	Innovation dilemma
	Urban cultural heritage

Table 5: STS enterprise perspective of the factors influencing successful initiation of the proposed data-integrated STS application

5.1 STS technology

The findings in this study revealed the fundamental role of STS technologies in both the design and implementation processes of STS initiatives. STS technology in this finding refers to various types of technologies required to underpin and lay the foundations for the development and further operation of potential data-integration STS solutions. Participants perceived that these technologies have existed for a long time and have been used in a variety of STS applications; however, they have not been systematically applied in an application that integrates data coming from various places. These technologies would bring changes to citizen end-user engagement in urban life, organisational configurations, and socio-political-economic dynamics that influence on the integration process. Put another way, STS technologies are not only seen as the foundation, but are also laid as the core variable in developing technology-driven STS initiatives that impact, and are impacted by, all the other essential factors.

The interviews conducted with STS companies revealed the following key technologies, which might lead to the successful design and implementation of the proposed STS data-integrated applications: *information architecture of the integrated information systems*, *data mining and fusion technology, big data analytics* and *AI (Artificial Intelligence)-based sensor technology.*

5.1.1 Information architecture of the integrated information system

Both citizen and enterprise participants expressed that 'applications' are regarded as products that are eventually used by their end-user citizens. Urban STS as a broad concept can be divided into many sub-systems. Within each single STS there are many distinct applications that work differently to provide people with a variety of transportation services (Sherly & Somasundareswari, 2015). The integration of data from myriad applications is built upon the system architecture (An et al., 2016) of the integrated STS. Technician participants suggested that there are many challenges in building integrated system architecture to enable effective integration of different sub-systems. The most important obstacle is considered as the conversion of the structure and the Geographic Coordinate System (GCS)[1] of data involved in different sub-systems. However, there are some mature solutionist approaches that are

[1] Geographic Coordinate System (GCS) is a system that uses three-dimensional parameters to define locations. *(Source: http://desktop.arcgis.com/en/arcmap/10.3/guide-books/map-projections/geographic-coordinate-system.htm)*

deemed to be able to tackle this issue; for example, WGS84 (World Geodetic Systems 1984)[1] is applied to unify GCS. Project manager participants further emphasised the importance of the construction of a unified data protocol so that data can be processed throughout its life-cycle under the same set of data standards.

> *"The differences of data format, data structure and data geographical coordinate system between systems stand in the way of the process that data produced in various systems are shared with, and used to, each ... The government has been constructing unified data protocol. There are also protocol interface ports between STS companies in order to establish long-term cooperation."* (C2-PM)

Apart from a unified data protocol[2] and data structure, participants also highlighted the logic of data usage in the system. The logic of data usage resonates with the system usage scenario wherein data are strictly used and reused for a specific business purpose. This usage scenario determines the business logic within which a particular set of services are created to benefit the end-users. Although the STS as a whole aim to benefit citizen end-users with more convenient and efficient transportation services, different sub-systems can achieve this in different ways. Herein, participants stressed that the business logic in which data are embedded and further converted into actual services used by the end-users typically varies across different systems. This means that without similar embedded business logic, data involved in one system are usually not usable in one another. Many technician participants indicated that data analysts have been seeking for a solution that endows data with more than one business logics so that data from two different systems can be transferred, exchanged and even integrated together. But they also expressed both technical and socio-economic difficulties in achieving this, such as lack of communication mechanisms between sites of data practices.

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[1] WGS84 (World Geodetic Systems 1984) is the currently used standard and reference of Geographic Coordinate System (GCS) for the Global Positioning System (GPS). *(Source: https://gisgeography.com/wgs84-world-geodetic-system/)*

[2] Unified data protocol, also known as open data protocol (OData), refers to standardised web technology that is used to query and update data and enable interoperability between datasets. *(Source: https://www.webopedia.com/TERM/O/odata-open-data-protocol.html)*

Notwithstanding these challenges, participants revealed that what has been achieved so far is that the data interface in one system[1] can be embedded in one another. This means that, for example, although a traffic light system is used to monitor real-time urban traffic and ensure smooth traffic flows from time to time, the embedded data interface is also applicable in digital maps that are used in the Geographic Information Systems (GIS) (Interview: C1-TS2). Hence, system professionals can use GIS-based digital maps to monitor and regulate traffic lights through data transferred between data interfaces embedded in both systems. Such embeddedness of data interfaces across systems is identified to be the first step of a possible data integration solution from a technological point of view. The next step is the exploration of logical relations between data sets that are produced from a large variety of data practice sites.

> *"Simple data interface exchange and embeddedness work across several sub-systems and corresponding applications. When it comes to myriad data types, such approach will no longer work. Instead, there is a need to explore fine-grained logical relations between datasets..."* (C3-TS3)

C3-TS3 was actually suggesting the challenges to excavate and re-construct logical relations between data when a large number of sub-systems and their associated applications need to be integrated. Participants hinted that such big job would necessitate the technologies of deep data mining and fusion. Findings of this will be presented in the next sub-section.

5.1.2 Data mining and fusion

Whilst system architecture of integrated STS is identified to be indispensable to realise the integration of data from different systems, data mining and fusion is focused on the excavating, analysing and processing of data that come from one single application in order to be integrated with those from other applications. Data mining refers to the extraction of information from an existing dataset and the transformation of information into a logical structure for certain purpose of use (Interview: C1-TS4). In this process, data fusion plays a role in the construction of unified data structures and data standards amongst different

[1] Data interface is identified as a template with various attributes that represent a given entity which can be read or altered by another system through a set of processes via interfaces. (Source: https://www.oracle.com/webfolder/technetwork/data-quality/edqhelp/Content/concepts/datainterfaces.htm)

datasets. In order to unify the data standard, the configuration of data parameters becomes important when data from various places is being fused. However, the technician participants who are responsible for data processing revealed that they have been facing a challenge in seeking for a standardised parameter setting. A Project manager participant (Interview: C1-PM) revealed that STS data structures and attributes are not standardised nationwide; rather, they are contingent upon local characteristics. This implies that the cost would be high for commercial enterprises to establish their own unified data structure and GCS without a national standard.

> *"I believe this is not a technical issue. Rather, the establishment of national standard of parameter setting of the conversion of data structure and coordinate system is very important. All commercial enterprises would follow such standard for their own purpose of development. … Yet, it is shame that we have not had such a nation-wide standard."* (C1-TS3)

According to the findings, with a unified data standard, the collected data from different sites of data practice would be processed through a set of data processing steps, such as data screening, data cleansing and data extraction (Interview: C2-TS3). Data that are screened out should not be used anymore as they may impact overall data accuracy. Furthermore, for a typical STS application, data that needs to be processed includes real-time data, end-user data, road-network data and Point of Interest (POI)[1]data, each of which has its own algorithm. These algorithms are expected to be inter-linked with each other when data are processed in order to decrease data deviation and therefore reduce the risk of data inaccuracy (Interview: C1-TS1-LIN).

Whilst the data mining and fusion technologies emerged as a code was identified as crucial in regard to data processing issues, the next sub-section will present issues in relation to the analytics process of big data.

[1] Point of Interest (POI) is a specific point of geographic location that might be of interest to someone. *(Source: https://en.wikipedia.org/wiki/Point_of_interest)*

5.1.3 Big data analytics

The findings in this sub-section revealed three main aspects of big data analytics: predictability, data accuracy and data "realtimeness" (referred to by Kitchin (2018)), and two types of big data involved in STS - historical end-user data and real-time traffic data. Firstly, participants revealed that historical end-user data relates to system predictability and data accuracy. Data collected through cloud technology by which end-user traces of behaviour are uploaded in real-time from end-user devices to terminal database for future data analysis (Interview: C3-TS2). To develop a data-integration solution which may involve a plethora of data types, C1-PM claimed that the form of data being uploaded would be shifted from '*purposive data collection'* (only those associated with the main business are collected) to *'all-encompassing data collection'* (all types of data are collected). The bigger the data sets are, the more accurate the data analytics would be. The analysed historical end-user data could facilitate the prediction of end-user preferences and the way in which they are engaged in transportation activities. This could further enhance better end-user decision-making when they are involved in multiple transportation services.

> *"I envision that all-encompassing data collection would be very important because the integrated system is built on the integration of large troves of data types. I believe these data can be analysed with consistent improvement of accuracy."* (C1-PM)

> *"Historical end-user data are important in terms of mobility because they can inform users about estimation of time and distance. This significantly enhances the predictability of transportation incidents that ensue."* (C2-TS3)

Secondly, participants stated that the quantity and quality of real-time traffic data would have influence on data realtimeness on the side of end-users. Two project manager participants from different companies revealed that real-time traffic data are usually produced from traffic light systems and road monitoring systems which are administrated by urban traffic managers, i.e. Traffic Management Bureau (Interviews: C1-PM, C3-PM). They further indicated that real-time traffic data in each STS initiative can be harnessed to provide a smoother, well-connected, dynamic and real-time transportation service; this means that real-time traffic data would become indispensable when many different systems are integrated as a centrally coordinated system that involves various transportation services.

> *"The reason why [citizens] complained about the delay of information transmission through applications is that the companies who develop the applications did not have access to the government's real-time traffic data. Compared to end-user cloud data which are rather random and uncertain, real-time traffic data covers nearly every single corner of the city road network. The more sizeable the application is, the more useful the real-time traffic data will be."* (C1-TS4)

The interplay of big data analytics of historical end-user data and real-time traffic data has shifted the focus of smart transportation on behalf of citizen end-users in Chinese cities from shortening travel distances through to reducing the amount of time wasted on the road (Interviews: C2-TS2, C3-TS3). There are many controllable, instrumented and data-driven urban transportation systems that enable dynamic and flexible traffic management in order for overall end-user time reduction. For example, traffic lights systems in many cities have achieved real-time traffic coordination through the automatic changing of traffic lights particularly during rush hours according to real-time traffic data analytics. Such coordination is on the basis of system developers' understanding of data structure, the logical relations between involved data sets and integrated system algorithms discussed in the last subsection. It also relies upon infrastructural underpinnings and solid hardware configurations which will be discussed in the later sections.

> *"Realtimeness cannot be achieved without substantial end-users and algorithmic mechanism … Big data technology applied to both historical end-user data and real-time traffic data acquisition relies on hardware support, such as DHDV (Digital Highway Data Vehicle), mobile applications, GPS installation and road cameras."* (C3-TS1)

Overall, the application of big data technology in STS applications places an emphasis on the quality of data and *'just-in-time'* delivery of service. In order to achieve the predictability, accuracy and realtimeness of involved STS data, participants from different companies echoed on the needs for applying Artificial Intelligence (AI) technology in the process of data algorithmic analysis and building sensor networks on the side of hardware and infrastructure. These will be discussed in the next sub-section: AI-based sensor technology.

5.1.4 AI-based technology

The findings of Artificial Intelligence (AI) in this analysis are twofold. First, deep learning. The majority of participants placed their emphasis on the importance of predictability, safety and convenience of future STS applications. The voice recognition and natural language processing technologies under development are expected to make these goals achievable by establishing a closer relationship and smoother interaction between applications and end-users (Interview: C1-PM). These technologies are built upon big data analytics with the focus and output of predictability. Herein, the AI-based services developed on future applications based on such predictability would address citizen participants' concerns about senior citizens not actively engaging in STS initiatives due to their resistance to use new technology. From STS expert point of view, therefore, enhancing deep learning technology on the proposed data-integrated STS application was identified as a potential technical advantage.

> 'Hand-free is just built on deep learning technology, with which people do not need to watch the screen. This guarantees their safety … This technology benefits senior citizens in particular who have problems with using smart technologies." (C2-SD)

Second, customisation. Some technician participants revealed that they have been specialising in developing custom-built functionality that aims to provide citizen end-users with individually unique services by use of the STS applications. This customisation is built upon more user-centric human-computer interaction, through which the characteristics of individual end-user behaviours, habits, preferences are recorded and analysed. Thus, individual end-users can be offered unique personalised services from the application. C1-TS4 gave an example of what they have been doing with custom-built services in their business:

> *"We have been endeavouring developing customised service by analysing end-user data from time to time to obtain characteristics of individuals including their frequent locations, time spent on using the application and usage logs*

etc… Ultimately we offer our end-users individually distinctive journey planning strategies." (C1-TS4)

C1-TS4 also briefly suggested that there is more need to develop custom-built services when different usage scenarios come together into one application. The outcome of this is meant to be flexible, smart and customised end-user choices in terms of transportation services. For instance, when end-users need to switch the means of transport during a journey, the application would offer end-users different types of user-centric, efficient and time-saving solutions at any point of their journey. Although customisation in a complex transportation usage scenario may not be highly required by the end-users, C1-TS4 asserted that this is necessarily important for system developers to establish smarter communication mechanisms between end-users and fast-changing and complex transportation scenes.

Overall, AI technology was found to be a potentially indispensable technology that should be used in developing future STS initiatives from the point of view of both expert technicians and project managers. However, the findings also suggested that technologies do not work alone without interactions with people. Therefore, participants maintained that the application of frontline technologies needs to be aligned with citizen participation in STS. It is acknowledged by participants that a significant amount of data is generated by end-user citizens involved in smart transportation activities, e.g. using the application. Potentially, this means that whether they actively engage (with willingness and proactiveness), whether their opinions and perceptions upon service delivery are listened to by system developers, whether their concerns over online information security are considered by STS regulators, would determine the effectiveness of the development of new technology-driven innovations. Findings in later sections will illustrate an expert perspective on end-user effects as well as their participation in designing and implementing data-integrated STS applications.

5.2 STS infrastructure and hardware

The thematic analysis found that the upgrade of STS infrastructure and hardware would affect the initial stage of STS data acquisition and the effectiveness of STS service delivery of the developing STS initiatives. The findings of this factor were explored and divided into two dimensions: data and urban road planning.

The findings around the dimension of data were further divided into data acquisition and data storage. The acquisition of data relies upon positioning systems and requires high capacity and flexibility of data-acquisition hardware and relevant equipment. The participants suggested that whilst the current outdoor positioning systems have been well developed and can be used in various places, the development of indoor-positioning based applications are blocked by physical buildings, poor tele-communicative signals and the acquisition of 3D models of buildings. The current data-acquisition devices and equipment are not deemed as capable to collect accurate data through the traditionally used outdoor data-acquisition hardware.

> *"When you direct yourself to a big shopping centre with many floors and you would like to know where exactly a particular shop is located, the traditional [smart navigation] application will not be able to work anymore. What you can do instead is to check the text-based address information displayed on the map."* (C1-TS2)

C1-TS2 also suggested that the current data-acquisition hardware needs further upgrade to be capable of collecting different types of data that are created from various data practice sites. Moreover, apart from data-acquisition hardware, the upgrade of public transportation infrastructure was also explored as a crucial factor that may impact on the capability and quality of the data acquisition process. This means that many existing transportation infrastructures as well as their embedded services are no longer workable with future STS initiatives, as the technological configuration involved in these initiatives need further upgrade of the infrastructure to enhance the capacity of data-acquisition. Further, the damaged transportation infrastructure (e.g. signposts, bridges, drainage system, etc.) caused by everyday wear-and-tear and traffic accidents need to be fixed in time, otherwise they would pose a threat to traffic flows, personal safety and the utility of embedded data-acquisition devices.

> *"Data-acquisition hardware such as sensors cannot be installed in some old-style public transports [e.g. buses], so real-time positioning cannot be achieved. ... But government has been upgrading public transports to be technology oriented. For example, many buses have installed various types of*

ADAS [Advanced Driving Assistant Systems] so that all data of the bus can be gathered in real time." (C1-TS1)

The hardware devices that are used for data storage were also deemed to need to be upgraded for the high capacity of big data analytics practices. C1-TS1 maintained that the productivity of data storage hardware reflects the evolution of the way in which the data are stored. For example, data that used to be stored on hard drives at early stage of informatisation, tended to be stored in databases in the later stage, and now are tending to be stored in the cloud (Interview: C1-TS1).

The second part of the findings within this theme is inappropriate urban road planning. This inappropriateness gives rise to the imbalance between supply and demand, where the current urban road capacity is not satisfactory enough for developers to initiate public transportation solutions to address public needs. Such imbalance is also caused by the inappropriate making of traffic rules and regulations on roads with low capacity.

"Actually, many traffic congestions are originally caused by intensive deployment of traffic lights on narrow streets. The government should either reduce the number of traffic lights or add more lanes on the street or even broaden the street." (C1-TS4)

This statement suggests that traffic congestion caused by an inappropriate combination of road planning and traffic rules and regulations would create more innovative STS solutions. But these solutions are not able to work effectively without upgrade of the road infrastructure as well as adjustment of traffic rules and regulations.

It is suggested by the participants that the acquisition and processing of data with various attributes coming from various places, necessitates the overall upgrade of transportation infrastructure and hardware in the city. This means that the integration of these data requires high capacity hardware that conducts data acquisition, processing and data storage; the initiatives that are based on data integration need further consideration of urban road planning and the making of relevant traffic rules and regulations.

5.3 Citizen end-user effects

With regard to the citizen end-user factor, there are some issues surrounding their involvement with smart technology, products and services. To be more specific, citizen end-user effects in this finding revealed STS developers' perspective on how citizens interact with technological change, how they engage in the design and implementation of STS initiatives and what roles they play in STS. The findings in this aspect resonated with the 'New-Type Urbanisation' agenda in China released by the central government in 2014 (CNDRC, 2014). Therein, the government placed a strong emphasis on the roles of urban residents in regard to their participation in smart city construction (J. K.-S. Chan & Anderson, 2015; Cheshmehzangi, 2016); this was a different approach from the old-style urbanisation that exclusively focused on economic development. The following subsections unfold enterprise participants' perceived rights and power that citizen end-users have in building STS in Chinese cities, the modality of their digitalised participation which is followed by an interrelated factor of information security, and a more general vision of smart citizenry in Chinese cities.

5.3.1 The rights and power of citizens

The rights and power of citizens in this finding reflected participants' perception on the important roles that citizen end-users play in developing STS initiatives in Chinese cities. The afore-explored AI technologies that benefit senior citizens suggested that many STS developers have taken 'technology disadvantaged people' into consideration when new STS solutions are being developed. Participants further emphasised that it is not only senior citizens who have problems with using operationally complicated systems, but also those who need more efficiency in daily interactions with urban transportation, are benefited from citizen-centric and simplified services from the applications. These solutions indicate that citizens' demands are significantly important for STS developers, and that the demand analysis has been identified as an important step in the design process of developing the applications.

Typically, the findings suggested that there are three types of 'listening' that are usually undertaken by the project team (or a department) who are responsible for market analysis. First, end-user data analysis. This analysis takes place at the initial stage of user demand analysis, with the purpose of gaining a basic judgment and understanding of potential end-user demands and their further latent change.

> *"Our big data analytics always takes UGC (User Generated Content) into account to understand what end-users are interested in and what potential services they desire to have."* (C3-TS3)

Second, end-user investigation. The findings revealed that this occurs subsequently after end-user data analysis when there is a need to update particular services on the application. Third, feedback. Most STS enterprises never ignore end-user feedback to their services, products and operational functionality. This takes places persistently via telephone, emails and user interface on the applications after the system is implemented (C3-PM).

> *"We then start conducting [end-user] investigations. We firstly do questionnaires to hear the voice of citizens in terms of general pros and cons of particular functions and services of our products as well as points of interests. After that, we conduct some individual interviews with loyal customers to have face-to-face conversations about their in-depth opinions. We also invite them to fulfil some tasks to observe their interactions with the application."* (C1-PM)

The findings implied that the analysis of end-user demands would facilitate the design and further advancements of problem-solving capabilities of applications. These problem-solving solutions are expected to benefit citizen end-users from being able to make more effective decisions in their interactions with urban transportation systems using applications. In general, participants' perspectives on analysing end-user demands are twofold.

Firstly, end-user demands might change, and these changes might bring about transformation of technology and the form of service delivery via applications in which technology is embedded. For example, C2-TS3 stated that such change of end-user demands would push STS developers to upgrade technological infrastructure and update the functionality of applications. Previously involved services or functions might be dismissed and replaced by a set of new-technology-oriented services. Secondly, rather than to force end-users to engage in something completely different, the embedding of new STS technology into existing applications purports to generate more user-oriented information and services, built upon the analysis of current end-user demands and behaviours, and to provide more appropriate decision-making solutions. This suggests that the interplay between the changes of citizen end-user demands and system technology design can lay the foundation of citizen rights and power in the interaction with STS in Chinese cities. Their rights emerge from technological change and are enacted as, and converted to, power through technologies steering and guiding their further course of actions. Meanwhile, their engagement in turn exerts an influence on future advancements of current technology and can even bring about the emergence of new generations of technology.

> *"[For example], governments and commercial application developers do not force citizens to use mobile devices, but the reality is that most smart city services are designed and delivered to the public through mobile technologies, [e.g. smartphones]. These applications are being developed, with considerations of what citizens have had and what they would like to have."* (CS-TS3)

> *"We had two separate products quite a few years ago; one was only specialised in location inquiry and the other was in navigation service. As our users increasingly tended to use both services together, we integrated these two products into one platform to guarantee a smoother go of journey planning."* (C1-TS3)

Although end-user demands have potential and would lead to the emergence of new technology, some participants revealed that end-users do not actively engage in the actual design process; instead, they are only engaged in the implementation process as well as in future system updating exercises (Interviews: C3-PM, C3-SD) by raising their voice of suggestion and feedback (Interview: C3-PM). This takes place particularly when problems with end-user interaction arise. STS developers would need to know what end-users say and perceive in regard to further advancements of the system performance and operability. However, participants also implied that citizen engagement and their roles in developing STS initiatives are constrained by government political power and policy-making. This will be discussed later in this chapter.

5.3.2 Digital participation

The afore-mentioned analysis of end-user historical data actually reflected that enterprises imagine the ways in which citizen end-users are somehow digitally engaged in the development of STS initiatives. The interviews conducted with technician participants revealed that amongst all possible vehicles of digital participation, mobile devices through which STS services are delivered have become an essentially instrumented, networked, digitalised form of urban 'mobility aids' in Chinese cities. They also hinted that the increasing development of mobile solutions in STS would attract more citizen end-user interactions, which were deemed by participants as imperative in increasing future digital end-user involvement in STS construction.

Overall the analysis of interviews indicated two critical success factors for this form of specific digital participation through mobile technology. The most highlighted was crowdsourcing. In the context of smart cities, crowdsourcing refers to two means of organisations collecting citizen end-user data. Firstly, end-user physical data (e.g. real-time location) are captured via cloud technologies and stored in the cloud data centre of the application site of practice. Secondly, citizens' views and opinions (e.g. feelings, report or feedbacks about a particular service or function) are collected from a wide group of people who are always willing to participate and are relevant to the needs of a particular city. For example, citizens who usually are considered as volunteers report abnormal social transportation behaviours and traffic incidents to the application developer through the sharing of text information, images or videos. As Bovaird et al. (2016) state, citizen participation in the general context has been transforming from the mode *'I believe people can make a difference'* towards the mode *'I believe I can make a difference'*, pointing to data contribution leveraged from the wide citizen end-user site of practice.

> *"Typically, users are able to be informed in real-time about what is happening in the front through looking at smart indicatrix shown on the application which typically is marked green, red and amber lines. This function, based on big data prediction, is conducted through data generated from end-user mobile devices and uploaded to the cloud from time to time."* (C3-TS3)

> *"An individual end-user can share the information about the damage of transportation infrastructure. The application will then conduct an inspection, verify its veracity, and finally get it published, so that all users who are close to the point of damage will be able to be informed."* (C1-TS1)

Participants suggested that many STS enterprises have been committed to developing personalised user-oriented services and have been competing against each other to attract an escalating number of end-users. The competition between commercial technology companies has been identified as an important avenue to stimulate more intensive digital participation. The more powerful the application services are, the more citizens will become end-users. Therefore, overall operating performance and interoperability between services of STS initiatives are generally regarded as the second critical success factor that impacts on end-user digital participation.

Furthermore, participants believed that information converted from the application crowdsourced data is more useful to the end-users than that published by relevant government transportation departments, for example traffic news or daily updates released from urban traffic management bureau and urban broadcasting stations. This is because the latter type of data is always delayed, even though they are generally more accurate and veracious than the former. For example, participants told that a large number of end-users have expressed that they never pay attention to traffic information updates published by the government through urban transportation infrastructure, e.g. traffic dashboards positioned on the road-side to indicate the traffic status, news updates on the government website, or in-car radio broadcasting (Interview: C3-PM).

> *"Crowdsourced form of data collection might not work so accurate when road work is on. Under such circumstance is information from the government more reliable than that through end-user data uploading, which is why many dominant STS companies cooperate with government?"* (C2-SD)

C2-SD, who is the Strategic Director, underlined the importance of STS application developers establishing strategically cooperative relationship with government transportation departments and transportation agencies in the public sector. Such cooperation benefits each of them in regard to the growth of data quality and data accuracy, with the aim to stimulate more active digital citizen end-user participation. Nevertheless, digital participation in Chinese cities has been facing challenges in information security. This will be discussed in the next subsection.

5.3.3 Information security

Information security is a general concept that has been discussed in the wider context of human activities on the internet. Information security is anchored in and derived from data security. *"Where there is data, there is a data security risk"* (Interview: C3-SD). The data that might be of concern to the end-users and enterprises are end-user data and commercially sensitive data respectively. Citizens are not able to guarantee that the data involved in their interaction with urban transportation are secure and hence take measures to mitigate the risks that the insecure data would bring about.

From participants point of view, information security depends upon technological and political solutions such as the construction of internet data security mechanisms on the side of STS developers, and political constraints and regulation on the side of the government. On the one hand, STS developers establish on-line network security protocols for a safer, detectable and multi-authenticated environment of online information flow. On the other hand, the running of these protocols is aligned with government law-making and executive force of real-time detection of network security.

Technician participants further stated that, for many STS applications whilst the developers produce and process their end-user data (which are saved in their central database), relevant government agencies and law-enforcing agencies would have direct access to the database when necessary with official and legal excuses for specific purposes of traffic regulation, traffic administration or the dealing with emergent incidents (e.g. traffic accidents, cyber frauds). In addition to this, these government departments can also have persistent access to STS developers' database if long-term business cooperation is established, built upon data being commercialised and moved between the government and STS enterprises with the aim of co-creation of better STS services in the city. Furthermore, C3-TS3 in particular claimed that they have been bombarded with torrents of critiques from the public regarding their poor hardware capability and capacity, and software operability of the data security mechanism.

> *"Unless you do not use the application at all, your end-user data of real-time locations and tracks are consistently and automatically uploaded. The likelihood of these data disclosed to the public depends on the censorship of data processing especially those concerning individual privacy."* (C3-TS3)

C3-TS3 explained that data security censorship is generally embedded in all STS technology companies, referring to a set of specific evaluation instruments based upon a range of criterion for data encryption in the process of data processing, and data decryption in the process of data sharing to the public. These instruments include, for example, frequently updating the passwords of databases, electronic archives and WiFi etc., using self-sufficient hardware, equipment and IT system architecture, and augmenting the volume of data flowing to the database.

Some technician participants argued that system computer algorithms on which the decryption of these data is undertaken need to conform to the national standard. The decrypted data need to be constantly inspected, assessed and eventually tested in order to be published on the internet. The participants who have relevant experience (or knowledge) in these processes suggested that decrypted data evaluation needs to be strictly regulated by the government in a way that government officials carry out regular inspection of the evaluation process. This generally takes place when the data sets implicate something related to government affairs or they are to be re-used or re-framed in the government site for a legal purpose.

5.3.4 Smart citizenry

Smart citizenry as a broader concept has been coded as the last important factor of citizen end-user effects, with close links to the previous three dimensions. Firstly, the findings suggested that smart citizenry in the context of this study stands for citizen end-users actively participating in building STS in urban areas, particularly with awareness of using smart technology driven STS services, belief in the embrace and cultivation of an eco-friendly ethos, and conformity to the public principles of right and wrong, transportation-related standards of behaviours and urban transportation rules and regulations. Secondly, the afore-presented crowdsourcing from the dimension of citizens is a typical way of active participation through data uploading and information sharing. Thirdly, citizens who can be regarded as smart citizens would be actively willing to try and know more about new technology trends and initiatives, i.e. what STS solutions are currently being used.

> *"... we usually take all types of end-users into account and carefully examine their state of engagement in the interaction with our applications. We give the title of 'loyal customers' to those who have been using the vast majority of services [or functions] of our platform. These customers have knowledge about using different services under different circumstances, and they would like to participate in our surveys regarding future updates."* (C1-PM).

What C1-PM hinted here is that citizens who have the potential to be awarded as loyal customers would be entitled as 'smart citizens', devoting themselves in smarter transportation development (e.g. providing feedback, suggestions, green engagement). Reciprocally, the widespread growth of smart citizens in urban areas would draw many more citizens to involve themselves in the incentive system of STS applications (i.e. designated as loyal customers), which would enable more citizen participation in developing STS initiatives and further sustainable development.

Further, participants revealed that STS companies need to seek a way that transforms people's traffic behavioural habits, ideology and mentality of daily interactions with STS. For example, C3-TS1 argued that the fast growing IoT-driven STS initiatives alongside the deployment of associated infrastructure is now transforming people's transportation ideology towards convenience, precision and efficiency, such as sensor-based smart car parks and public transports. In addition, participants implied that 'smartness' in this sense requires the application itself to be not only technically powerful but also user-friendly, especially for people who are disadvantaged in using smart technology.

> *"Citizens being able to be designated as stakeholders of STS initiatives is led by the service providers delivering smart services and the government promoting STS ideologies and mentalities, rather than the citizens themselves seeking a way of [smartly] engaging without guidance and specific intention."* (C1-TS1)

However, notwithstanding STS developers' efforts, participants also underlined that people who deliberately break widely accepted public standards of behaviour in transportation in a way that they are not actually breaking the traffic laws but exploiting the legal loophole (e.g. not giving way to the pedestrians), are less likely to actively participate in STS development. In this sense, participants pointed out that it should be the government authorities who play a key role in mitigating and remedying such moral and ethical issues. In particular, C3-SD maintained that the government should take enforcement measures to legally restrict people's behaviours (e.g. official rules for 'give way to pedestrians') along with specific contingent local transportation policies (e.g. car license plate restriction).

Overall, the combination of citizen end-user active participation and the leading and directing role of STS developers and the government is considered by enterprise participants as an important approach to help achieve smart citizenry. The next sub-section will uncover participants' perspective of organisational and managerial dynamics of developing STS initiatives in Chinese cities.

5.4 Organisational and managerial dynamics

The interviews conducted with three case companies placed much emphasis upon social collaboration and cooperation across relevant STS stakeholders (e.g. the local government agencies, public institutions, private STS enterprises, commercial businesses in other sectors of society), organisational structural change and overall strategic design of new STS initiatives. These dynamics of organisational and managerial operations were explored from the point of view of STS commercial enterprises but not limited to the scope of any particular organisation. Rather, they were identified amongst various stakeholders such as the local government and other types of enterprises, as being in close relation to co-creation. The following four subsections present detailed analysis of the organisational and managerial dynamics of designing a data-integration solution of STS initiatives, including (1) data sharing, co-creation and co-production, (2) centralisation of departmental functions, (3) technocratic visions, and (4) top-level design strategy.

5.4.1 Data sharing, co-production and co-creation

From the perspective of STS companies, data sharing, co-production and co-creation take place throughout the development of STS initiatives, from their initial design through to their implementation. The interview participants from all three case companies strongly argued that co-creation across organisations lays the foundation of the integration of data from various places. The findings on this point revealed three primary means of STS developers sharing data and co-creating with other relevant stakeholders in society. The first way of this is business-led cooperation with local governments; the latter has data concerning urban infrastructure and resource distribution and basic urban road networks. These data are usually deemed as valuable resources with more accuracy and high quality (Interview: C2-PM), are typically owned by the local government, and are not usually shared with commercial enterprises unless strategic business-led cooperation is established between them. This cooperation helps the government to leverage technical support from enterprises to alleviate the pressure of urban transportation, and in turn, enterprises can acquire real-time traffic data from the government to develop their business. The findings suggested that within such a cooperative relationship, government acts as a 'leader' with top-down decision-making power to determine the form of cooperation, overall co-design and co-production strategy, and planning and decision-making of the design and implementation process. Whereas the commercial enterprises play a major role as an 'actor', empowered with some rights to set out project proposals, executive plans and deployment of technical configuration and implementation.

> *"It is not easy for enterprises to get financial support from the local government to cooperatively work on a particular initiative. They only provide their data that are not usually shareable without project collaboration. [Within collaboration], enterprises use such data to develop advanced services on the initiative alongside government."* (C2-TS3)

The second way of data sharing, co-production and co-creation is through industry coalition between STS commercial enterprises. The status quo of industry coalition in Chinese cities is that unconditional data-sharing practices without exchange of commercial interests between two commercial organisations happens less than strategic business cooperation with equal-value exchange (Interviews: C1-PM, C3-SD, C3-PM). As C3-SD stated, *"If services are* *metaphorised as tissues and organs, data needs to be analogised as the heart",* meaning that data cannot be shared without appropriate purposes.

Moreover, some participants argued that companies who are widely designated as STS platform vendors (e.g. AutoNavi, Baidu, Google) shall play the leading role as the 'protagonist' in such coalition relationships. This is because these companies have strong capability in terms of producing high quality data, they possess a large number of data types, and serve large end-user groups. Armed with these advantages, they are able to benefit enterprises in a large range of business sectors by offering their platforms; the latter can exploit their own services that are built upon the platforms. Further, the government, acting as a "broker", is also involved in industry coalition, with the role of discovering, inducing and exhorting other enterprises to co-produce and co-design a particular STS initiative along with STS platform vendors.

> *"[For example], the transportation bureau would like to construct a digital metro command centre two years ago. They launched a project between themselves, Shijiazhuang Metro and us. What we could actually contribute to this project was our GIS platform. Once they had obtained necessary resources from both Shijiazhuang Metro and us, they started outsourcing their essential technical components of system architecture to external IT companies."* (C3-TS3)

The openness of serviceability in this context further suggests long-term strategic cooperation between platform vendors and other businesses; more specifically, the latter develop their own applications in which the GIS-based STS maps from the former are embedded. For example, Didi as the current dominant car-pooling and car-sharing company have built up a concrete cooperative relationship with Baidu (whose Baidu Map has been developed to be one of the best GPS digital maps in China). Some services on Didi, such as 'recommended pick-up points' and 'route planning', were developed on the basis of the digital map supported by Baidu. Nevertheless, there are many impediments that stand on the way of such cooperation. Participants identified that one of the key concerns is in relation to the security and stability of data transmission mechanisms between the cooperating information systems. Regarding this, project manager participants resonated upon the importance of organising conferences and industry symposiums amongst CEOs, technical experts and technocrats to put forward potential solutions to tackle the system weaknesses and mitigate issues raised from the cooperative relationship.

> *"Sometimes I am invited to the symposiums co-organised by STS committee in Beijing and other core Chinese STS enterprises and institutions. Part of the symposiums is about technical configuration of the system concerning security issues, feasibility, stability, flexibility and system architecture, etc. … There are very useful discussions around these topics and there are many insights that are useful to convert into practice."* (C2-SD)

The third type of data-sharing, co-production and co-creation is the collaboration between STS platform vendors and commercial firms in other business sectors. These firms include, for instance, urban taxi companies, telecom operators, airports, public transportation sector, IT companies and hardware manufacturers, to name a few. STS platform vendors with these types of companies usually come together to work on projects with common goals to address a particular issue in urban transportation. The cooperation between them is sometimes built upon the exchange of resources, but in most cases, upon profit-driven commercial transactions and purchases. Through whichever way the cooperation is carried out, however, the pre-requisite is that the shared and exchanged resources need to be equivalent. From the participants' perspective, once such cooperation is established, organisational structure in terms of information sharing and information flows across organisations and divisions of individual companies need to be taken into account.

5.4.2 Centralisation of departmental functions

Organisational structure is influenced by organisational culture including its human resources, administrative operations and departmental functionality and responsibilities. From the perspective of STS experts, the findings in relation to this illuminated the significance of the centralisation of project implementation on the basis of cooperation between companies, and the centralisation of departmental managerial functionality within individual companies.

Participants stated that STS enterprises and government transportation agencies usually have many departments that take different responsibilities in STS service production, and in most cases these departments are independent of each other in terms of business administration and coordination. For example, typical car-pooling and car-sharing companies set up both a Product Department and an Operations Department; therein the former is usually considered as 'demand recipient' whereas the latter is often regarded as 'demand supplier' (Interviews': C2-PM, C2-SD). There is clear division of work between both departments; each is responsible for a particular phase of application development but with effective communication between each other in order to ensure a smooth path towards highly efficient productivity. Such communication is usually achieved by the Operation Department's identification of end-user demands and provision of end-user data, and the Production Department's problem-solving practices that reflect back to the issues raised from business operation.

However, there are many obstacles that exist in such a structure. First, informatisation varies across divisions. This leads to differentiation of business operation in each individual division, which ultimately impacts on information sharing, data transfer and work efficiency across divisions.

> *"Vectorising physical data into digital form is a rather complicated and time-consuming process. This would become a worse case if the extent to which the division is informatised is quite low; herein, many information transfer practices are relied on physical man work... but we have been attempting to avoid this."* (C1-TS2)

Secondly, whilst the geographic locations of each department are in the same city, they are still far apart. This hints at a lack of effective and efficient communication between different divisions. Also, the information-based business operation in each division can easily be independent of each other. This results in a delay of information dissemination, which is more likely to be the case during the time of a project. For example, the operatives or anyone else from the project team, would need to travel many times across different divisions, just for the purpose of face-to-face confirmation of project-related documents, and negotiation, discussion or fine-grained analysis of something imperative about the project.

> *"For some companies, the head office is separate from the operation departments. Some departments are even located in another city. This type of*

> *organisational structure is very disadvantageous to the initiation and even implementation of the project, for example."* (C3-TS3)

Overall, when it comes to data sharing and transmission, both above-stated disadvantages concerning non-centralised organisational structure could bring about mistakes, including misunderstanding of datasets, loss of data and perhaps significant delay of the project cycle. Therefore, the centralisation of departmental functions has been explored to be able to benefit the organisation from information transparency, real-time data sharing and clear order distribution.

When different STS companies work as a group to design and implement new STS initiatives, participants who had similar experience suggested that establishing temporary command centre and telecommunication systems aligned with centralised information management mechanism between organisations, would be an effective way to enable fluent information flows across different sites of practice. In addition to this, they also implied the necessity of empowering dominant STS platform vendors with decision-making and leading roles in the above-discussed industry coalition. In such an attempt to integrate data, the centralised GIS-based STS platform, produced and coordinated by the vendors, could undergird the system's capability of data integration, and could reduce risks that emerge from the process of information sharing and transfer, and overcome the hurdles that stand in the way of cross-division decision-making.

5.4.3 Technocratic visions

The findings revealed that there is a strong need to bring technocrats, or government officials with technocratic visions of future technologies, into the design process of STS initiatives. From participants' point of view, technocrats are those who are technically and politically skilled elites with comprehensive knowledge and in-depth understanding of technology. To be more specific in the context of this study, technocrats represent a group of elites entitled with decision and policy-making rights of the design and implementation of government-oriented smart technology initiatives. Participants stressed that these people are rather knowledgeable with high-level expertise in particular technology-driven initiatives, not only from a technological perspective but also from the points of view of corresponding social settings, organisational structure and operation, political environment, and urbanism.

> *"Our solution to particular transportation issues is usually divided into two successive solutions: ideal solutions which are based on incipient system modelling practices, and realistic solutions which are more concrete measures in practice. Technocrats are usually invited at the design process at the transition period of these two types of solutions to perform critical assessments and give useful suggestions for the solution to put down roots."* (C1-PM)

Participants maintained that technocrats need to have in-depth grasp of current transportation policies. This requires them to not only have knowledge but practical experience in developing an STS initiative, especially in the design process. They should also discuss with each other about the orientation of business operation, potential influences and obstacles of the solution, and create a strategy canvas and blueprint for the company. The aim of this is to come up with a sustainable, efficient and economical technology-driven solution that can be better implemented to enhance overall serviceability. Consequently, many STS enterprises prefer to have contact with those who have experience of working in the government as they are more familiar with political constraints on the stance of the government. Therefore, the infusion of technocratic visions into STS initiatives development was perceived to be necessary and is usually embodied in the top-level design which will be discussed in the next subsection.

5.4.4 Top-level design

Top-level design is an important stage of a project and usually takes place at the beginning of the design process. Project manager participants in particular, argued that top-level design is of paramount importance to the general tactic of STS initiatives when the they involve multiple resources and stakeholders. A lack of top-level design is likely to bring about long-term negative effects that may still exist long after the implementation of the project. For example, the cause of 'information isolation' between Chinese government agencies was not only data not being shared between them, but also the shortage of both overall and long-term planning (Interview: C1-TS2). Herein the problems involved in government affairs were actually individually addressed without integrative solutions and a vision of the overall situation.

First of all, with regard to developing an STS initiative, participants claimed that the ways to identify factors affecting the implementation and subsequent effects that the solution would have and how to figure out the principal contradiction that reside in all factors, were perceived to be crucial to the top-level design. This suggests that STS initiators need to understand what the solution is supposed to be and what specific core issues are expected to be addressed by the solution. Participants on this point have different insights. For example, C3-TS2 argued that it is necessary for initiators to anticipate and recognise profound implications of data being integrated into one place to both citizens' lives and urban transportation, and to identify clear objectives of such proposed data-integrated solution in regard to problem-solving capability and serviceability. C3-PM-LIN argued that the three most important factors of the top-level design include *'who to be served'* (i.e. potential end-users), *'what to serve'* (i.e. services included) *and 'how to achieve'* (i.e. instruments of service delivery).

> *"Our business blueprint has always been focused on serviceability of GIS and global positioning. To achieve this, we focus on and always follow three interrelated top-level business objectives: system operability, accuracy of navigation system and cost reduction."* (C1-TS4)

> *"Different from ordinary car-pooling and car-sharing applications, we focus on tailored taxi services. We have strict requirements and set high-level standards to our cars and drivers. So we orientate ourselves as high-end car-pooling service providers and in many occasions we target on organisations, not only limited on individual end-users."* (C2-SD)

Top-level design to the development of a potential data-integrated STS application denotes the significance of overall planning and orientation of service in socio-economic urban context across various stakeholders. On the one hand, application design embodies social needs and citizen end-user engagement in enabling smart mobility and smart transportation within the current context of smart city construction; on the other hand, the data-sharing, co-production and co-creation of design strategies within industry coalition regarding serviceability and the way in which services are delivered to the public, reflect potential public-private partnerships in the marketisation of Chinese urbanism. Moreover, the government and relevant authorities play an important role in directing the development of

STS initiatives in a political way within the shared economy. Hence, in the next section, the findings will be focused on exploring the factors around STS policies and politics.

5.5 STS policies and politics

The findings revealed that STS policies and politics of STS initiatives point to their legality and validity in practice. This means the government plays a leading role in making and enforcing policies and relevant transportation rules and regulations. Also, the government is deemed as power holder of decision-making and orientation-setting for a particular STS initiative implementation. In the process of 'new-type urbanisation', the government plays roles as not only the initiator of new urban policies but also as the organiser of urban citizen participation (Huifeng Li & De Jong, 2017). This suggests that the government actually empowers the legitimacy of STS initiatives and steers the 'boat' of citizen-centric STS development mode in Chinese cities. The following subsections will be focused on both transportation legislation and regulations, and the government's political power and orientation.

5.5.1 Transportation legislation and regulation

From the perspective of project managers and strategy directors, it is commercial enterprises' responsibility to acknowledge political constraints and legislative effects of the technology initiative they propose to develop. An effective way of doing this is to scrutinise relevant political and authoritative government documents before taking a formal course of action. Though with legal protection in general, however, some services delivered to the citizen end-users might be restricted by the government at some point, such as limited use of a particular online service. This indicates the relationship between legislation and the development of initiatives, that they reciprocally complement and interplay with each other.

On the one hand, each single service of the initiative must be effectively delivered to citizens under the current legal system. These services need to be designed and implemented in commitments with existing transportation policies and laws, with the aim of normalising and restraining citizen mobility and transportation-related behaviours. In Shijiazhuang, for instance, the local government makes use of a car plate licence restriction policy to limit the number of vehicles in urban area. Vehicles whose licence plate begins with a '1' or '6', for example, are not allowed to be driven in the city centre on Mondays. The implementation of this policy has significantly reduced exhaust emissions, which has contributed to and helped consolidate green and sustainable development. STS companies which provide information goods to citizens must therefore coincide with such policy change, e.g. remind end-users whether they can drive on a certain day (see quote C1-PM below). On the other hand, legislation and policy-making operate upon the existence of trust that flows through the government, STS developers, right through to citizens, and upon the government's careful consideration regarding public interests as a whole, in order to build a complimentary, motivated, citizen-centric legislative environment. Within such an environment, legal restrictions could be proposed by the government to limit service delivery and functionality of the innovation which may pose a threat to stable social and traffic order.

> *"The frequent change of the license plate restriction rules in Shijiazhuang usually confuses people. [As a result, many people drive on the days they are not allowed to drive]. But our application can accurately notify people what plates are restricted on specific zones on what days, so that they will not break the rules." (C1-PM)*

The findings further hinted that STS initiatives, protected by transportation legislation and policies, should benefit society without contradiction to government policy-making. C3-TS2 pointed out that there are some commercial enterprises whose services are initially politically supported by the government as they optimise the market and tackle particular issues that exist in society, but their services are later outlawed by the government due to undesired adverse effects. For example, as many online car-hailing drivers refused to receive orders placed by customers a long distance away from them during rush hours, the government later enforced the car-hailing companies to eliminate the function that allows the drivers to deliberately choose orders, with an alternative that orders were dispatched to the drivers. However, C2-SD stated that making new legislation and policies may exert economic influence on the structure of traditional industry within the same sector.

> *"As the growth of tailored taxi service is supported and legally protected by the government, it has impacts on the traditional taxi service providers ... For example, many traditional taxi companies have made people redundant from*

the company as a growing number of taxi drivers tend to work in the private taxi firms." (C2-SD)

Such shift suggests that developing an ICT-based, data-integrated STS initiative that involves various aspects of transportation would change the way that social funds and capital assets are accumulated and transferred through marketisation and privatisation, and increase the employment absorption capacity of cities within the sector of urban transportation. C3-PM perceived that such change may need the integration of social and human resources and re-distribution of idle transportation resources (Interview: C3-PM).

5.5.2 Governmental political power and orientation

Whilst the last subsection was focused on government policy-making, the findings of this subsection revealed that commercial STS enterprises who develop initiatives need cooperation-driven resource support from the government. Participants from Company 2 have accomplished many projects that had long-term collaboration with Traffic Management Bureau in Shijiazhuang. These participants claimed that in most cases, cooperating with the government is built on the condition that supported enterprises should help the government address urban transportation issues. The government in turn provides some transportation resources and supporting policy, such as traffic-related data, project specific funds, open-door economics, etc. These resources pave the way for these enterprises to fulfil their projects without political impediments.

Participants explained that there are two types of government-enterprise cooperation. The first is the cooperation between the government and state-owned enterprises and public institutions. The findings suggested that government has political power and dominates decision making and formulating plans for the project schemes that they work collaboratively on (Interview: C2-TS2); when necessary government has the rights to forcibly initiate new projects to work with these organisations (Interview: C2-SD). In this case, government usually provides special funds to intensify such cooperative relationships and reinforces the implementation of the project (Interview: C2-PM). The project deliverables need to be delivered back to the government later when the project is completed.

> *"Unlike us [which is a private commercial business specialised in tailored taxi service], traditional taxi enterprise [state-owned enterprise] are directly regulated by the government. Their business data, such as information of taxi drivers and vehicles, are always backed up in the government."* (C2-SD)

This suggests that the government have top-down power and play a leading role in distributing resources and policy-making processes, and they usually give legal priority to the state-owned enterprises and public institutions through sharing government-owned data, providing financial support and making national dividend policies. For example, the government usually distribute some dividend pay-outs to collaborative shareholder organisations to encourage and promote urban innovations. This is because the government in China have almost full, or the majority of, control of ownership through which the government and enterprises are closely connected via resource sharing and national geopolitical dividend. For example, the Ministry of Transportation have established specific national standards and industrial administrative mechanisms to encourage the development of self-driving technologies. In 2016 the Ministry provided a government subsidy of 0.4 billion RMB and special funds of 1.8 billion RMB for dominant state-owned enterprises like FAW (中国一汽) to pilot self-driving demonstration projects (CIConsulting, 2016). When necessary relevant public institutions would need to be fully coordinating the progress of the projects (Interviews: C2-PM, C3-SD). Such dividend policy somehow reflects government political power in prioritising state-owned enterprises to advance technological innovations.

The second type is the cooperation between the government and enterprise in private sectors. Within this cooperation, private enterprises work with the government on a project task in a particular phase of the project. In this case they need government-owned transportation resources (which are usually not sharable) as resource support from relevant departments, in order to ensure smooth progress of the project under their business objectives. These resources include basic geographic information, transportation infrastructure data, road network data etc. (Interview: C3-SD). The government in turn would expect effective solutions from private enterprises to tackle the "wicked issues" that exist in urban transportation. For example, the Company 1 has strategic cooperation with local government to manage real-time transportation. Such collaboration usually starts from a pilot project that is launched in a particular geographic area in a city; later it will be expanded on a larger scale if the issue can be addressed (Interview: C3-TS1). Participants expressed that though not with full control of ownership of private enterprises, the government still have leadership with political power in making industrial standards and criteria, and orienting the procedures of the project. In such a government-private partnership, government only provides data- and document-based resources (e.g. road network data, government work report) that the firms need, rather than allocating financial resources such as government subsidies or special funds as they do for state-owned enterprises and public institutions (Interview: C2-PM).

> *"When we do need data from government, we usually assign our lobbyists to seek for potential opportunities for cooperation [with government]. We then demonstrate our past project accomplishments and serviceability. They may consider collaborating with us. It depends on whether they think we are able to address a particular issue for them ... We do have a department that deals with government business; they keep following government policies regarding developing smart city initiatives."* (C2-PM)

> *"Government has rights of decision-making and standard-setting, which we see as a stumbling block. They usually amend the project proposal or re-set the project standard on their behalf without listening to our advice and opinions. So what usually happens is we keep re-working because of the change."* (C3-TS1)

From the perspective of participants, while state-owned enterprise and public institutions who may not have key resources but have concrete political support from the government, play a dominant role in the market with priority given for development, the private enterprises, who have cutting-edge technology, are dominated and constrained by the government's top-down political regulation and administration. However, C3-SD suggested that in recent years the government has been increasingly inclined to initiate cooperation with private enterprise as their technological advantages can help government tackle the urban issues that have existed for a long time. This is because the booming technological innovations from dominant private enterprises (e.g. Baidu, Alibaba, Tencent) have proved themselves to be capable to augment the entire level of the state's creativity and innovativeness. In addition to this, the government has strengthened their support to small and medium enterprises (SMEs) in order to consolidate innovativeness from grassroot social fabric. Conversely, these SMEs are also willing to develop their services under government policy-making orientation and effective urban strategic economic plans, in order to receive persistent benefits from politics through such government-private partnership. However, due to the centralised and top-down political power, the findings revealed that the issues of bureaucracy and 'guanxi' relationships are likely to take place, such as the 'red tape' (i.e. excessive regulation and adherence to official rules and formalities) (Gupta, 2012) and the 'pecking order' (i.e. an informal hierarchical system amongst social or organisational entities) (Berrell et al., 2008). These issues have been considered as barriers to the cooperation between private enterprises and the government.

5.6 Smart governance

As stated in the previous chapter, the Chinese economy has transferred from a planned economy towards a market and shared economy (B. Hu & Chen, 2015). In the area of smart transportation, this type of economy allows various STS vested interests (e.g. state-owned enterprises, consortiums and private enterprises) to competitively launch a variety of STS initiatives. In the process of China's new urbanism, the local government tend to enhance the social governance capacity of city administration in order to more effectively deal with the interrelationships (i.e. competition, cooperation) across these vested interests (B. Hu & Chen, 2015). As the findings stressed, standing within the era of smart city, such social governance capacity is shaped and moulded as a digitalised, data-driven and real-time form of smart governance. Therefore, smart governance was explored to be another indispensable aspect of designing and implementing STS initiatives. More specifically, smart governance in these findings is focused on the cooperation between the government and enterprises regarding data governance and the use of data for real-time urban transportation management.

5.6.1 Data governance

According to the findings, smart governance should give priority to data governance; particularly for this study, the integration of data generated from various places requires good strategic governance. Participants expressed that the notion of data governance should highlight high data quality, including accuracy, reliability, usability and quantity of data, from its generation, through to it being used and reused (Interviews: C1-PM, C2-SD, C3-PM). These data practices were identified by participants as having two significant dimensions.

From a social point of view, these data practices are reliant upon the afore-mentioned government-private partnership. Participants stated that ICT-driven information dissemination needs data that are owned by stakeholders and are accessible and shareable to other sites of practice for further use. In addition, compared to those developed by the government, solutions provided by enterprises are more effective, problem-centric and public-oriented. In other words, the government is happy to cooperate with private enterprises. In contrast, private enterprises need data from government sites in order to develop their own business.

> *"We use big data analytics ... and data from government authorities [i.e. transportation agencies] to come up with a solution aimed to alleviate road pressure at particular point of congestion. ... They also have cooperation with other enterprises that are specialised in other business sectors doing the same job… information coming from these data are integrated via the cloud network."* (C1-TS4)

Nevertheless, some participants suggested that there are stumbling blocks that stand in the way of effective data governance practice within such cooperation. These obstacles mostly refer to the extent to which government data are shareable to the enterprise. Shareable datasets include demographic data, road network data and real-time traffic data, to name a few. Non-shareable datasets, for ethical and data-security reasons such as personal information disclosure, involve road surveillance and parameters of the configuration of transportation infrastructure.

> *"We are able to know [via data acquisition vehicle] whereabouts the traffic lights are as well as its quantity and allocation, but what we do not know is the specific parameters of the traffic lights configuration, such as the time change."* (C2-TS3)

Participants suggested that it has been discussed by technocrats and other government officials concerning whether some typical non-shareable data should be shared to relevant commercial STS companies for them to develop more effective transportation services to citizens. With these data, participants believed that they would be able to create more functions on their innovative applications that enable more decision-making rights for their end-users. Citizen end-users being able to track real-time changes that are reflected on the applications enables them to make decisions in advance, such as adjustment of speed, or change of the mode of transport. These changes would be expected to improve traffic conditions in general and stimulate sustainable transportation development.

Participants very briefly pointed out the need to set up data-sharing criteria to ensure the security of such data-sharing practices. More specifically, the integration of data coming from various data-owners into one place requires an establishment of a data protection mechanism that is set up by both the government and the enterprise. Herein, many requirements ought to be stipulated, such as data structure, data format, data standard, and usage scenario.

From technical point of view, the findings suggested that data needs to be governed particularly when a large volume of data is involved (e.g. intensive data exchange and data flows), and when data acquisition is not achieved in a timely fashion (e.g. limitation of data sharing, low capacity of data-sharing mechanisms in the government, and relatively less crowdsourced data in less developed cities). However, some participants in a senior position maintained that the aim of data governance is not to manage data per se, but rather it aims to explore the core value of big data and convert this value into actual service. The design and implementation of the proposed data-integrated STS solution needs various data-holders to conduct their own data governance and share this data value with each other (Interview: C1-PM).

> *"Companies that are specialised in smart car parking, self-driving technology, car part manufacturing, all need basic road network data. These data are usually owned by online car-hailing service enterprise. Once the cooperative relationship is established, these online car-hailing service providers will excavate the core value of these data and share them with these companies for them to develop their own business."* (C2-SD)

The findings further indicated that the extraction of value is based upon a strict set of essential data analytics procedures, including data acquisition and update, data processing, and quality inspection. Technician participants revealed that these are important steps of data governance practice and are useful in discovering the core data attributes and their potential embedded value.

5.6.2 Real-time transportation management

Real-time transportation management was identified to be another aspect that is deemed as crucial to the smart governance of STS initiatives. From the participants point of view, real-time transportation management refers to smart distribution of transportation resources, the governance of which relies on the collaboration between the government and various STS enterprises. There are three main types of collaboration that facilitate such governance of the real-time distribution of transportation resources.

First, problem-solving oriented cooperation. Participants expressed that cooperating enterprises of this type usually develop citizen-centric STS initiatives with services delivered to the public for general smart transportation activities. This cooperation with the government requires them to carry out big data analytics to end-user activities in a particular public area, e.g. tourist attractions. The results enable the government regulators to predict the traffic state (e.g. population density, the quantity of vehicles being active) in advance, so that solutions can be made to ease the traffic pressure around the area through, for instance, allocating traffic human resources (e.g. traffic wardens) and re-scheduling transportation infrastructure (e.g. traffic lights).

> *"If end-user data [crowdsourced data] demonstrate high population density on the street next to the main entrance of Zhongshan Park, [for instance], transportation management bureau will then consider changing the time of the traffic lights and switching one-way roads to be bidirectional nearby."* (C1-PM)

Second, the governance of means of transportation. The cooperating enterprises of this type are usually those whose STS services are aimed at both government-related and citizen-oriented business. Company 2 is a typical representative that is involved with this type of cooperation with the government. Their main business is online car-hailing service, and they possess a large amount of urban real-time vehicle flowrate and traffic state data. Cooperating with such types of enterprise allows the government to have better control of real-time traffic flows as well as the schedule of public transportation. In addition, Company 2 also helps the government administrate and supervise the official vehicles that are used for government business only. Through the embeddedness of GIS-based technology, these vehicles can be distributed and controlled whenever and wherever possible.

> *"Government does not allow private use of government vehicles, so they asked us to set up a programme on the system to limit the temporal-spatial attributes of these vehicles. For example, the system will respond if any car is being active outside working hours."* (C2-PM)

Third, the application of transportation infrastructure. The cooperating enterprises of this type provide STS services that only cater to government affairs, traditionally with innovative solutions that are used to enhance the capacity of transportation infrastructure. These solutions are mostly ICT- and IoT-driven applications, with sensors installed, that enable the government to coordinate the status of infrastructure in due course in the city traffic control room. C3-SD gave a typical example of such type of cooperating enterprise (manufacturers of urban monitoring equipment) who provide not only the data captured by the surveillance but also a series of related post data services.

> *"The time of traffic lights varies at different time in a day, so does the number of lanes on a road. For example, the time of the red light is usually shorter on the east-west direction than on the south-north direction during rush hours because more vehicles tend to move across the east and the west."* (C3-TS2)

Overall, participants suggested that the three types of cooperation between the government and enterprises coexist in smart transportation development. Data that are generated from the data point move between the government and the cooperating enterprise under each type of cooperation with the purpose of being converted into information that is used to help collaborative management of real-time transportation. It is implied by participants that the interplay between these three types of cooperation would enable the government to monitor and govern more comprehensive real-time transportation as they acquire data from various sites of practice.

5.7 Global STS development trends

The data analysis in this stage identified 'STS trends' as a theme of developing an STS initiative. Though not defined in Chourabi et al.'s (2012) Smart City Initiatives Framework, STS trends was deemed as important by many participants who advocated that this would shape the pathway to the success of the design and entire strategic planning of STS initiatives. From participants point of view, STS trends refer to the tendency of new STS technology development and the current state of play of prominent STS initiatives that are being developed.

The findings revealed two fundamental underpinnings that form the trends of STS. The first is the investigation of technology innovation both in global and Chinese contexts. From the perspective of STS companies, such investigation is focused on the evaluation of the involved technologies as well as the fitted context wherein these technologies are used, understanding of political constraints, and review of end-user feedback and market research of new STS innovations. Project manager C2-PM, who used to be the product manager, indicated that some technologies or technological ideas that originated overseas are now widely used in Chinese smart transportation. Typical examples include 'open street view' technology (which is used to demonstrate real-world view of place) and the idea of 'volunteered geographic information' (which is used as a major way of data generation and acquisition). However, these technologies and ideas ought to be applied with consideration of the characteristics of Chinese cities and specific usage scenario. C2-SD maintained that as part of innovation development, keeping in step with global STS technology trends with in-depth assessment of their validity, flexibility and reliability, is an effective way for Chinese enterprises to discover their own strengths and weaknesses.

> *"There is a department called the Department of Frontier Technology which takes responsibility for exploring new potential technological solutions and innovative ideas from all over the world. Apart from new initiatives, they also investigate what are mentioned in the Government Work Report and national conferences. So we always position ourselves at the front line."* (C2-SD)

The second foundation that contributes to STS trends is market competition. The process of China's 'new-type urbanisation' is not only determined by internal factors (e.g. productivity, promoted entrepreneurial city advances), but also affected by external factors (e.g. globalisation-driven foreign direct investments (FDI)). Herein, this new urbanisation plan echoes participants' perspective in regard to the infusion of social capitals and high-tech innovations and initiatives from around the globe, especially developed countries, into Chinese cities, would create more employment opportunities, open up more channels for social financing and enhance the transformation of industrial economic structure (B. Hu & Chen, 2015). In this sense, business enterprises that specialise in STS initiatives tend to increase their market share by enhancing the quality of service and expanding the range of business.

In order to achieve this, many enterprises investigate the modality of business within marketisation of STS initiatives and seek ways that stimulates economic growth and market supremacy. For example, C2-TS1 suggested that some innovative STS services emerge from the fact that commercial enterprises compete against each other by developing differentiated services within competitive economic environments. These differentiated services developed by each business could enable themselves to be distinctive in STS market. Consequently, participants argued that the diverseness of services in the market would enable the multiplicity of information exchange, information dissemination and service delivery. This would create an open environment for STS market that incubates many opportunities for innovation and embraces diversified innovativeness, and such modality of STS innovation enhances market capacity that calls for the trend-setting of future potential initiatives development.

5.8 Socio-economic influences

The applied thematic analysis approach further explored potential factors in relation to the societal and urban level dynamics that may lead to the success of STS initiatives in respect of socio-economic influences. This factor involves in-depth identification and investigation of current wicked problems (e.g. risk assessment), human-structural change brought by the potential data-integration STS solution, market analysis approaches to mitigate the issues raised from the market, and city competitiveness.

5.8.1 Social investigation of potential transportation issues

At the design stage of STS initiatives, the developers tend to conduct social investigation into various aspects of potential transportation issues that may impede the development progress. These issues include existing urban transportation problems that are yet to be tackled and expected risks of the initiatives after implementation. In addition to examining these issues, the investigation also contains end-user requirement analysis for a particular respect of transportation activities.

Firstly, the focus group investigation conducted with citizen participants in the last stage of this research raised concerns with existing urban transportation issues as well as problems with the current STS applications, such as traffic congestions, damage of transportation infrastructure, ill-behaved and poorly-educated transport system users, and information security, to name a few. However, the interviews conducted with companies suggested that the current STS innovations are not able to tackle these issues. This is because the practitioners do not really take into consideration how their service offerings match the way in which these transportation issues can be addressed. From the perspective of their business objectives, they are specialised in creating smart services for end-users to conjure up a plan or a solution that can speed up efficiency and avoid problematic situations, rather than aiming to solve deeply anchored urban transportation issues.

In a nutshell, many of these issues cannot be addressed simply by applying the current technology-driven STS innovations. Rather, they should be addressed in conjunction with overall urban planning and integrative coordination of transportation resources; herein the latter paves the way for maximising the effectiveness of these innovations. In other words, pure technology-driven solutions may not be able to serve all types of citizens unless a holistic design and plan are backed up to support problem-solving for certain types of issues affecting a certain group of citizens. For example, urban transportation administration legislating the protection of, and priorities for, disadvantaged groups (e.g. senior citizens, disabled citizens, children), lays the foundation of special (smart) transportation service delivery that are developed by relevant STS service providers.

> *"In Shijiazhuang, some public transports are only available for old people who have mobility impediments and have rights to drive on the lanes that are only*

> *available for them. Based on this, some STS application developers have developed mobile applications that are only designed for such type of public transport. [For example, the old people can use the application to check available buses and their time schedules.]"* (C2-SD)

Secondly, participants C1-PM and C2-PM, who used to be responsible for the risk assessment of their businesses, highlighted the significance of conducting risk assessment of the main services or functionality, of STS initiatives that are being developed. The outcome of such assessment involves precautionary measures of anticipated problems that may emerge during the process of implementation. C2-PM particularly underlined that the initiatives would not be trusted by end-users if serious issues appear without proper solutions to overcome them.

> *"For example, many people are inclined to call a taxi online during rush hours in order for the saving of time, but the taxi cannot arrive in time due to traffic. In this circumstance, users are not allowed to cancel the order for free by themselves unless the driver does so."* (C2-PM)

C2-PM believed that such trouble brought to the end-users is out of the service provider's expectation, which results in a situation where an increasing number of people stop using the service. This indicates that it is necessary for the STS service developers to thoroughly understand the current traffic policies and regulations and the characteristics of local urban transportation. Moreover, the solution to a specific issue needs coordination of transportation resources from across various resource-holders.

Thirdly, end-user requirements in this case suggests the extension and expansion of the main services of STS initiatives that are expected to tackle the issues that end-users face, and meet the demand they have, through the exploration of their additional requirements of transportation activities.

> *"As you said, many users have complained that it is not easy to find the taxi when it arrives, which, might be because of inaccurate navigation and positioning on sides of both the drivers and users. We started cooperating with AutoNavi to come up with a [value-added] service called 'recommended pick-*

up point' [with which] both the drivers and the users are easily to find each other." (C2-TS2)

The 'recommended pick-up point' service implies that the development of such value-added services is not limited to single usage scenario of STS services. In order to integrate various standalone systems as well as their data, there is a necessity for developers to understand the benefits to be brought to the end-users and the problems to be addressed for the urban transportation system, which are all based on an analysis of end-user requirements.

5.8.2 Structural change of human capital

The presentation of the findings in previous sub-sections in relation to big data analytics and data governance both underlined the input and output of large quantity of transportation-related data throughout the entire data lifecycle from data acquisition to data processing. The interview participants declared that, in the past when the volume of data was small, they either dealt with the data by themselves or outsourced data processing related work to third-party technology enterprises. Consequently, a substantial amount of capital investment was made to human resources. In the era of big data, the participants suggested that manual operation needs to be replaced by large-scale automation in the business because of the imbalance between limited human resources and the large concurrent volume of data. Otherwise, it is common to see the overlap of employees that are assigned to work under different sub-systems. Such overlap of human resources is likely to result in disorders of work in terms of efficiency, effectiveness and quality of data processing. Considering the significance of the changes that technological upgrade and human resources would bring to the business, the project manager participants suggested that the savings that come from the replacement of human resources with automation outweigh the costs consumed from the upgrade of technology. Therefore, their business is increasingly transforming to develop ICT- and IoT-driven automatic data-processing systems in order to replace complex and low-efficient human operations.

"We are currently transforming our company to be automation-driven because human-based data [processing] work is poorly efficient." (C1-TS4)

This is echoed by participant C1-TS3 who claimed that *"the overall automation throughout the business is a crucial measure to improve the quality of data"*. This is because, on the one hand, compared to humans, the automated systems rarely make mistakes as long as the initial settings are correct; on the other hand, manual operations provide low efficiency, which results in data not being updated in real-time, and therefore relevant information not being delivered to the end-users (Cichocki et al., 2012).

Apart from changes within the business, the overall automation that is applied in the entire urban transportation system was perceived to also bring about structural changes to human capital (Interviews: C2-TS3, C3-TS2, C3-TS3). This is because automation would lead to the redundancy of employees by replacing them with machines and systems.

> *"The emergence of smart car parking makes human-based work no longer needed. The big change is the payment method, shifting from people manually making payment to the ticket wardens [towards] payment being automatically made via mobile devices."* (C2-TS3)

Furthermore, C3-SD suggested that it is common to see human resources flow from one business to another throughout the entire STS sector because of similar characterised technological deployment and business operations. Therefore, they have similar requirements to the technical experts and employees in other fields of business including their understanding of technology, expertise in business processes of data processing, and operational business skills.

> *"It is not uncommon that employees flow across different companies within STS sector because business involved in each company is somehow relevant to one another with technical support of each similar to another as well. We usually welcome those who have experience of employment in another STS company."* (C3-SD)

Such flows of human resources are hence expected to be further strengthened under social collaboration of various STS stakeholders working on the integration of data that come from different sites of STS data practice. This would bring about STS experts, technicians and technocrats with integrated expertise who are expected to be grouped as STS think tank (Interview: C2-PM) to concertedly develop future urban STS services.

5.8.3 Market research

From the perspective of STS enterprises, the interview findings revealed that STS market research is a crucial step of the strategic enterprise development. Market research was identified as one of the main factors to help maintain the level of competitiveness in the sector. C2-TS3 even specifically emphasised that STS market research accounts for 30-40% of the success of the development of new STS innovations. As far as interview participants are concerned, STS market research, which contains technical analysis and social and opinion research, helps STS enterprises orientate themselves in the market, explore value of their services and products, and analyse market requirements, especially those coming from the end-users. For example, for the customer-centric initiatives, market research is usually focused on the analysis of whether service delivery matches end-user demand (Interview: C1-PM). When it comes to the relationship between market and demand, some participants implicitly revealed four dimensions of such relation: ‘known market’, ‘unknow market’, ‘known demand’ and ‘unknown demand’ (Interviews: C2-SD, C2-TS1, C3-SD). The enterprises ought to explore the gap in each of these dimensions in order to identify what is currently required in the market and what ought to be delivered to the citizen end-users; this should be an on-going process.

The findings further explored two major visions of market research for the benefit of STS enterprises. The first is the balance between end-user satisfaction, the cost and feasibility. On the one hand, priority should be given to those with high potential profits and values that could be delivered to both the enterprise and end-users when various demands take place due to the limitation of human resources. In this circumstance, the enterprises tend to undertake a business case project at the first place as a ‘testbed’ in a particular geographical area through cooperation with local government and other corporations (Interview: C1-PM) and evaluate its potential outcome, e.g. end-user satisfaction and feasibility of some specific services (Interview: C3-TS1). The input-output ratio analysis of the outcome would determine whether the case project ought to be expanded on a larger scale. On the other hand, some participants indicated that the enterprises would need to conduct multi-stage market research to identify weaknesses, challenges and end-user desires of their service and products especially when the response from the market tends to be negative at the initial stage. C1-TS4 said that service will be terminated if feasibility and end-user satisfaction are hardly achieved after several rounds of market research, for instance.

> *"You may see the update of the application quite often… some people said that they could not use the service [or function] anymore even though they did just a few days ago. This is because we keep exploring what the weaknesses are and what could be improved by doing market research."* (C1-TS4)

The second vision of market research is the maximisation of benefits to citizen end-users. Such benefit maximisation, suggested by C2-SD, is based upon consumption upgrade in Chinese cities. Participants suggested that this growth determines that enterprises should position their business priority to exploring the way of maximising benefits to their end-users. This needs in-depth investigation into market gap regarding what the current market lacks and what end-users expect by conducting analysis for the current initiatives that are developed by various STS developers including both their advantages and disadvantages (Interview: C3-TS3), and by developing custom-built services that are aimed at personalising end-user mobility in smart transportation (Interview: C1-TS3). These solutions would be able to stimulate effective leverage and replenishment of STS resources because the initiatives developed by different enterprises complement each other by covering the shortage from one to another.

> *"Our end-users use our application to search the information they need. … We record inaccessible information and keep an eye whether they are accessible on the competitive application. If they are, we will not only update our system but also develop value-added services on top of these information or explore more correlative information."* (C1-TS1)

Given the large range of potential STS initiatives developed by various enterprises, market research is carried out within different sub-sectors of smart transportation. The initiation of data-integrated STS applications, whose data emerge from various places, is expected to be necessary to conduct comprehensive market research of each sub-system of smart transportation that different data and their associated service belong to.

5.9 Cultural influences

The data analysis identified cultural influences as the last indispensable factor. Different from the previous factors wherein stakeholders were the focus of discussion, this sub-section explores the opportunities and challenges for initiating the proposed data-integrated STS application from the dimension of the wider society and cities themselves. More specifically, the findings of this factor are threefold: city competitiveness, innovation dilemma and urban cultural heritage.

5.9.1 City competitiveness

Data analysis suggests that city competitiveness underpins relevant STS developers better exploiting new possible solutions for urban transportation development. Participants resonated that city competitiveness is not only regarded as the catalyst of STS initiatives development but also as resource superiority for commercial STS enterprises to develop their businesses (Interviews: C1-PM, C2-TS2, C3-SD). Participants suggested that the enhancement of city competitiveness is attributed to the interplay between the following three facets: marketisation and privatisation of public smart services alongside market competition; industrial coalition across all types of indigenous and foreign smart city enterprises and other relevant stakeholders; and professionalisation of smart city services and applications.

Firstly, with the goal of achieving market supremacy, competitive enterprises seek avenues of service delivery that are more optimised, profitable and beneficiary for citizens and city administration (Cardullo & Kitchin, 2019a; Hollands, 2008, 2015). The findings suggested that these avenues would render more active citizen participation and end-user satisfaction in using the smart services. Such form of business competition would strengthen city managers' problem-solving capability to mitigate wicked problems in the city. For example, realising that citizens in Shijiazhuang are rather dependent upon taxi service (including online car-hailing service) due to intensive traffic congestions, air pollution, low road capacity etc, C1-TS2 suggested that many online car-pooling and car-sharing enterprises tend to compete against each other through price reduction and distribution of end-user dividends in order to encourage more citizens to participate in their business. Furthermore, as internet and mobile technology play an increasingly prominent role in STS service delivery, the competition between enterprises would stimulate the advancement of related industries, e.g. payment industry, telecommunication industry, which would enable effective integration of services, data and information in the city (Interviews: C2-SD, C3-TS2).

> *"Didi and Yidao entered into Shijiazhuang in succession to initiate their services. With competition against each other, they tend to come up with many solutions that aim to attract more and more people to be their users, such as preferential price, discount rules, value-added services, etc. The competition between them stimulated the generation, proliferation and further advancement of internet payment applications [e.g. Alipay and WeChat Pay]."* (C1-TS2)

Secondly, many participants revealed that serviceability is crucial to business development. Herein, participants suggested that on the one hand, STS companies should be committed in developing high-quality, professional STS services in their particular business rather than attempting to include all types of services that are beyond their service scope without specific business purpose. On the other, dividend policy put forward by the local government and government-private partnership would generate large-scale businesses that provide the city with a large range of distinctive professional public services. The aggregation of the serviceability of a large range of enterprises are expected to enhance the entire level of city competitiveness. Moreover, participants underlined that the augment of city competitiveness would further increase the rate of economic growth and prosperity of marketisation, which would generate more enterprises and create more business opportunities. Such positive relations between city competitiveness and market opportunities they argued would pave the way for more collaborative, resource-sharing and networked development of STS initiatives.

> *"Many years ago, when internet services became just popular, an increasing number of SMEs tended to be specialised in O2O [Online-to-Offline] services attempting to include various forms of both online and offline services. However, they were not strong enough to be able to make their services really professional and citizen-centric. AutoNavi was one of them but had shifted their focus immediately ever since towards electronic maps, smart navigation, and journey-planning platform, and now they have become the biggest e-map developer and one of the leading STS applications in China."* (C1-TS4)

Thirdly, the enhancement of city competitiveness allows STS developers from other regions or cities to launch their business in new locations. However, they face a dilemma where they need to showcase their innovative solutions that are superior to the current businesses within the city, which may lead to significant benefits to city administration and local residents (Interviews: C2-TS1, C2-PM). Local technocrats and STS relevant experts will need to evaluate their business ideas and projects in terms of whether they can reach the standard of social financing (Interview: C2-PM) and how beneficial their solutions would be to public services (Interview: C3-PM). Those who successfully 'pass' such evaluation, leveraged from their unique and strong professional serviceability, would be able to initiate their business in the city. This suggests that city competitiveness, as an urban development indicator, attracts inward investments which stimulates all-round socially industrial coalition across cities and regions and social resource integration. This would eventually increase the entire level of urban STS.

> *"When every time we enter into a new city, we have to make a strong declaration of our business advantages to the local STS consortiums, government officials and big corporations. … The first step of this process is to gain support and approval from the local government. … The second step is to discuss and make specific action programs with relevant government agencies who are in charge of STS initiatives. The new initiative project will not start until these two steps are complete."* (C2-TS1)

These two officially administrative processes of outside financing further indicate the interrelations between city competitiveness and city administrative level. Herein, almost all government department head offices and public institutions are located in provincial capitals (e.g. Shijiazhuang). This benefits these cities with faster decision-making and information dissemination processes across organisations, hence resulting in faster smart city development in provincial capitals than in secondary and lower-level cities. Furthermore, the formation of city clusters across geographically adjacent provincial cities would promote city competitiveness (B. Hu & Chen, 2015). Regarding this sense, participants asserted that the local government, who are aiming to transform the city to be an entrepreneurial city, should diversify the channels of social financing in order to raise funds for more opportunities for smart and sustainable city construction. Diversified social financing channels would stimulate more inter-provincial direct investments. The increase of city competitiveness in provincial capitals and the inter-provincial agglomeration of cities might be able to stimulate corresponding social and economic development of their satellite cities (i.e. small and medium sized, lower-tier cities). As a result, the formation of city clusters would be expected to entirely augment the overall provincial competitiveness.

5.9.2 Innovation dilemma

"Innovation and creativity are not dependent on technology breakthrough or revolution, but upon the way in which smart public services are delivered", argued by C3-PM (who has previous experience of the design of STS application). Resonated by some other participants, in a word, the means of service delivery was identified as an important aspect of innovation dilemma that many cities in China face. Within the era of instrumented, networked, data-driven cities, whilst the vast majority of smart services are delivered to people through mobile device applications (Harrison et al., 2010; Kitchin, 2015a; Townsend, 2013), participants however, hinted that in future, data from across various systems being integrated into one place with newly launched services would not necessarily be reliant on mobile applications.

> *"It could be achieved by the operating system of smartphones, wearable devices, in-car command systems … [suggesting that these facilities are highly system-encapsulated, data-integrated.]"* (C1-TS2)

To overcome such a conundrum requires technocrats, initiators, innovators who advocate for technology-driven smart governance to have more thorough, open and all-encompassing interpretation of STS technology – whether or not the potential solutions are comprehensive and take into account civic benefits and concerns (Interviews: C2-SD, C2-TS1), and whether or not they self-examine themselves regarding the underlying issues of current means of service delivery (Interviews: C3-PM, C3-TS2, C3-TS3). Hidden behind these reflections indicates more citizen-centric customised service production and delivery, which was identified as the second aspect of innovation dilemma. Customisation here, from the point of view of participants, points to smart and personalised algorithmic solutions that are designed for, calculated for, or recommended for, different people, rather than one-size-fits-all or cure-all solutions that provide everyone with homogeneous data and information. For example, some existing STS applications ask end-users to type in their own transport preferences (e.g. frequent locations and routes, preferred means of transport), so that they can provide so-called personalised traffic plans to the particular end-user based upon end-user data analytics. Technician participants revealed that many current STS companies are tending to remain committed to such customisation-driven business.

> *"...however, these customised services can only ask users to set up their [transport] preferences and usage habits. ... But the solutions based on these are still not really individually distinctive. They are not able to explore complete individual user behaviours, tracks and traffic patterns only through simple datasets they have captured."* (C1-TS2)

C1-TS2 further indicated that the reason for this is because data generated from each of these applications are simple-structured without interoperable practices and integration of each other's data between them. Whereas on a potential data-integrated STS solution, diversified data types and structures would bring highly-centralised and comprehensive services. Therefore, it is likely to generate individually distinctive algorithmic schemes to the end-users who would be able to achieve individual autonomy. These potential data-integrated, individually customised services further suggest the increasing rights of citizen end-users participating in smart transportation from being passively receiving benefits (from a less individually distinctive customised solution) towards actively creating value for their own (from individual-centric analytics of integrated data). Citizens are therefore endowed with more self-autonomous decision-making power and active willingness of engagement.

Besides, C2-SD raised some issues surrounding the term 'the second half of the internet', an era which we are currently in. What lies in the core of this 'half' within the smart city is not merely technology driven (e.g. sensors, cables and smartcards) but also in respect of human and cultural networks (e.g. business innovation and creativity), with profound implications on social and environmental sustainability. The proliferation of such networks in a wider context can generate a large number of cultural industries (Interview: C2-SD) which might result in cities that are designated as smart being transformed to be innovation- and cultural-driven entrepreneurial cities in which diverse types of businesses emerge to provide similar public services to people and local government. Some participants named such a phenomenon as 'imitation' and 'homogenisation', meaning that an increasing number of business-led STS initiatives become analogous to each other providing near identical types of services.

> *"When one company comes up with an innovative business idea, many others would imitate and further advance it with better functions and services created. But, it is only the first company who can be designated as 'innovative business'".* (C1-TS1)

Some participants believed that homogenisation is the result of marketisation and privatisation of public services and the advancement of the business-led entrepreneur city. Put another way, on the one hand, the local government open their policy to encourage social financing and open policy for SMEs to create social value, with the aim of enhancing city competitiveness. On the other hand, these companies are not strong enough to develop innovative and creative technology-driven solutions, hence attempting to make something from an existing model. This contradiction with regard to urban STS development results in market chaos, waste of social resources and disorderly market competition, which further impacts on urban STS innovation and city competitiveness. In order to mitigate such an issue and remedy urban innovativeness, C2-TS1 and C2-PM further underlined the importance of SMEs unearthing differentiated services, cultivating innovative and creative business culture from across the entire organisation and establishing strategic collaboration with larger corporations.

5.9.3 Urban cultural heritage

One of the major goals of China's 'New-Type Urbanisation' plan was to enhance the historical and cultural heritage of cities in parallel with the fast development of smart and sustainable cities (CNDRC, 2014). This suggests that the development of smart city initiatives should not be reliant on sacrifices of urban cultural heritage and inherent quality of city cultural services. Participants expressed that urban cultural heritage in the context of ICT-driven smart city initiatives is construed as in relation to digitalisation of cultural goods. The advancements of smart city initiatives allow both local citizens and visitors to digitally and readily gain access to the value of these cultural goods, especially in the cities with a rich history and myriad points of historical interest.

On the one hand, this means that urban cultural heritage can be seen as part of social capital on which smart city initiatives are built, hence needing persistent preservation. On the other hand, this suggests the enhancement of urban innovativeness, city competitiveness and socio-economic boom with the purpose of refashioning cities as smart, lively, inclusive and encompassing, and sustainable places to live. Company 1 developed a smart mapping application that aimed to help visitors navigate themselves to tourist attractions with digitalised information provided regarding historical background and relevant cultural goods. C1-TS2 who used to be the Technical Director suggested that the advantages of this application pointed to the seamless combination between tourism-based entertainment and e-maps based smart journey planning services, which significantly stimulate tertiary-industry prosperity.

> *"Unlike many of existing tourism-oriented applications through which users can get basic information about 'Tiananmen Square', [for instance], our application involves more historical information behind the place and user experience through virtual reality [(VR)] and augmented reality [(AR)] technologies … Apart from this, our system incorporated with AutoNavi's free digital base map to develop our own e-map services for the users."* (C1-TS2)

The use of VR and AR characteristics suggests optimising technological use in urban cultural heritage. However, the project manager C1-PM mentioned further potential optimisation of such application, that it is expected to involve more data types and functionality on the side of transportation service (e.g. not only limited to smart navigation service). In a word, this means data coming from different sites of practice of transportation data points could be involved in, and further converted into, services in this application.

At this point, it is suggested by some C1 participants that the combination of STS and services that are built upon digitalised cultural goods requires close collaboration between STS enterprises, local Bureau of Culture and other tourism-related businesses (Interview: C1-TS2); the scrutinization of relevant data reports (Interview: C1-PM), and the strengthening of data security and protection mechanisms are also required (Interview: C1-TS2). They mentioned and echoed a Chinese political slogan in relation to the protection of cultural goods – 'De-IOE' (A political and business campaign, first proposed by Alibaba and further promoted by the Chinese central government, that describes state-owned enterprises disconnecting themselves from U.S. software and embedded services, primarily from IBM, Oracle and EMC). On the basis of this, in STS, they expressed that the government are inclined to encourage indigenous STS business development in the sectors that involve strong and sensitive cultural heritage characteristics, and place an emphasis on the restriction of foreign enterprises to access data and embed their technical configuration into Chinese indigenous system architecture. Consequently, this would lead to positive growth of innovativeness and competitiveness of Chinese indigenous STS enterprises. Furthermore, C3-TS3 and C3-PM claimed that industrial coalition between the leading STS corporations would become necessary to enhance business innovation and creativity in order to stimulate large-scale all-industry economic prosperity.

5.10 Summary

This chapter presented STS developers' perspective of designing and implementing the proposed data-integrated STS solution in Chinese cities. The data analysis explored these findings and revealed nine thematic but interrelated dimensions of issues that may influence successful design and implementation of the proposed data-integrated STS application. These nine issues are *STS technology, STS infrastructure and hardware, citizen end-user effects, organisational and managerial dynamics*, *STS policies and politics*, *smart governance*, *STS trends*, *socio-economic influences*, and *cultural influences*. It is notable that rather than only exploring what the issues would be in the implementation stage, the findings also revealed participants' insights about what they perceived as crucial in the design stage of initiating the proposed data-integrated application. These nine issues were sequentially explored and finally presented according to the extent to which participants perceived these to be prioritised and how crucial they are in initiating the proposed data-integrated STS solution.

The findings depicted participants' perspective on the current challenges and opportunities for STS developers harnessing STS technological underpinnings to collaboratively work on potential data-integrated STS solutions with involved stakeholders. These stakeholders include citizen end-users, state-owned enterprises, private enterprises, public institutions, and government authorities. Participants suggested that different stakeholders play distinct but interrelated roles in the design and implementation processes of initiating STS innovation projects.

The findings revealed that STS developers would need to listen to citizen end-user voices and analyse their demands in order to enable digital participation by means of crowdsourcing and overall operating performance and interoperability in a data-integrated STS solution.

However, issues found regarding end-user information security and smart citizenry were explored pertaining to the interplay between organisational and managerial dynamics, government's political roles and orientation in making policies, rules and regulations, and smart governance practices. More specifically, such interrelations are three-fold. Firstly, STS developer enterprises should commercially collaborate and cooperate with each other to establish an 'industrial coalition' in order to co-produce and co-design STS initiatives. Particularly, centralisation of departmental functions, technocratic visions and top-level design were highlighted as imperative to stimulate highly efficient social collaboration. Herein, the dominant STS platform vendors should play the leading role in such coalition. Secondly, within China's new-type urbanisation, government's STS policies and legislation would support STS developers to design new innovations, but meanwhile restrict the implementation of some services which contradict the government's policy-making and legislation. Moreover, the findings indicated that the government play a role in steering and directing the development of STS initiatives under collaborations with all types of social organisations, with decision-making rights upon goal-setting, standard-setting, resource-exchanging and information sharing. But in this sense, political priority is given to private enterprises as they are capable of providing cutting-edge, innovative STS solutions to help them address wicked urban transportation issues. Thirdly, the findings highlighted the importance of e-governance practice to enhance ICT-driven, top-down data-sharing practices from the government to social organisations. In commitment with e-governance, participants raised the issue about 'data governance' which was used to examine the quality of data in all sites of data practice.

The findings also revealed STS developers' perceptions upon society and city related factors that may influence on the design process of the proposed data-integrated STS solution. In terms of society related factors, developers and STS technocrats play a crucial role in identifying the current global and domestic trends of STS development in the wider context. This was explored in close connection with socio-economic influences, the identification to which unearthed potential enablers of STS developers undertaking social investigation, analysis of structural change of human capital and market research. Socio-economic influences brought about city-related factors of cultural influences, which contained city competitiveness, innovation dilemma and urban cultural heritage.

In summary, this findings chapter revealed the STS enterprise perspective on the challenges and opportunities for designing and implementing the proposed data-integrated STS solution. The perspective unfolded an in-depth expert view with the combination of empirical insights and expertise in a particular area in developing technology-driven STS solutions. The next chapter focus on the government perspective, which was explored from a more legally and politically rooted STS regulator and policy-maker point of view.

Chapter 6: The perspective of government

This chapter shifts the focus from end-users and STS experts' points of view towards that of policy makers and regulators in terms of designing and implementing the proposed data-integrated STS application. To achieve this shift, interviews were carried out with government officials who work for two government transportation agencies in Shijiazhuang: Shijiazhuang Transportation Bureau and Shijiazhuang Traffic Management Bureau in Department of Public Security of Hebei Province. Drawing on the analytical findings of the last two rounds of research, the interview questions were set out with the aim to examine the roles of government data, influential factors of government administration and political structure, the collaborative relationship between government and other sites of practices, and the socio-technical forces that would drive the proposed solution towards success. Same as the investigation of STS enterprise perspective, the interviews with government participants aimed to explore the key issues and factors influencing both the design and implementation processes of initiating the proposed data-integrated application. The following table (Table 6) demonstrates the full list of findings of the themes and codes extracted from data analysis.

<table>
<tr><th>Themes</th><th colspan="2">Codes</th></tr>
<tr><td>Data-driven, networked STS technology</td><td colspan="2">Data-driven, networked STS technology</td></tr>
<tr><td>Urban transportation infrastructure and hardware</td><td colspan="2">Urban transportation infrastructure and hardware</td></tr>
<tr><td rowspan="4">Communicative and integrative government administration</td><td colspan="2">Government devolution</td></tr>
<tr><td colspan="2">Government officials' expertise, knowledge and vision</td></tr>
<tr><td colspan="2">Inter-department synergistic collaboration</td></tr>
<tr><td colspan="2">Special Purpose Entities (SPEs) constitution</td></tr>
<tr><td rowspan="9">Political legitimacy</td><td rowspan="3">Policy enactment and enforcement</td><td>Emerging technology purposed policy-making</td></tr>
<tr><td>Policy circulation and propaganda</td></tr>
<tr><td>Transparency of government data</td></tr>
<tr><td rowspan="3">Centralised political power</td><td>Enterprise data handover to government</td></tr>
<tr><td>Normalisation of government datasets</td></tr>
<tr><td>Transportation regulatory oversight</td></tr>
<tr><td rowspan="3">Trust system</td><td>Data ownership and copyright stipulation</td></tr>
<tr><td>Data trust</td></tr>
<tr><td>Set-up of transportation credit system</td></tr>
<tr><td rowspan="2">Open-door economics</td><td colspan="2">Demonstration project implementation</td></tr>
<tr><td colspan="2">Market-driven local investment promotion</td></tr>
</table>

	Regionally characterised business modelling
Purposive citizen participation	Citizen requirements elicitation
	Citizen reporting and monitoring
	Citizen incentives
Sustainability vision	Sustainability vision

Table 6: Government perspective of the factors influencing successful initiation of the proposed data-integrated STS application

According to the findings, the first four factors (i.e. ‘data-driven, networked technology’; ‘urban transportation infrastructure and hardware’; ‘communicative and integrative government administration’; and ‘political legitimacy’) were identified as endogenous driving forces which participants deemed as the foundation of designing and implementing a data-integrated STS initiative. These forces were focused upon the nature of data, legal definition and specifications of data, the means by which they are used, and the organisational underpinnings of the data sharing environment. Whereas the other three factors (i.e. ‘open economy’, ‘purposive citizen participation’ and ‘sustainability vision’) were analysed as exogenous enablers that provide socio-material support for the data integration process. The following sections demonstrate more details of the findings for each code.

6.1 Data-driven, networked STS technology

This section is focused upon the technological underpinnings of designing the proposed data-integrated application. In particular, this section revealed participants’ knowledge, expertise and their perceptions of indispensable technologies that are expected to achieve such integration of data in STS. These technologies that are divided into two big data driven interrelated domains (i.e. cloud network and dynamic traffic guidance system), form a data-driven, networked STS which provides the foundation for the integration of data coming from various places.

First, cloud network. From the government participants’ perspective, building cloud networked STS is perceived to save more human resources and enhance end-user traffic efficiency. For example, GP2, who takes responsibility for car-parking transport services, pointed out that there has been a shift towards automated online payments through mobile devices. Herein QR-codes are widely used to generate individual parking ticket on users' smartphones for payment making when they are ready to leave the car park (Chia & Salimi, 2013). This has not only significantly reduced end-user time wasting and improved the efficiency of the running of the car park, but has also normalised car park management and regulation standards (e.g. charging standard). Beside the QR-code technology, GP2 also revealed that many public car parks in Shijiazhuang are tending to construct sensor networks in order to achieve car park space reservation services. The cloud-based parking reservation system is built upon Short Message System (SMS) that allows people to reserve car park space by creating an account and sending reservation details (Hanif et al., 2010). People will not need to spend time seeking for a space to park, which to some extent remedies traffic congestion around the car park.

Second, dynamic traffic guidance system. This has been identified by participants as a multi-scalar system that is used by transportation officials to monitor traffic, assess accident risks and guide traffic resource distribution. H. Wang (2018) explained that traffic information release and transmission function is the major component of a traffic guidance system, while participants GP3 and GP4 emphasised the importance to make traffic guidance dynamic, as it helps traffic managers (e.g. Traffic Management Bureau) to make known what is happening and what is going to happen, thus delivering better scheduled route planning and guidance to citizens who are travelling. A typical example of such technology is dynamic guidance screens which are widely used on the main roads of the city; most of time these work during the rush hours to guide and mitigate traffic congestion. However, GP3 indicated a major issue with these screens which is the occurrence of insufficient traffic data sets which sometimes results in inaccurate guidance. Such a complaint has been made by many people, and the government is therefore tending to leverage big data to enhance system accuracy through collaborating with enterprises for more data resources (Interview: GP3); this is especially important when data sets are complex, coming from various sites of practice.

> *"Local residents never see it [the screen] because they do not trust our data. They instead would like to use mobile apps developed by private companies because they can provide them with more accurate information. Therefore, we have started cooperating with private companies to get them use their big data to facilitate us guiding and managing traffic."* (GP3)

Another example of dynamic traffic guidance is urban transport surveillance; whilst suggesting it is a form of government authority, participants echoed that the government traffic management officials should be able to address the issues (e.g. congestion, accidents) immediately so that they have minimal impact on near-by traffic. To achieve this, dynamic cameras and video monitors have been put into effect to capture real-time emergencies. When asked about what technologies worked behind such monitoring systems, GP3 explained that they have started to implement an AI-based automatic vehicle identification (AVI) system. This system allocates a data set for each single vehicle on the road and monitors their movement in real time; all information about the vehicles are read and transmitted by the central system through registered number plates (Patel et al., 2013; Wen et al., 2011).

Participants further explained that such transport surveillance is not only handled by municipal government, the system is further divided into sub-systems respectively managed by various district governments, county governments and township governments, with a focus upon different geo-administrative levels. This multi-level transport surveillance not only facilitates real-time traffic management, but also provides good public safety protection and is a means of obtaining evidence when investigating traffic accidents and emergencies. However, these surveillance systems may infringe public privacy (by constantly monitoring citizen traffic behaviours and movements), which is what many citizens are concerned about. In particular, the findings of citizen end-user perspective hinted that they wish they could understand more about the deployed surveillance infrastructures, in terms of what types of personal information are being captured.

> *"Transport surveillance involves a large range of traffic data types, such as traffic flowrate, vehicle information, and so on. But these data are usually only stored for three months [in Shijiazhuang], after which the data will be removed. […]. In most cases, the system is not so capable to involve so much data sets."* (GP2)

What GP2 expressed here means that the system and its databases that were built many years ago are not able to match todays escalating volume of big data; for example, data storage capacity is low, hence needing system upgrades towards the orientation of high system capacity of integrating big data that are generated from various sites of transport practices. GP4 in particular extended that high system capacity to handle big data volumes could be harnessed to develop self-driving technology in the future; the other participants echoed that this has the potential to become the main technology stream in urban transportation.

6.2. Urban transportation infrastructure and hardware

Following the technological underpinnings discussed above, the findings further identified infrastructural and hardware components as another exogenous factor that would have influence on successful design of the data integration process. This subsection will closely examine this factor in the context of urban road planning and technological infrastructure and hardware upgrade.

Miller and Hoel (2002) proposed the concept of ‘smart growth’ which stated that cities designated to be smart in urban development involve regulatory, financial and educational practices that might facilitate transportation management and land use by means of systemic urban planning. For urban transportation in particular, urban road planning would be considered as an essential pillar of the fabric of STS development. To some extent, GP2 and GP4 expressed that STS innovations are not able to effectively work without good urban road planning.

On the one hand, Shijiazhuang is advantaged by initial urban road planning because its grid-based urban road network enables high evacuation and resource distributing capacities (GP2). This means there are many different ways for traffic wardens and rescue teams to approach emergency sites. On the other hand, Shijiazhuang is disadvantaged by inappropriate planning of auxiliary road construction alongside the increasing number of vehicles. The number of vehicles in Shijiazhuang’s urban areas has increased at a dramatic rate over the past two decades, with 248 million vehicles reported in 2017, which was almost 80 million more than that five years before, and 200 million more than that 17 years ago (Sina Hebei, 2017). Such rapid escalation of vehicles became the driving force to construct urban ring roads and urban overpasses which aimed to mitigate traffic pressure in urban areas especially during rush hours.

However, GP4 pointed out latent risks brought about by initial planning of these roads. The primary risk is that the expected benefits that urban ring roads and overpasses bring turned out to be weaknesses that resulted in even more traffic congestion. For example, many people who initially tended to make use of the high-speed capacity of ring roads and overpasses were found to be contributing to congestion at the entrance and exit points. As a result, traffic congestion formed discrete agglomerations of vehicles, which *"significantly restricted the functionality of technology-driven STS initiatives, e.g. smart navigation system"* (Interview: GP4). This is to say, internet and big data driven STS applications wouldn't work well with serious agglomeration of vehicles however integrative and comprehensive the data of applications are. Further to this point, GP2 maintained in the interview:

> *"Rather than aiming at speeding up private vehicles for high traffic efficiency, the spirit of urban road planning instead is focused on upgrading road embedded transportation infrastructure so as to enhance public transportation capability. This would be ultimately able to release the pressure of traffic congestion as well."* (GP2)

Participants expressed that Shijiazhuang government have made great effort to upgrade urban transportation infrastructure, especially for those involved in public transportation. For example, GP1 highlighted on the construction of urban motorways. These motorways are embedded with technologies of geomagnetic induction, traffic surveillance and detection system, magnetometer sensor and inductive loops (Interview: GP1). Such technologies have proved to help enhance road carrying capacity and have stimulated more public transports engagement. GP2 mentioned the joint effect of a smart traffic light system and smart lanes applied on main roads in urban areas; these allow special access for public transport (e.g. buses and taxis) avoiding conflict with other means of transports, which favoured the uptake of public transportation. GP3 suggested successful adoption of sensor technology and radiofrequency identification on buses and taxis where the bus and taxi companies can track real-time location, the number of passengers, distance of journey, and so on. Notwithstanding the upgrading of these technological infrastructures and hardware, participant GP4 and GP5 pointed out the limitations of them and their associated data that are enabled by government only and emphasised the role of big data coming from citizens and applications of private technology enterprises.

> *"We usually provide Didi [a car-pooling firm] with traffic data generated from our infrastructure and hardware and urban control room [e.g. traffic*

> *counting]. They use these data to optimise the distribution of cars, and in turn they offer us data of traffic density and vehicle information for us to better manage traffic."* (GP5)

This suggests integrated use of data coming from both the government and private sectors and data flows of both types transferring between these two sites of data practice. Herein, government infrastructural and hardware data are used by private enterprises for a new purpose via big data analytics, and in turn new data that creates more value are transferred back to the government for efficient and effective transportation management. Such data flows further suggest value creation from the integration of data generated from different sites of data practice, which is enabled by co-production between different types of stakeholder organisations.

6.3 Communicative and integrative government administration

This section reveals the third endogenous factor that may influence on the design and implementation of the proposed data-integrated STS application. Participants pointed out that the problem with independent administration still exists in Shijiazhuang government, resulting in impediments of information dissemination and policy delivery across different levels of government administration, both vertically (hierarchically) and horizontally between departments. This challenge exerts serious influence on inconsistency across government and executive force of subordinate departments. The design and implementation of the proposed data-integrated solution would be therefore hindered by the lack of effective communication and integrative vision of government administration. The following sub-sections will explore this issue respectively from the perspectives of government devolution, government officials' expertise, knowledge and vision, inter-department synergistic cooperation, and the constitution of Special Purpose Entities (SPEs).

6.3.1 Government political devolution

When asked how a government could be a smart government, more than half of the participants indicated the necessity to overcome bureaucratism and 'will of the leader'. This is an issue that, on the one hand government officials take course of actions by virtue of historical experience and in many cases take things for granted, and on the other hand they ignore the role of subordinate divisions who have insufficient resources from higher levels of government and limited power to put decision making into effects. As a consequence, subordinate government departments have no alternatives but conform to what they are asked to do by higher levels of government, though actually they are more familiar with what needs to be done. This results in many emerging 'vanity projects' which are accomplished by the government, purely for the purpose of benefiting vested interests (e.g. higher-level government officials waiting to be promoted), without carefully taking citizens' demands into consideration, hence giving further rise to significant waste of government and social resources.

Narrowing this issue down to proposing STS initiatives, the data analysis found that government devolution would play a pivotal role in setting out clear work commitments (Interview: GP2), making more effective hierarchically organisational decisions (Interview: GP3), and in empowering lower level departments (Interview: GP1). This was deemed as a necessary enabler to enhance the government's integrative executive force and efficient top-down information dissemination. In particular, the empowered subordinations can directly intervene in social resources and activities. However, it is noticeable that although the government has made certain efforts in political devolution, participants expressed that the subordinate organisations are not really empowered to make independent decisions, relevant rules, or regulations. According to their knowledge and experience, therefore, participants maintained that real political devolution might be helpful to coordinate on-the-ground transportation resources. For the data integration scenario, such devolution could mean that subordinate departments are empowered to engage in communicating with different stakeholder organisations and coordinating data resources from different sites of practice.

> *"Sometimes we know what we need [e.g. the adoption of some technology], but we are not [empowered] to make a decision of doing so. It is not because we are not allowed to do it, but because no specific and clear documents from top leadership stipulate its legality. We cannot do anything but to wait, dealing with daily routines."* (GP2)

What GP2 is saying here exposes a serious challenge that exists in government administration: lack of seamless top-down information (e.g. policy) dissemination and information-sharing mechanisms, which results in non-objective subordinate execution. However, in Shijiazhuang, the government has acknowledged the need to overcome the issue of devolution, thus it had significantly empowered many subordinate offices of transportation departments. For example, the top Shijiazhuang government declared to empower the Office of Traffic Congestion Governance who were endowed with rights to make decisions of rewards and punishment to inappropriate traffic actions, and to set rules and conditions to STS private enterprises in regard to business pertaining social collaboration. Community Committees and Urban Management Offices are subordinate government agents that have direct communications with citizen representatives. They are empowered with rights to make policies to better govern the communities in their own district, but the problem is that they do not really listen to what citizens say about their life.

Apart from subordinate government departments, government devolution also works for empowering state-owned enterprises, e.g. taxi companies and bus companies. This type of organisation is fully controlled by the state without self-autonomy. GP2 argued that government devolution would expand their business capacity in terms of stretching out the channel through which they attract and gather transportation resources by means of public-private partnership, as stated below:

> *"They are expecting us to authorise them with more legal self-autonomous rights, so that they would not be corralled into the policy-based settings wherein they are not flexible to make their own decisions."* (GP2)

The perceived benefits of government devolution would therefore square with the data-integration solution of STS development, not from the perspective of data operation, but in terms of the opportunities of extending the avenues through which data resources are gathered.

6.3.2 Government officials' expertise, knowledge and vision

Whilst the last sub-section pointed out the necessity of government devolution which helps augment subordinate departments' force, this sub-section is focused upon the way in which executive force is further strengthened by enhancing government officials' expertise, knowledge and vision. In the context of smart transportation, although government officials have made great effort to promote big data technology under the banner of 'being smart', they lack relevant expertise and adequate knowledge. As a result, there are risks of senior management making inappropriate decisions and not being able to accurately respond to issues brought about by technological changes. Therefore, it would be imperative to enhance knowledge learning amongst senior management within the government in order to have basic expertise and knowledge of big data related technologies - as stated by GP4:

> *"If you ask top management three basic questions (what is big data? What is cloud computing? What is cloud?), I would not think they are able to interpret them well."* (GP4)

It is argued that enhancing government officials' expertise and knowledge would become more important, provided the proposed data integration solution of STS innovation involves diverse expertise and STS per se embraces cross-disciplinary knowledge. Moreover, vision was also identified as an enabler to stimulate data-driven STS innovations. Participants expressed the significance of leadership support for a particular urban innovation executed by collaborative stakeholders. GP5 in particular pointed out that the pre-condition of leadership support was government officials being able to fully understand the profound implications of data being integrated. Such good comprehension would enable a broad vision of building STS in general and the overall design of data integration projects.

> *"It is necessary to increase the awareness of leveraging big data to urban transportation and integrating data with different types for an integrated service. Meanwhile, the organisational structure should be configured as data-driven, digitalised and networked, in order for government officials to have a strong sense of datafication."* (GP5)

Further to this, GP3 suggested regularly organising special training events about the basic principles of transportation data and the use of data (e.g. data sharing, data flows and big data) to relevant government officials, including both general employees and top management. The next sub-section will be focused upon internal synergistic collaborations between different government departments.

6.3.3 Inter-department synergistic collaboration

Participants expressed their empirical experience in collaboratively fulfilling smart city projects with people working in different government departments. Such kind of collaboration was identified by participants as synergistic collaboration and was perceived as indispensable in data-integration projects which involve a concerted effort between different sites of practice. Such synergistic collaboration has two-fold meanings in terms of the scale of government administration both within the transportation sector and beyond it. Within the transportation sector different departments work synergistically, with each being responsible for a particular phase of the project. For urban innovative projects, it is imperative to set up a synergistic engagement mechanism wherein the projects run through an organisational structure of *'leading department – coordinating department – engaging department'* (Interview: GP2). For a particular department, the role it plays varies across phases of the project. For example, urban planning bureau is usually designated as the *leading department* when a particular STS innovative project is being planned at the initial stage; they then step down at the policy making phase and become the *engaging department*, at which point the transportation bureau takes over as the *leading department*. Such role shift suggests the importance of synergistic cooperation wherein every single participant is part and parcel of all components of a project which involves many stakeholders - as suggested by GP3:

> *"We [Traffic Management Bureau] only stay involved without needing to lead or coordinate anything [in the planning stage], as it is not our main responsibility. But this does not mean they do not take our advice into consideration. […]. I would say every department is indispensable, just acting as different roles in different stages."* (GP3)

Beyond the transportation sector, different departments make a concerted effort towards a comprehensive government smart city project that involves not only the domain of transportation but also other sectors, such as education, healthcare, and so on. Participants revealed that transportation related departments would be regarded as a whole, working synergistic ally with each other to support project advancement. In this sense, the administrative boundary across different transportation departments would become weakened, in order for smoother communications and frictionless data sharing.

6.3.4 Special Purpose Entities (SPEs) constitution

Participants as a whole expressed the need to constitute Special Purpose Entities (SPEs). SPE in the general context is a legal entity that is established by enterprises who are enacted as the initiator to transfer organisational assets for a special purpose or circumscribed activity (Gorton & Souleles, 2007). In the context of government administration, SPE is regarded as a subordinate department or institution that transfers some government assets (i.e. data) to carry out some specific purposes which involve legal and formal protocol-based data input and output and commercial data transactions. In the interviews participants mentioned that Big Data Centre constituted many years ago with the objective of collecting and managing various data resources for smart city construction (Click here for more details: http://www.sjzbigdata.gov.cn/). This centre was jointly founded by Shijiazhuang government and state-owned technology enterprises, with the aim to efficiently manage and effectively coordinate data resources for distinct purposes, for example data integration. It contains business and administrative data from all government departments and state-owned enterprises across various sectors. In addition, GP3 revealed that there were many data operatives and government officials with data management expertise, who used to work in different departments, are now mandated to take charge of the Big Data Centre.

> *"They were granted with function and power of coordinating, dispatching and distributing data resources, and arbitrating relevant stakeholders for the case of inappropriate and illegal use of data. They were also vested with power of legislation to a certain extent in regard to the legitimacy of data use and sharing for different purposes."* (GP3)

When asked about how data integration would possibly work, GP3 explained that the mandated manager assigns data operatives to examine the attributes of data sets stored in different databases; these data are then extracted from the data centre and integrated with data coming from other sites of practice, for example, private sector organisations.

Participants also expressed the need in future to establish a SPE with the purpose of better communications across different government-relevant stakeholders. In particular different government departments communicate with each other to address any questions or challenges that stand in the way of inter-department collaboration (Interview: GP2). For the proposed data-integration STS solution, such SPE would play a crucial role in government informatisation, acting as an online communications committee to make sure problems with data coordination, data sharing, data use and data transfer from across the entire government site of practice can be addressed effectively.

6.4 Political legitimacy

This section revealed the last endogenous factor that was perceived by participants to have potential influence on initiating data-integration STS innovation. Participants provided in-depth insights of the inter-relationship between China's political system and the development of smart city initiatives. At the top of the political system is political institution, which forms the foundation of the second layer of the political system: legislation, policy-making and formulation of social rules and regulations. These political stipulations generate national urbanisation programmes, such as new-type urbanisation, smart city, smart transportation, etc. for the purpose of social and economic development. Within such a top-down political system structure, the government on the one hand leverages Chinese politics to the maximum to ensure all types of social innovations meet legal requirements, while on the other they promote these innovations to stimulate economic prosperity through the attempt of privatisation and marketisation (Pang & Plucker, 2012). This means that STS innovations in China's political context are developing towards the orientation of government-enterprise cooperation, public-private partnership and marketisation but are fully controlled and circumscribed by government political power (Zhu & Zhang, 2018). This section demonstrates the findings of political legitimacy from three different dimensions (sub-themes), with each looking in detail at corresponding factors (codes) that were perceived to be important for initiating data-integration STS solutions.

6.4.1 Policy enactment and enforcement

This sub-theme reveals issues around legislation, policy-making and implementation procedures, formulation of transportation rules and regulations, and the perceived approach of using government data. It is noteworthy that participants on a whole emphasised the need for opening government data for public use (e.g. citizens, the private sector). In particular participants expressed that the government has attempted to make some data available for public to access through government websites and mass media. However, these attempts lack political underpinnings to make them effectual. The following sub-sections will explore these issues in more detail.

6.4.1.1 Emerging technology purposed policy-making

Participants expressed the circumstances in which some policies are made purposively in order to put technology-driven innovations into effect. They further highlighted that the emerging technology-based STS initiatives could be a two-edged sword to the urban transportation system if they were not to be legitimated by city authorities. Whilst the positive side is that these innovations would be able to enhance urban transportation efficiency (which echoed citizen participants' perceived benefits), they can also give rise to an imbalance between service delivery and their end-users. Such imbalance could further lead to managerial issues, such as traffic disorder and chaos. GP1 argued that these issues would mitigate once new relevant laws and policies are enforced. Therefore, not only would such purposive policy-making support the development of STS initiatives, but would also set restrictions on their operation. For example, GP1 mentioned E-bike (i.e. a newly launched business of Mo-Bike Ltd.) as a typical example of purposed policy-making for emerging STS innovation.

> *"E-bike was created to tie in with sustainability and smart mobility banners. It, indeed, has brought great convenience to people, but no specific legislations were made at its initial stage of implementation. […]. People really like it because it is fast, convenient and eco-friendly. […]. The problem is they ride on any type of road as they please. As a result, the proliferation of e-bikes throughout the city gave rise to serious traffic congestions everywhere in the city, especially in city centre."* (GP1)

What GP1 implied here is the lack of legally effective measurement (e.g. speed limit, specified lanes) to limit the utilisation and operation of the e-bike service. It is interesting to acknowledge here that the government would tend to support a particular enterprise to develop innovative business but would possibly object to some specific products or services that they deem as harmful to the city, unless concrete underpinning policies are enacted. For instance, the bike-sharing business is widely accepted by the government, but e-bikes are not encouraged due to concerns with regard to public safety.

It is also noteworthy that although many STS innovations are legal, they would bring about potential hazards (in relation to not only public safety but also latent economic, cultural or environmental dynamics) that threaten STS advancement. Rather than to force and push, the government would instead tend to nudge or exhort the enterprises who initiate these innovations to terminate relevant services with such kinds of hazards by means of incentives for instance. A typical example is the rules of guarantee deposit that are widely applied in many sectors; therein customers would not be able to use a particular service until they have paid a deposit. In the context of STS, many bike-sharing firms enforce their own rules of guarantee deposits which ask end-users to pay for the deposit before they start using their bikes. However, the government nudged bike-sharing firms to abolish the deposit rules as they might give rise to issues regarding information fraud (Interview: GP1). In this sense, the majority of enterprises who resist the nudge to terminate the services/operating policies/rules, and in such do not conform to the requirements set by the government, are likely to be gradually excluded from the existing market.

6.4.1.2 Policy circulation and propaganda

Participants held that STS policies ought to be made for the consideration of long-term benefits and profits holistically from the city point of view (e.g. to achieve sustainable smart transportation), rather than be enacted for short-term interests for some particular groups of people, for example to enhance traffic capacity for car users. For example, GP4 expressed his perceptions that government policy makers should have holistic view of decision making, and thus steer citizens towards using low-carbon means of transport (e.g. buses, underground trains) by virtue of mandatory political power, rather than simply come up with solutions in particular to address their transport demands (e.g. expanding roads, building road bridges). Such perception chimes with citizen participants' desires in regard to the eco-friendly development of STS initiatives. In this sense, the findings indicated the need for government propaganda, policy circulation and relevant strategic planning agendas, in order to enhance policy learning (Interview: GP1), and speaking from a government standpoint, to cement and maintain the affinity with citizens (Interviews: GP2, GP3).

> *"We usually launch theme publicity campaigns for promoting government policies at public places like squares, parks, etc. in special days, such as Labour Day, National Day, etc. […]. There are individual citizens, social communities, private enterprise representatives, public organisations*

involving in the campaigns. […]. We distribute some little presents and rewards for participating individuals and organisations and those who volunteer. We also send out our pamphlets on which recent policies, government stipulations and regulations are stated." (GP5)

These particular actions of policy circulation and propaganda apparently reveal that the government play a steering control role in the relationships between themselves and citizens, and also between themselves and enterprises. With such a vision of centralisation, many techno-political initiatives turn up (e.g. Harmonious Society[1]), which are widely promoted by both government and social organisations; these are acknowledged as being helpful to urban sustainable development (Interviews: GP2, GP4), and are fundamentally at the heart of smart city development (Interview: GP2).

6.4.1.3 Transparency of government data

It is nowadays widely acknowledged that transparentised government information is regarded as important to enable democratic participation, people's trust in the government, prevention of socio-political corruption, strong decision-making and policy-making capacity, and provision of government information goods, and so on (Bertot et al., 2010; Cuillier & Piotrowski, 2009). Lord (2012) argued that nations that embrace transparency are more likely to share government information to the public. When asked about the state-of-play of Chinese government's transparency, participants expressed a positive attitude towards government data tending to be accurately collected, measured and processed and more effectively accessed and shared with the public in recent years, compared with a decade ago. This advancement means smooth data mobility, that data can move across boundaries of sites of practice (e.g. government, enterprises and citizens), wherein information and knowledge would be generated and finally put into use. For the purpose of this research, participants argued that the effective transparency of government data would be essential to initiate the proposed data-integration STS solution, and they particularly highlighted:

> *"Transparency of government data would benefit both citizens and organisations for co-production objectives and values."* (GP1)

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[1] Harmonious Society refers to a socio-economic vision in China that advocates social justice and equality. It is interpreted also as a technology-driven governing philosophy of balanced economic growth and moderate prosperous society. [Relevant references: K.-M. Chan, 2009; S. Li et al., 2013]

Nevertheless, these citizens and organisations should make known transparency policies, such as:

> *" [...]. I would say [the following aspects are important:] the characteristics of government decision-making process, stipulations of shareable data, transparency conditions, and so on."* (GP3)

First, characteristics of government decision-making processes. Participants emphasised that government information/data would not become transparent when decisions about a particular innovative project are being made; instead, they would become accessible to the public during or after the process of project implementation. GP5 further argued that the government has full power to decide what, when, and by what means, information/data can be made transparent and how it is shared with the public. For example, he said:

> *"Every time when traffic density around the train station is tense, or on-going road work on a particular road is in progress, for examples, we assign bus companies to temporarily add a few more routes and ask cruising taxi firms to distribute more taxis, in order for release traffic pressure. Then we suggest citizens to take public transportation instead of to drive, notify them to avoid passing through those areas, and let them know the recommended routes of buses and metros, through mass media and the internet."* (GP5)

Second, stipulations of shareable data. Participants revealed two types of data that need to be transparent to people. The first type is data pertaining to people's livelihood, such as the quantity of available car parking spaces in cities. The second type is data coming from city surveillance systems that infringes public privacy, e.g. road cameras. In this sense, participants argued that citizens should have their rights to know what these data are about and how the government may use these data to police them. Taking road cameras as example, GP2 claimed that citizens should know whether these cameras are used to detect traffic flows, capture speeding vehicles or to record other types of offences. However, participants also acknowledged that in order to ensure transparency and to officially define usage conditions, all data sets should be scrutinised.

Third, transparency conditions. Participants' concerns about transparency conditions includes two issues. The first issue is in relation to decryption. GP4 emphasised that only decrypted data (i.e. after the removal of confidential government data) can be shared with the public for both citizens and commercial organisations to use. The second issue is subsequent data update and maintenance. GP5 revealed that only 17.21% of government data that are shared with the public can be updated in a timely fashion, resulting in government data sources not being regarded as reliable and stable and which cannot be firmly anchored in commercial applications. This means transparency of government data should not only be concentrated on the manner of data sharing and data accessing practices, but also upon long-term regulative maintenance.

6.4.2 Centralised political power

Following the last section which was focused upon policy making and implementation, this section reveals participants' perceptions of government centralised political power that were seen as enablers to initiate STS data integration based upon government-led social collaboration. The findings reveal that the government always plays a leading role in government-enterprise collaboration. Specifically, the government has significant access to private enterprises' data assets and relevant resources, and almost full control of the administration of state-owned enterprises (Berkowitz et al., 2017). As such, in order to effectively direct, coordinate and lead such partnerships, the government would tend to establish power mechanisms, such as setting requirements in terms of enterprise data that should be handed over to them, and the normalisation of data sets and regulatory oversight. These issues will be illustrated respectively in the following sub-sections.

6.4.2.1 Enterprise data hand-over to government

Participants emphasised that government data are more accurate and of higher quality than those owned by private enterprises, but lack real-time capacity and diversity. Hence the government needs complementary data acquired from private sectors which are regarded as comprehensive, diverse and updatable in real time. In the context of STS, these data are usually big data that contain values which can be harnessed by government for efficient urban control and management. For example, vehicle density data owned by taxi firms would be of value for government to better manage traffic (Interview: GP1).

GP1 revealed that the government has the power to force enterprises to share their data that they deem utilisable and valuable (for example bike-sharing businesses made to share GPS data of real-time bike allocation). Many enterprises thus set up an account with authority for the government to access their database, but they would provide the government with limited access; they would not share their end-user data and data pertaining to their trade secrets. This is because end-user data are related to end-user privacy which may result in ethical issues, and core business data sharing would give rise to potential risks that may exert influence on their business prosperity. However, it is notable that the findings regarding this were only established in the interviews with the selected two sample government agencies in Shijiazhuang; other government agencies therein would need to be investigated as well to identify if the two types of enterprise data have ever been shared with them.

> *"For car-pooling firms [e.g. Didi, Uber], we are not interested in, and they would not share with us, their end-user related data, such as real-time user location, driver information, etc."* (GP2)

> *"[For business data of bike-sharing business,] what we [government] could see is whereabout has how many available bikes for use. What we cannot see is the extent to which a particular bike is damaged and the time it has been used, and so on. […]. The reason why they would not share these information with us is that these data are regarded as their core business data, and the sharing of which would affect end-user utilisation rate, hence impacting their business."* (GP1)

Data analysis demonstrated that on the one hand, when enterprises hand over their data to the government, this benefits the government by more effectively managing and allocating data resources, normalising data use standards, and coordinating different data owners' interests, whilst on the other hand it enables centralised regulatory oversight of business activities and online information dissemination across society. Under such centralised political power, participants revealed that enterprise data are shared with the government more often than government data are shared with enterprises. The government needs data from different private sites of data practices to facilitate decision-making and prediction processes. In addition, for data from private sector practices to be legally legitimate and nationally standardised and to somehow be shared back to enterprises for commercial use, would enhance industrial productivity efficiency. In the sense of STS data integration, such a *"win-win"* solution (Interview: GP3) augments the efficiency of government-led industry coalition and government-enterprise collaboration of STS initiatives.

6.4.2.2 Normalisation of government datasets

The afore-mentioned government related data types are two-fold: first, data generated from urban infrastructure, data acquisition tools and sensor equipment; and second, data handed over from private sectors. For the first type, these data are usually raw data that need a set of data processing procedures, including data cleaning, data testing, data computing and data storage, in order to be utilisable. As such, GP2 stated that raw data requires holistic data standards so that they can be used for legal and official purposes, especially when the raw datasets are diversified in data formats, structured for different purposes of use, and need to be integrated. Likewise, for the second type, data from other sectors need to be normalised based upon national data protocol standards in order to be compatible and integrable with data from the government site of practice (Interview: GP3).

> *"For government-led STS projects, there are always special agreements set by the government, including data protocols (wherein data need to conform to national standards), division of work agreement, and project deliverables agreement, and so on. These agreements need to be set out at very initial stage of the project."* (GP3)

The clear setting of these agreements for a particular innovative project would enable normalisation of market activities, particularly when the project involves a variety of stakeholders. Here, participants highlighted the social and market advancement enabled by STS data normalisation which is built upon big data and IoT technologies. They pointed out that in the past, many transportation services incubated by the market were not unified by industrial standards, including data production, system architecture and pricing mechanisms. In the car parking market for example, many private car parks were randomly priced, and customers were charged without an appropriate pricing mechanism in place, leading to complaints, market disorder and poor governance (Interview: GP1). In contrast, the big data and IoT driven car-parking configurations have allowed technology to replace human intervention, therefore allowing the government to normalise management standards and market conduct (e.g. unified pricing standards for car parks). For the proposed STS data-integrated solution, it can be argued that normalising data standards would be considered as a fundamental condition, as such a solution would involve many stakeholders' interests which embrace various commercial and social purposes.

When asked about what measures could be taken to enable high quality normalisation of government datasets, GP5 emphasised the need to firstly make data produced from various places machine readable, and secondly to establish 'data release censorship' to ensure normalised data sets are utilisable without problems. Machine-readable data help to unify data structures and the channels through which data are converted to information and disseminated to other sites of practice. The 'data release censorship' enhances the efficiency of data normalisation and is considered as a precautionary measure against potential risks and mistakes.

6.4.2.3 Transportation regulatory oversight

Participants expressed that an important aspect of sustainable smart city development is the creation of an effective regulatory oversight mechanism, and that the government needs to leverage their political power to direct transportation-related social and market activities towards normalisation. In the context of STS, this oversight is primarily focused upon urban transportation infrastructure management, enterprise business operation and public transportation coordination. Here, participants particularly emphasised the importance of monitoring and regulating transportation-related internet services and physical properties that are provided by private enterprises. The findings of this sub-section reveal participants' perceptions of the need for overcoming regulation issues of shared bikes and ride-hailing taxis. Behind their perceptions is the significance of leveraging governments thorough the configuration of regulatory oversight systems, which was deemed as necessary to initiate data -driven and -integrated STS innovations.

> *"I think irregular management of shared bikes would easily result in traffic disorder issues, which impacts the image of a city. For example, people who ride shared bikes would randomly stop and park. As a result, you can see bikes disorderly parked every corner of the city. […]. Although apparently this is a management issue, we can force corresponding companies to use technical solutions to mitigate this issue."* (GP1)

What GP1 was indicating here is that the government would ask affected companies to re-examine their top-down design and system architecture, and to back up their GPS data from each single bike/taxi (e.g. quantitated data representing ratio of road to traffic flows, traffic counting, road carrying capacity) to the urban control room. Therefore, the government would be able to track, supervise and regulate these transports in real-time in order to achieve smart coordination. For ride-hailing taxis in particular, another solution to tackling this issue is through legal administrative power, as GP2 stated below:

> *"At the meantime of encouraging, we have also been attempting to improve our supervisory system to monitor their business operation. For example, we ask all potential drivers to pass a special driving test in order to be able to be a competent ride-hailing service provider. Companies who are joining the ride-hailing market also need to obtain our newly updated business certificate."* (GP5)

The purpose of improving such a supervisory system is to make sure STS services in relation to public safety, both in online and offline forms, can be regulated and restrained by legal administration. In order to guarantee the performance of such a system, the government would make relevant rules and regulations, particularly for managing shared bikes and car-hailing taxis, for instance, and may constitute temporary administration offices and online communities to directly communicate with corresponding firms, with the goal of rapidly responding to emergencies. These firms need to report to the government any emergent irregular information, such as vehicle order dispatching routes, moving trajectory, citizen complaints, customer service reviews, emergencies and incidents, and so on.

6.4.3 Trust system

The last component of political legitimacy was identified to be a trust system. Participants expressed that, apart from leveraging policy making and centralised political power, the government should also establish an appropriate trust mechanism to specify data ownership, copyright and end-user credibility. This trust mechanism was deemed necessary when considering data from various sites of practice being integrated into one place. This subsection will explore the issues around trust systems from aspects of data ownership and copyright stipulation, data trust and the set-up of transportation credit system.

6.4.3.1 Data ownership and copyright stipulation

Stipulating data ownership and copyright in this study means a clear statement of consistent legal proprietor and data property, whoever the data are shared with. For the proposed data-integrated STS solution which involves various data owners, participants claimed that it is imperative to stipulate which sets of data belong to which data owners:

> *"It is necessary to ensure data ownership will never change no matter how data flow and are used across different sites of practice. This would avoid disputes about copyright issues between data owners. Stipulating data ownership and copyright is the pre-condition and basis of data sharing, transactions, trades and value-added services."* (GP3)

GP3 further argued that it is crucial to raise data stakeholders' awareness about protecting data ownership and copyright. GP5 emphasised the necessity of ensuring data traceability, meaning that operating systems should be able to figure out where a particular set of data originates from, i.e. generated from which data owner. GP4 mentioned that data authorisation protocols need to be clearly and legally set up, i.e. specifying, granting and protecting data user rights (e.g. free data-sharing rights).

6.4.3.2 Data trust

The findings found that data trust plays an important role in validating data sets during the process of data integration. This trust embodies both data users and data owners entitling validity and credibility to the data sets which are yet to be integrated. For a data-sharing or data transaction process, trust suggests that data owners trust the data to be shared would not be used for other purposes, and that data users trust the shared data are new and authentic (Interview: GP3). Data users are divided by participants into two types: business users (i.e. organisations, who re-use the data for other business purpose, e.g. government departments, enterprises, public institutions) and citizen end-users (individuals, who access data for the purpose of everyday information. GP3 highlighted that the government should take responsibility to force both types of data users to register as legal users through a user authentication system before they can access data or use services that involve relevant data.

> *"[For example], many STS mobile applications ask users to link their resident ID to the application, just to prevent online information fraud and other relevant legal problems from happening."* (GP3)

In the case of the proposed STS data-integrated application, such a user authentication system was perceived to record individual use of all transportation services delivered by the integrated application. The technology behind such a system (e.g. big data analytics) would be able to predict potential future end-user use trends, based upon the analysis of historical records (e.g. frequently used means of transport, frequent locations, online transaction record, etc.). Not only would this authentication system be able to ensure legal, secure and the appropriate adoption of STS services, but would also be expected to provide users with predictable suggestions and recommendations for their future engagement. Furthermore, participants expressed their thoughts of the perceived requirements of data trust practices for the proposed data integration solution, for instance:

> *"It is important to guarantee individual and organisational privacies involved in data sets would not be disclosed [to the public]."* (GP4)

> *"When a great quantity of data is integrated together, we should make sure data would not be repeatedly, mistakenly and aimlessly used."* (GP5)

> *"I believe data inter-operability is rather important. We should enable data from one site of practice are adaptable, compatible and associable to one another."* (GP4)

> *"[...], error-correcting mechanism/scheme needs to be established, in order to fix damaged and lost data sets."* (GP3)

Overall, it is the government's responsibility to make sure that trust exists across different sites of data practices, from the perspectives of both data users and data owners. Building a user authentication system to make data trustworthy was perceived as being key in terms of guaranteeing the validity and credibility of data sets for the proposed data-integration STS solution. The next sub-section will explore trust issues, which is based upon participants' perceived solution to constrain and normalise citizen behaviours.

6.4.3.3 The set-up of transportation credit system

Transportation credit system was explored to be an effective way to encourage citizens to behave appropriately during transportation-related activities. Participants suggested that the idea of credit systems used in banks should also be applied to data-driven, networked STS. Different from the aforementioned user authentication system which was focused on legitimising individuals to be authenticated end-users, the proposed credit system is regarded as a form of surveillance that monitors citizens' social behaviours, thus enabling measurable assessment of both individuals' and enterprises' social and economic reputation (Yongxi Chen & Cheung, 2017; Liang et al., 2018).

> *"[For the proposed data-integrated STS solution], this can be seen as a comprehensive and more integrative version of driving licence scoring system, but used not only for car driving, also in other forms of transportation services, [e.g. car-hailing service, bike-sharing service, public transportation, etc.] "* (GP2)

This depicts a scenario where each individual user is given an account that involves all-encompassing transportation information and a credit record of their engagement in transportation activities, e.g. speeding, car renting, metro taking, etc. When asked about ethical issues participants emphasised that the real purpose of such a credit system is to legalise and normalise the use of urban STS initiatives, rather than discriminate people by classifying them into different credit classes. Admittedly, those with extremely lower scores, due to whatever reasons, would need to be marginalised and their rights to use urban public transportation services (particularly in relation to driving) would be circumscribed. Participants claimed that such scoring practice could be a good measure against unscrupulous transportation involvement of citizen end-users. For the proposed data-integrated solution, participants perceived it necessary to embed such a credit system into the integrated system, as people's daily interaction with such a data-driven complex STS could be normalised and restrained within legal bounds. In a word, the might of such a credit system used in STS was perceived to be an enabler to propel citizen end-users to strictly conform to the laws, policies and relevant transportation rules and regulations (Interview:

GP2), and to circumscribe all stakeholders' business and social behaviours in legal terms (Interviews: GP2, GP3), hence avoiding any flaw of these legal stipulations that could become a loophole for unscrupulous individuals and organisations. Such kind of loophole could be the concerns regarding surveillance and privacy that citizen end-user participants might have been concerned about.

6.5 Open-door economy

This section demonstrates a set of perceived exogenous factors that would not impact on the fundamental settings and necessities that underpin the design process of the proposed data-integrated STS application, but would enable effective and efficient implementation of such a proposal. In this section, the findings explore several facets that act as economic catalysts and are pinned down to the issues of the way in which innovative solutions are implemented; these innovations are propelled by, and have further strengthened, China's open-door economic policies. Such mode of economy derived from the Reform and Opening-up in 1978 which marked an important China's transition from a planned economy towards a market economy (J. Y. Lin, 2004). Millions of enterprises in all sectors have sprouted up ever since and more and more market-oriented innovations have been encouraged to stimulate high rate of GDP growth (Yifu Lin et al., 1996). In the era of smart city, therefore, the state has taken drastic measures to further enhance such open-door economics via marketisation (P. Liu & Peng, 2013). Amongst these measures, participants particularly raised the issues surrounding demonstration project implementation, open-door economics for investment promotion, and regionally characterised business modelling, which they perceived as crucial to promote the proposed data-integrated scenario.

6.5.1 Demonstration project implementation

The demonstration project in the context of STS for city development means a particular STS initiative that is legally ratified by government for implementation, then subsequently seen as the paradigm that can be replicated and generalised towards wider geographic settings. Participants expressed that for a particular initiative, it is imperative to firstly launch a demonstration project in a particular region (e.g. a district, a city) before all-out implementation. If the expected performance and outcome are not reached, the initiators or practitioners ought to make further effort; if they are reached, such a solution would be expanded towards large-scale implementation and other regions would see it as a prototype and simulate whilst taking into consideration their own local characteristics to implement the solution on the basis upon their own urban settings (Interview: GP1). The purpose of this is to see whether the proposed initiative is really capable of addressing citizens' demand (e.g. tackle the challenges that citizens struggle with), reaching organisational goals (e.g. business objectives), and conforming to governmental and national industrial standards (e.g. data structure). This should be carried out with reference to its Key Performance Indicators (KPI, referring to the comparisons of actual, and estimated operational, organisational, structural, and managerial performance, in regard to effectiveness, efficiency and quality of work (such as Meier et al., 2013; Parmenter, 2015).

> *"The smart car-parking service [rolled out by a state-owned corporate, subordinate of Shijiazhuang Transportation Bureau] was initially launched as demonstration project to several a few public car parks. The overall performance and outcome were rather positive [fed back from car park owners and citizens]. […]. Such service spread out afterwards to peripheral regions of Shijiazhuang."* (GP1)

Here, demonstration project implementation would offer 'testbeds' of the booming economy, on which enterprises would grasp the opportunity to develop innovative solutions for city competitiveness. This would eventually stimulate urban innovation capacity. In addition to demonstration project being implemented to provide innovative solutions, participants also claimed the need for some specific policies to be demonstratively enacted for a period of time before receiving long-term validation. For instance,

> *"The policy of vehicle license plate number restriction was firstly applied in Shijiazhuang in 2016. The government announced this policy through all channels of media (e.g. telecast, newspapers, internet), and highlighted that the restriction would be deregulated in two months."* (GP5)

GP5 further explained that the purpose of such restriction policy is apparently to reduce exhaust emissions from vehicles. But from the very start, the government was not able to estimate to what extent such an ostensibly effective measure would mitigate the problem of the air pollution. The outcome of the demonstrative enactment of such policy proved capable of reducing the figure of PM2.5, which, thereafter, was identified as an effective avenue to remedy the urban environment.

6.5.2 Market-driven investment promotion

The Chinese government launched a new policy in 1978 which was widely referred to as 'open door policy'. This policy reformed Chinese economic strategy from being self-sufficient towards being actively participative in the global trade market (Xue-qiang & Si-ming, 1990). Participants maintained that this policy should not only be applied on a national scale, but also at city level, stimulating regional innovative economic prosperity. When asked about STS innovation of business in Shijiazhuang, participants emphasised the fact that business homogenisation, which had become increasingly severe, rendered low city competitiveness in general. Such homogenisation denotes that many businesses simulate, or even copy, good business models from others without endeavouring to create their own innovations.

For STS innovative applications, high homogenisation across businesses suggests that there would be little data or other relevant resources of value to be shared and utilised amongst them. This may exert bad influences upon business innovation and industry coalition for urban economic development. In this sense, participants pointed out that the government needs to encourage and promote market innovations and competitiveness and invite investments from businesses located in other cities and provinces. Such 'open door' economics would offer a hotbed to incubate STS SMEs to develop their innovative STS products and services, thus stimulating innovation diversity. This would further provide multiple opportunities for initiating the proposed data-integrated STS application that is based upon industry coalition.

> *"To reach cooperation, I think it is important to encourage business competition. This is because, with competition, one business would come up with services/products that others do not have. This distinction would in future become the pre-condition of cooperation and collaboration across enterprises. On the one hand, they would continue pushing forward their*

market supremacy, and on the other they may seek for win-win cooperation opportunity with other enterprises." (GP3)

Participants further revealed that an effective way for government to promote investments is through open tendering. GP4 claimed that open tendering happens when government would like to promote city competitiveness or would like to leverage business innovations to address particular urban issues. The government would provide good entrepreneurship conditions and welfares for potential enterprise, for example reducing commercial land price, establishing research centres, offering customised entrepreneurship trainings, and so on (Interview: GP4); they would even offer policy bonus, such as corporate tax reduction, and the allocation of funds for innovation (Interview: GP5). These measures offer a level playing field for various enterprises to develop innovative solutions. For STS, through the shift from competing against each other towards cooperating in a way of industry coalition, these enterprises on a whole would promote an integrative STS solution that integrates data and relevant resources from independent systems and applications.

6.5.3 Regionally characterised business modelling

Whilst the last sub-section explored the issues around government promoting investment and encouraging STS innovations, this sub-section reveals that the power and extent to which government enforce particular innovative projects and the amount of investment that enterprises make, are contingent, varying from city to city. Participants suggested that Tier-1 cities have significantly more opportunities of investment promotion than those in lower level cities. For STS development, this means that STS-related innovative projects are usually dominated by local enterprises in lower level cities (e.g. Tier-3, Tier-4, etc.), while big corporations usually give innovation priorities to Tier-1 and Tier-2 cities. This is because upper level cities have resource advantages wherein government agencies, academic and research institutions and private enterprises make a concerted effort to develop new smart solutions. With such collaboration, STS initiatives can be developed more effectively and smoothly without impediments in Tier 1 and 2 cities compared to lower-level cities which lack stakeholder support.

Participants believed that innovative businesses, taking regional disparity into consideration, is of paramount importance in successfully initiating new projects, especially for those who are non-indigenous businesses. As such, innovative enterprises should consider characteristics of the city in terms of their cultural, political, and economic dynamics competitiveness before any course of action. GP1 revealed that for non-indigenous enterprises to expand their business in Shijiazhuang, they should firstly familiarise themselves with these local characteristics, usually by both formally (e.g. official meetings in government office) and informally (e.g. informal chats) communicating with relevant government officials. Government officials would not only introduce local characteristics of the city, but also innovation conditions and guidelines of entrepreneurship, which are what the enterprises would like to know.

> *"Innovative business ideas, proposed by enterprises who come from other cities, should not be cookie-cutter that are not much different from those adapted in other cities. They instead should conform to Shijiazhuang's local geo-spatial characteristics, such as the traits of urban planning, road planning and road networks, and characteristics of population density, cultural dynamics and local residents."* (GP1)

For these enterprises, some of the information above is more useful if it is provided by city managers compared to searching for it online. For example, as GP3 said:

> *"I do remember when OFO [a bike-sharing firm] first came to Shijiazhuang, we had a chat with its top management about the master-planning and local characteristics. We told them that local Shijiazhuang residents in general need material incentives to participate in the so-called smart city construction. […]. Then OFO rolled out a business called 'red packet bikes" [people who used their shared bikes were likely to win a red packet, a random amount of money, as bonus]."* (GP3)

6.6 Purposive citizen engagement

This section continues to illustrate the second exogenous factor, purposive citizen engagement, that was perceived as a catalyst to initiate the proposed data-integrated STS solution. Purposive citizen engagement was explored to have indirect influence upon the success of implementing the data-integrated application, because it would not lead to any fundamentally structural change of the overall process. However, it was perceived as an indispensable enabler too, because it embraces several aspects of citizen engagement that may stimulate more effective and efficient project planning of the proposed solution. These aspects include citizen requirement elicitation, citizen reporting and monitoring, and citizen incentives.

6.6.1 Citizen requirement elicitation

Participants emphasised that 'citizen-oriented' is the core value of the Chinese government in terms of developing smart innovations. They suggested that all municipal governments throughout the country have been attempting to sense citizen requirements, in order to make plans, decisions and policies. Moreover, when these official government schemes are put forward, they also constantly follow up what citizens feed back to them in order to make adjustments and corrections.

> *"For example, Shijiazhuang Transportation Bureau rolled out customised shuttle buses, which was developed upon the basis of customer demands and requirements. Citizens were advised to raise their traffic preferences and relevant demands through its official website. According to these, the government developers then designed routes and smart services including reservation of seats, online payment, customised pick-up and drop-down, etc."* (GP4)

The findings reveal citizen requirement elicitation for citizen-oriented innovations is important because it effectively enhances the extent to which citizens participate in the creation of STS initiatives. End-user data and feedback generated from citizen participatory activities help the government take further action upon decision making and service delivery. For example, the customised shuttle bus service developed by the government involves an increasing volume of citizen end-user data because of the escalating degree of citizens participation. Hence the government can leverage the data that emerges from end-users to make better plans for routing and scheduling buses, which would further help enhance operational efficiency and reduce resource waste. For the proposed STS data integration solution, exhaustive citizen requirement elicitation would make each single facet of the solution more citizen-centric.

6.6.2 Citizen reporting and monitoring

Participants expressed that for city managers to be smart they need to listen to citizens' voices, not only from the perspective of what they demand, but also from the point of view of what they are dissatisfied with, what they complain about, and what they would like to say. In the past when ICT was not widely adopted in government affairs, people complained (e.g. about government services and citizen-related information delivery), petitioned (e.g. desired social services) and reported (e.g. abnormal incidents, government corruptions, damage of urban infrastructure) through letters, informants' telephone hot-lines, or visiting municipal authorities' office ('Shangfang' in Chinese). Nowadays, however, the way in which people do so is diversified through the internet, such as mobile phone apps, government websites, etc. Here, participants maintained that ICT-driven citizen reporting and monitoring would help the government to remedy issues citizens have found in real time, and for the most part relevant system data would be updated shortly afterwards. GP1 revealed that there are three primary channels of citizens reporting and monitoring: mobile applications, mass media and government websites:

> *"[...]. Mobile applications include two types: government applications and commercial applications. The former plays as the same role as government website, on which people can complain, petition and report everything they concern about. The latter is used for people to report to the enterprises what they have seen that are concerned with the city, for example, the damage of transportation infrastructure, large-scale traffic congestion, traffic accidents, etc."* (GP1)

> *"On many bike-sharing applications, there is a kind of function for users to report disorderly clustered bikes in a particular area, so that the manager can take drastic actions to tackle the issue. Users who have successfully reported could be able to obtain special bonus as incentives by the company."* (GP1)

It is noteworthy that these citizen reporting and monitoring mechanisms are not a one-way form of communication, i.e. the government in turn also provides useful information, suggestions and recommendations, to citizens.

> *"Citizens' reporting and monitoring enable more effective city governance. However, government at some point remind, warn, advise and recommend citizens in order to improve the quality of their life."* (GP1)

GP4 pointed-out that citizens' complaints about government service are sometimes seen as instrumental in improving the government's service capability, illustrated by the example of the mobile application, '12306', rolled out by the government railway department:

> *"'12306' has been bombarded with critiques from citizens since it was implemented, because it was not user friendly. People preferred and tended to use another app called 'Railway Steward' which was developed by a private company. Due to intensive inclination to 'Railway Steward', '12306' stopped their services, and it was sold to Alibaba who further re-fashioned the application and finally brought it back to the public."* (GP4)

In general terms, to overcome the issues complained about by citizens, participants expressed the need for the government to demonstrate in more detail their work plans in government annual and seasonal work reports, regarding what they have achieved, what they aim to achieve, and what resources they can share with the public. Whereas for the proposed data-integrated STS, this would mean more open, transparent government administration, a change in the government's attitude towards addressing citizens' concerns, and more importantly, an exhaustive plan for how the integration of data from across the city would work.

6.6.3 Citizen incentives

In the last sub-section, the findings revealed that citizens actively reporting abnormal traffic incidents or any emergencies, and monitoring bureaucratic corruption, would raise trust between government and the public. Further to this, this sub-section found that the citizen incentives mechanism propelled citizens to actively report and monitor. As such, citizen incentives was firstly raised as an enabling factor that would stimulate more citizens to participate in smart city construction, and secondly perceived as crucial to enable an efficient data integration process in STS where latent issues and risks that haphazardly take place, which may affect the integration performance, could be for the most part mitigated. GP5 mentioned the adoption of e-scorecard for garbage sorting and recycling in Chengdu, China. Citizens can receive recycling points if they hand in sorted recyclable items to the government. These scores can be used directly to pay for accommodation bills, or when the scores accumulate to a certain amount, they can be converted to cash. He proposed that such an incentives mechanism could be referred to STS development in Shijiazhuang, in order to incentivise more citizens to actively report anything abnormal and disruptive.

> *"Government should also roll out such e-scorecard system for citizens to engage in smart and sustainable transportation development. Data embedded in this system could be integrated with data from other sort of sub-STSs. I would argue that citizens would be willing to more actively report, feedback, thus further easing the obstacles of general transportation management."* (GP5)

6.7 Sustainability vision

This section reveals the last exogenous factor that provides opportunities for the long-term implementation of the proposed data-integrated STS initiative: sustainability vision. This factor was not identified as an enabler, but as an orientation that indicates what a successful and longstanding integrated system should look like.

Participants highlighted that the purpose of developing STS in a city is to sustain the long-term efficient and robust operation of urban transportation systems (Interviews: GP1, GP4), whilst creating and retaining eco-friendly living and working conditions with minimal environmental impact (Interviews: GP1, GP3). Therefore, the government as city managers, take responsibility to promote green transportation schemes and initiatives from both their own site and those within private sectors. Public transportation is identified as a typical green transportation solution. Both GP2 and GP4 mentioned the banner of 'public transportation metropolis' which is what Shijiazhuang is pursuing. To achieve this, the Shijiazhuang government has budgeted a large amount to invest in public transportation schemes. This inspired participants to perceive that the proposed data-integrated STS application should embrace elements of sustainability in order to make sure the progression of urban transportation efficiency would not come at the cost of damaging the urban environment. In particular, GP3 claimed *"the best way to govern traffic system should be to steer the groups of people who drive a lot towards taking public transports"*; GP4 reiterated *"rather than to sweep away the stumbling block for cars, smart mobility should be instead aimed to make commuting traffic smoother and smoother".*

The Shijiazhuang government has taken drastic measures to prioritise public transportation, for example:

> *"During smog days, government usually put two or three numbers restriction upon the vehicle license plate, depending on how bad the air quality is. At the meantime, buses are free of charge in those days throughout the city centre. This significantly improved the air condition as many people reduced their carbon footprint indeed."* (GP3)

> *"On many urban traffic arterials in Shijiazhuang, smart bus lanes have been configured specifically for buses and coaches. Other types of vehicles are not allowed to move on these lanes. The traffic lights are also specifically designed for bus lanes where the red-light time is significantly less than that on other lanes".* (GP4)

Due to these government measures and corresponding policy-making practices, as well as their political power, private enterprises tend to develop their businesses with sustainability in mind. For example, online car-pooling firms have been showing an interest in purchasing NEVs (new energy vehicles). Furthermore, in order to enable sustained STS growth, participants argued that it would be imperative that government officials have holistic vision of sustainability, and leverage their political power to propel sustainable innovations and legalise their practices.

6.8 Summary

This chapter presented government agencies' point of view of designing and implementing the proposed data-integrated STS application in Chinese cities. The data analysis explored these findings and revealed seven thematic, but interrelated, dimensions of issues that may influence the success of the proposed solution. These seven issues are: *data-driven and networked STS technology, urban transportation infrastructure and hardware, communicative and integrative government administration, political legitimacy, open-door economics, purposive citizen participation, and sustainability vision*. They were sequentially explored and finally presented according to the extent to which participants perceived these to be prioritised and how crucial they are in designing and implementing the proposed data-integrated STS.

Similar to enterprise participants' perspective, government participants proclaimed the importance of leveraging big data-enabled technologies as well as ICT-based urban transportation infrastructure to develop more citizen-focused and data-integrated STS initiatives. However, these technological underpinnings were deemed as necessary to work alongside appropriate government administrative and managerial strategies, suitable political and legal systems, and applied open-door economics.

In particular, from a communication point of view, the findings stressed the need to empower subordinate government agencies to directly be in touch with on-the-ground STS issues, augment inter- and intra-organisational communications in order for smooth data sharing, and establish special purpose entities (SPEs) as a frontline office to better coordinate various STS resources. As far as political legitimacy is concerned, the findings revealed participants' perceived necessities of centralising policy-making procedures and political power in order for normalisation and standardisation of STS-related industrial and civic activities, and for building trust system between STS stakeholders. Moreover, considering the role of citizens, participants highlighted the importance of constantly undertaking citizen requirement elicitation, encouraging citizens to actively participate in building STSs, and harnessing citizen incentives in order to engage with more citizens. Finally, the findings unfolded a higher-level standpoint of successful design and implementation of the proposed data-integrated STS – i.e. embracing sustainability vision.

Chapter 7: Discussion

7.1 Introduction

The aim of this research is to explore the potential challenges and opportunities for initiating a data-integrated STS application within the Chinese new urbanism from a socio-technical system perspective. In this chapter, the significance of the findings presented in the last three chapters (Chapter 4-6) is extracted by relating them to the existing literature about smart city and STS initiatives; the purpose of which is to conceptualise the findings of this study and understand the position of their contribution in the wider context of this research.

The literature reviewed in Chapter 2 provided an outline of the smart city, the STS, and data integration literatures which was crucial in shaping the theoretical and conceptual framing of this study. The key points of the literature are reiterated as follows:

- Many smart city initiatives, in a general sense, are viewed as socio-technical systems which consist of both technical components and social dynamics, and the successful implementation of which are determined by a number of factors, including: policy, technology, organisation, people communities, economy, built infrastructure, natural environment, and governance (Alawadhi et al., 2012; Chourabi et al., 2012). However, these indicators vary across different contexts according to local contingencies and variations.
- Citizen roles and the way in which they participate in co-shaping smart city initiatives are not neglectable in neither the neoliberal smart city (Cardullo & Kitchin, 2019a) or the Chinese new urbanism (Huifeng Li & De Jong, 2017) contexts. It is crucial to understand what a 'citizen-centric' initiative truly means, and how it is played out. Simply put, the neoliberal citizenship favours individual autonomy but is corralled into the practices of stewardship and civic paternalism. In China, however, citizen participation is seen as a political issue, i.e. political engagement, which particularly accentuates limited citizen roles in political debate and participatory design.
- Data integration for Chinese smart cities (including the STS) have been studied by a variety of social scientists from the technical and system points of view (e.g. An et al., 2016; EUSME, 2015; C. Huang & Kennan, 2016). However, the literature is significantly deficient in terms of the non-technical dimensions, especially when it

comes to political economic factors standing in the way of mobilising various stakeholders and their heterogenous data sources.

- Key issues around 'data' – unintended risks and underlying social problems of data practices – were reviewed, including: data sharing across organisations especially within government (Clifton et al., 2004; Fan et al., 2014; Hashem et al., 2016; Jing & Pengzhu, 2009); privacy, surveillance and social control (Guha et al., 2012; Van Dijck, 2014); and dataveillance and social sorting (Kitchin, 2014b; Zuboff, 2015).

Driven by such a socio-technical theoretical and analytical view of general smart city and STS contexts, the empirical research of this study veered towards a contextual issue of Shijiazhuang's STS data integration to explore more specific possibilities and challenges in an inductive way. The findings resonate with, but extend in more depth, the existing literature at some point of the new urbanism discourse wherein political interventions were observed to be an imperative factor within the given context. As such, uncertainties remained as to the very specific aspects of the design and implementation of the data-integrated STS from different perspectives. This chapter aims to disentangle these problems by integrating these findings into both the reviewed socio-technical literature of smart cities and STS initiatives, and also a broader political scientific literature that provides an essential understanding of the Chinese socio-political context.

The chapter begins with articulating key findings in general terms with regard to how each group of participants define and perceive STS data integration, followed by a brief summary of the cross-cutting themes identified from the three findings chapters and, based on these, the researcher's own understanding of STS data integration (Section 7.2). From sections 7.3 to 7.6, key arguments are presented with in-depth analysis of both findings and literature, which shape the theoretical framing of this study; the chapter then goes on to present the integrative framework (section 7.7). Section 7.8 presents a summary of the chapter.

7.2 Key findings and insights

The chapter firstly summarises the key findings extracted from the focus groups and interviews. These key findings lay the foundation of the theoretical framing of this study in regard to the identified potential challenges and opportunities. The first findings chapter presented citizen end-user participants' expression of their perceived STS data integration scenarios regarding what it could possibly look like and what could be the possible benefits and challenges in implementing the proposed data-integrated application. The second and third findings chapter illustrated more in-depth and socio-technically oriented understanding of potential challenges and opportunities for designing and implementing the proposed data-integrated STS application, respectively from the STS enterprise and government perspectives. In this section, cross-cutting themes developed from different groups are outlined. Differences and similarities between the groups within each theme are highlighted with regards to what the different groups understand about data integration for the STS. These themes include technology and infrastructure, organisational and managerial dynamics, stakeholder power relations in the STS market, political legitimacy, and smart citizens and citizenship.

STS Data integration as a proposed concept is complex and varies across the different groups of participants of this study, because they have distinct levels of digital literacy, technical knowledge, expertise, and practical experience of STS developments. The findings revealed that **the citizen perspective of STS data integration** is more concerned with functionality and serviceability. They imagined the proposed data-integrated STS application as an all-inclusive platform that provides all kinds of transportation information and services they need in their everyday life; in a nutshell, this could be claimed to be a 'super system' that is versatile and all-encompassing. **The STS enterprise perspective** is far beyond functions and services and is construed as a way of real-time and universal data access and as the unification of rules and regulations of heterogenous data sources. From their point of view, notwithstanding some problems to the detriment of their commercial interests, this data-integrated STS application stands for efficiency, flexibility and intelligence of urban mobility. Slightly different from this is **the government perspective** which places emphasis on not simply technical means of integration but also political and regulative integration of data sources. Here, data does not only suggest data per se but more often its associated political-economic relations between key data stakeholders (citizens as the data points, firms as the data producers and the government as the data regulators). Thus, they perceived the proposed data-integrated STS application to be the embodiment and guardian of the centralisation of the entire transportation ecosystem, and therefore it is termed as what this study will argue in this chapter – being state-steered. Comparisons between different groups' understandings of STS data integration are summarised in more detail in the following cross-cutting themes.

Technology and infrastructure

All three groups highlighted the importance of embracing effective technological and infrastructural deployments. Despite a lack of expertise in this area, citizen participants expressed their desires of the real-time functionality of the proposed data-integrated application services; on the other hand, however, they perceived that a highly integrated solution might be less functionally accurate in terms of data. On the expert and city manager stance, both enterprise and government groups argue that algorithmic and computational technologies that enable networked urbanism would be helpful to the data integration scenario. Data generated from different sub-systems and infrastructure of urban smart transportation, could be effectively processed, re-used and integrated into one place, enabling dynamic and encompassing data processing and analytics. However, these data processing procedures would rely on the standard system of the smart city that unifies data attributes and business logics, positively leading to the success of data integration.

Organisational and managerial dynamics

Organisational and managerial dynamics refer to both inter- and intra-organisational collaborations and management. Citizen participants perceived that the transparency of transportation information could be a benefit gained from the proposed integrated solution. Enterprise participants further explained that the vision of co-creation of value, such as advocating for industry coalition and government-private partnerships, is crucial in making information transparent. They claimed that data integration would need a concerted effort which involves STS data resource coordination amongst government transport agencies and all types of STS enterprises. Government participants also elaborated on this point by extending to intra-governmental information dissemination and communication, e.g. synergistic collaboration across departments and offices, political devolution, problem-solving mechanisms for purposes such as the Special Purpose Entity (SPE). In summary, citizen participants placed more attention on end-user effectiveness (transparent STS) as one of the potential results of integration, whereas the other two groups demonstrated empirical thoughts of underpinnings and running of cross-organisational collaboration.

Stakeholder power relations in the STS market

In this study, citizen end-users, enterprises (private) and the government are considered as the primary stakeholders in the given Chinese smart city research context. The power relations amongst them (e.g. data ownership, political hierarchy, civic rights) were identified as being critical in the contribution to data integration. This critical exploration of power relations was built on the unpacking of socio-economic factors by which the proposed data-integrated STS application is influenced. Citizen participants raised a noticeable issue in relation to market competition and consequently competition-driven collaborations across relevant STS stakeholders. In a word, their previous experience of using different types of existing STS applications suggested that STS enterprises compete, and thus differentiated services are developed in order to win more market supremacy. Therefore, competition and differentiation could be a challenge for data integration. However, they understood that policies with regard to the state-market relations need to be parsed in order to identify potential opportunities and challenges.

Enterprise participants placed emphasis on data governance and influences of marketisation and privatisation. Firstly, the findings illustrated this by suggesting strategic planning for governing data that come from various data sites for the potential of data integration. Here, they claimed that government authorities would need to stipulate data standards on the one hand, and enterprises, on the other, would need to build data-processing mechanisms to guarantee the quality of data. Secondly, the findings echoed the call for the increasing growth of open markets and privatisation stated in the NUP agenda. Rather than exploring the STS economy from the political and policy-making points of view, enterprise participants specified how they leverage market forces to enable data integration, based upon their understanding of the current state-of-play of market competition and culture-driven business homogenisation, and their experience of doing market research for their own businesses. Government participants extended this point to policy-oriented factors, such as national demonstration projects, political control over investments of the STS market, and local socio-economic contingencies and characteristics. These factors were explored in close relation to the legal and political system of the Chinese state, its urban regime, and its municipal policy-making of the STS market.

Political legitimacy

Although the citizen data showed little relation to this theme, the other two participant groups placed much emphasis upon it. Enterprise participants pointed out both opportunities and challenges regarding political legitimacy. In terms of opportunities, they highlighted open state legislation for emergent STS services especially those created by SMEs and stressed that these services are run with the umbrella of directional legislation (for certain municipal and regional application). This resonated with the government perspective which placed emphasis on purposed-built policy-making procedures, circulation and propaganda, and the building of the trust system. These factors of opportunity manifested political power by which risks of data from various systems being shared across myriad stakeholders, are mitigated. However, political challenges in relation to the centralisation of state power and hierarchical structure of state administration also exist. Enterprise participants pointed out this by complaining about one-directional and top-down (i.e. state to enterprise) supervision and regulation, the red tape, pecking order, and so on. Government participants emphasised government efforts on harnessing the designated top-down and centralised political power to balance a large range of vested interests when it comes to the scenario of integrating data from each of these interest groups, which is challenging.

Smart citizens and citizenship

Findings revolving around citizens considerably developed from all three groups of participants. Cross-cutting findings in relation to this mainly include privacy, surveillance and the right to the smart city, modality of citizen participation, and the 'smartness' mentality. First, citizen participants mentioned information security as one possible benefit if data were to be integrated in once place. Particularly, they expressed that the integrated application would need to be under the state control (e.g. surveillance systems), so information created therein can be monitored and protected by effective security mechanisms. This idea was backed up by their actual experience of privacy infringement by the overflow of applications developed by private IT firms. Enterprise participants extended this point in more depth by highlighting the importance of strengthening security censorship, building multi-authenticated environment for online information flow, and retrofitting security hardware and software. These measures are more or less technical, but they also reflect political attempts to enable state control and supervision. Responding to this, government participants introduced on-going implementation of the trust system across the nation which defines data ownership and copyright and the idea of building the transportation credit system in a similar way to the social credit system used in the financial sphere. Alongside road cameras and other types of CCTV, these applications indicate state control via surveillance with the purpose of regulating civil society including market activities and citizenship.

Second, the modality of citizens participating in STS was identified from enterprise and government findings. Enterprise participants introduced the growing digitalisation of STS services, such as mobile phone apps and traffic guidance systems, which pave the way for citizen engagement in enabling smarter transportation. Enterprises regard citizens as consumers or end-users (so user demand in services and functionalities is of particular importance). The government however, consider citizens as a crucial component of society (not being end-users but also the proprietor of the city) but they do not empower them to engage in designing actual city innovations. An important government finding here is that citizens are only actively involved in suggesting, reporting and feeding back on smart city initiatives either during or after their implementation i.e. not at the design stage.

Third, participants in all groups discussed the meaning of 'smart citizens'. Citizen participants referred this to the 'smartness' mentality, i.e. raising smart city awareness and being smart citizens (i.e. citizens who have decent traffic behaviour and correspond with the smart city ethos). They questioned the extent to which citizens reach this label when it comes to the integrated scenario. The other two groups of participants extended that this is because the integration of STS is not only a technical imperative but also requires behavioural control and self-awareness – interacting with the integrated platform in a clever and appropriate way: embracing the ethos of sustainability, strictly conforming to rules and regulations, and taking the initiative to interact with emerging technologies.

Overall, critically reflecting upon the participants' perspectives from all three groups, STS data integration technically means data produced from various systems with diverse identities, coming into one platform that unifies and standardises their use and underlying purpose and objectives. However, going beyond the technical aspect, the researcher argues that there are many more socio-political-economic dynamics leading to the success of addressing independency of STS data systems. To unpack these factors, the design and implementation of the proposed data-integrated system would rely on stakeholders working in concert for cocreation of value.

The following sections will take a closer look at the issues which emerged from the above critical cross-cutting findings. After discussing these issues, the chapter will present a theoretical framework to visualise the key challenges and opportunities for successfully designing and implementing a data-integrated STS application in the Chinese city context.

7.3 Governmentality and smartmentality

The findings of this study resonated with the prior literature where Chourabi et al. (2012) argued that technology is considered as a mega factor that influences the successful design and implementation of smart city initiatives. However, in addition to technology, this study also defined another mega factor that may influence the success of the design and implementation of data-integrated STS applications in Chinese cities – i.e. the characteristic of top-down political legitimacy. It is evident that such a factor exerts significant influence upon many other facets of expanding STS initiatives, such as governance, socio-economic dynamics and citizen participation.

The socio-technical advances in Chinese urban society remain politically driven, with innovative solutions tending to be politically-centric (Tyfield, 2014). What Tyfield suggests here is that the ICT-based technologies would be substantially in conjunction with the existing political requirements of urban development. The Chinese government in this process (both at central and municipal levels) plays a major role in shaping such a socio-political regime of technological sophistication. As the smart city bandwagon leads to myriads of business opportunities in developing emerging technologies (Zygiaris, 2013), the Chinese government has increasingly positioned itself as a technology-driven smart government providing many government-led solutions for urban development, manifesting the sign of transformation of governmentality towards being ICT-driven and 'smart', whilst still emphasising the dominant role of government. This is in contrast to western cities, where the neoliberal smart city discourse places much attention on the city per se with focus upon the whole society rather than just the government (Vanolo, 2014). Hence, this discussion begins with a close look at the political legitimacy and urban regimes in both contexts, and how the Chinese shaping of smart urbanism differs from the neoliberal settings in various aspects of governmentality and, what Vanolo (2014) refers to as, 'smartmentality'.

The concept of governmentality refers to political rationalities, namely the way in which government programmes are constructed and stipulated on a basis of the 'mentality of rule' and technical imperatives (e.g. materials, agents and technologies) that put these rationalities into effect (O'Malley et al., 1997). In the neoliberal urban context, this has tended to mean a political discourse regarding the nature of rule and a range of practices that enable the governing of individuals from a distance (Larner, 2000); in other words, individuals in the cities are somehow 'controlled' by the urban regime, referring not to government but the governance of city, market and social places (Foucault, 1991; D. Harvey, 1989). Moreover, the ideology of neoliberal urbanism underlines a supposed utopia of free markets wherein government intervention is increasingly side-lined apart from setting market rules (Peck et al., 2009), and meanwhile citizens' as smart city consumers have become increasingly prominent as a bottom-up force in co-shaping smart city initiatives (Cardullo & Kitchin, 2019a). In the era of smart cities, neoliberal smart urbanism represents the ethos that many governments in the west embrace, namely to encourage privatisation (i.e. transferring public resources into the private sector) and marketisation (incubating market-oriented firms), and restructure the form of urban governance to be citizens as consumer centric, thereby leading to the cities flying the banners of smart growth, entrepreneurship and smart citizenship (Cardullo & Kitchin, 2019b; Hollands, 2008; Kitchin, 2015b; Söderström et al., 2014). It is therefore noticeable that the role that government plays in the neoliberal market-led smart city development seems reducing, whilst private sectors' roles in turn have increased and could become more dominant with possibilities of various corporations co-creating citizen as consumer-centric smart city initiatives; this is aimed at more efficient and effective urban governance.

In China, things are a bit different. Firstly, although the implementation of the 'New-Type Urbanisation' agenda also suggests the leveraging of market-driven smart city initiatives to address urban pathologies, the smart urbanism is still driven by heavy government intervention, political control and centralised administration, rather than being oriented by the power of market and private sectors (B. Hu & Chen, 2015). Embracing the global neoliberalism bandwagon, the new urbanism in China ostensibly looks rather analogous to what is happening in the west – the growing trends towards smartmentality (i.e. pursing technocracy, sustainability marketisation and entrepreneurship). However, the findings of this research suggest that the new urbanism does not achieve some form of market "emancipation" (referred to by government participants), despite many municipal governments claim otherwise. As enterprise participants explained, this is due to the municipal government's lack of government devolution (empowering subordinate governments and private sectors), and a holistic view of top-level design (namely that municipal government would need to have a foresight of how a potential initiative can address the issues that currently exist with the considerations of *'who to be served'* – i.e. potential end-users*, 'what to serve'* – i.e. services included, *and 'how to achieve'* – i.e. instruments of service delivery).

Secondly, the smartmentality ideology in Chinese smart cities represents a taken-for-granted form of citizenship. Given what the New-Type Urbanisation encourages – *"a favourable interaction between government administration, self-adjustment within society, and self-governance by residents through comprehensive grass-root service management platforms"* (CNDRC, 2014) – the study found that from a municipal government perspective, cities are labelled as smart simply because of the embedding of ICT-driven technologies with the purpose to benefit citizens. However, whether such a dominant ideology is built upon the governments' on-the-ground citizen investigation whereby capturing what citizens really perceive as their bottom-up demand, or is it just their ingrained belief that for citizenship to be smart it is just what they have always been offering to citizens, i.e. a technocratic form of urban governance, by looking at what is happening in the west and keeping on track of the global smart city campaigns?

Notwithstanding widespread critiques from smart city scholars (e.g. Kitchin), what has been happening long-term in the west (e.g. Ireland) is that many neoliberal smart cities are claimed to be underpinned by a neoliberal smart citizenship that favours consumerism and individual autonomy which are circumscribed into practices of "*stewardship*" and "*civic paternalism*" (i.e. the state distributes the resources that they believe are best for citizens) (Cardullo & Kitchin, 2019a, 2019b). As such, Cardullo and Kitchin (2019a) argue that it is in practice hard to achieve 'bottom-up, inclusive and empowering' citizen participation in decision-making process unless a sustainable foundation of public-based smart city initiatives is established. Whereas, in the context of China, the findings in general illustrated a somewhat analogous way of citizen participation in smart cities, but with differences in regard to the issues of ideology and mentality of how citizens believe that they themselves are involved, and how the state claims the form of citizen participation is, in building smart city initiatives. As the findings implied, prioritising market-driven innovations and raising technocratic and corporate forms of governance in Chinese smart cities have led to such taken-for-granted views of citizenship: citizens have always believed that what they have been offered is what they should be offered, with no different voice being heard by government. As a consequence, many smart city initiatives in Chinese cities are touted to be citizen-centric, but are actually government-led in nature, hence leading to a low citizenry voice.

The analysis of these two issues illuminated that the deep-rooted reason behind such a 'window-dressing' emancipatory progress – the freedom for citizenship – is the over reliance upon government political forces and government administrative planning (B. Hu & Chen, 2015). Although there have been many attempts to decentralise political system, the power of the government still remains significant (Bao & Toivonen, 2015). Bearing such a difference between the neoliberal smart urbanism and the Chinese state-led new-type urbanism, smart city initiatives in Chinese cities are advanced under the umbrella of top-down political legitimacy and centralised governmentality to transform "actually existing smart cities" towards being technologically advanced, sustainable and economically attractive (Shelton et al., 2015; Vanolo, 2014). In the following sections, key challenges and opportunities for initiating a data-integrated STS application in a particular Chinese city will be discussed, as a response to the research question. It is evident that all these challenges are formed, and determined by, the current Chinese political and legal system, but opportunities for such the proposed data integration solution are also lurking behind such government-led smart city advances.

7.4 System thinking of sectors integration

Considering STS is a complex system that consists of various socio-technical components, a system approach to thinking about the collaboration, coordination and interactions across different actors become imperative, especially for the proposed data-integrated STS scenario. A system thinking applied to implement STS suggests the understanding of behaviours of individuals and organisations as well as their interactions (Saviano et al., 2016). This understanding is also reflected in the insights provided by participants. In the context of initiating citywide data-integrated STS, this implies the need to (i) build coordination mechanisms, and (ii) smart data governance. Section 7.4.1 and 7.4.2 will discuss key challenges and opportunities that reside in (i) and (ii) by comparing the research findings and previous literature. The study reveals that system thinking of sectors integration should be considered as a fundamental part of governance of any efforts to initiate a data-integrated STS application because this determines who, and by what means, is taking part together in STS development which is orchestrated behind the scenes by the government.

7.4.1 Coordination mechanisms

Coordination mechanism in general refers to an administrative vehicle for achieving integration amongst different players within an organisation or a collaborative group of stakeholder organisations (Martinez & Jarillo, 1989). In the broad smart city literature, the concept of a coordination mechanism is closely associated with the concept of e-governance; the latter was identified as ICT-driven collaboration and interaction between citizens (and/or wider communities) and government administrations (e.g. social inclusion) in regards to efficient and effective public service delivery and information dissemination (Bătăgan, 2011; Bolívar & Meijer, 2016; Chourabi et al., 2012; Giffinger & Pichler-Milanović, 2007; Mervyn et al., 2014; Tomor et al., 2019). In the global smart city context, such collaboration and interaction necessitate cross-sectoral social cooperation mechanisms, leadership support, and working under different jurisdictions (Chourabi et al., 2012; Scholl et al., 2009). Narrowing down to this study, the coordination mechanism refers to managing STS stakeholder relations for the purpose of co-creation of value in regard to data, application and service integration, reciprocal accountability and reliability, resource management, and leadership (Alawadhi et al., 2012; Galvagno & Dalli, 2014; Giffinger & Pichler-Milanović, 2007; Lam, 2005; Odendaal, 2003).

A notable observation of this study is that municipal STS initiatives are always politically initiated by local government, co-designed by both government and enterprises (could be both state-owned enterprises and private enterprises), and finally used by citizens. Government participant GP1 stressed the fact that state-owned enterprises are not autonomous in decision-making and coordinating organisational resources, but rather they are legally led by government. This is also reflected in the literature, wherein the government is observed to empower themselves to make decisions, direct the orientation of organisational strategies, and legitimises both commercial and administrative data properties, for non-economic objectives (Berkowitz et al., 2017); although over recent years they have tended to be corporatized and privatised (Jones & Zou, 2017). As a player of urban innovations, state-owned enterprises are always considered as equivalent to the government, or at least, a part of the government (referred to by government participants). In contrast, private enterprises usually act as the counterpart against government within stakeholder collaborations. However, the findings unfolded that although the government does not have direct or full control over private sectors, political interventions always exist as if government acts as an 'usher' and tells private enterprises what the right way is in the market economy.

Therefore, a potential challenge here that impacts on the initiating of data-integrated STS is that the government has significant control over private sectors, resulting in limited self-autonomy of private enterprises and a highly government-led coordination mechanism through which the government steers the orientation of data integration process. Here exist three issues which will be discussed in the following sub-sections.

7.4.1.1 Government moving the goalposts

First of all, the study found that for cities to initiate the integration of transportation data from various sites, it would be necessary to establish a Government-Private Partnership (GPP) to push forward sustainable STS development. GPP is described by enterprise participants as a close-knit relationship between government and private enterprises within the process of marketisation and privatisation. In most cases of neoliberalism in the western context, municipal governments harness smart innovations to try to make city functionality and administration performance ultra-efficient, but are open to manipulation by vested interest groups from the private sector (Jessop, 2002; Kitchin et al., 2015). Conversely, in Chinese cities, the centralisation of political regime and top-down decision-making in allocating and distributing market resources, leads to the fact that in the process of 'co-creating' a project, the government constantly plays a leading role in setting project objectives, making project decisions, and coordinating project resources. As C2-TS2 suggested, *"government keeps moving the goal-post and we need to correspond to whatever the change they make".*

7.4.1.2 Bureaucracy and red tape

Moreover, the literature indicates that strong government power and their intervention in private business manifest inconsistent bureaucracy (Bao & Toivonen, 2015), which is what enterprise participants in this study particularly referred to as "the red tape". As has been reported in the literature, within a GPP, it is said that the private enterprises are confronted with opaque decision-making procedures, arbitrary approval processes (X. Zhao et al., 2006), and deep-entrenched lasting "guanxi" relationships (Ying Chen et al., 2011; Kriz et al., 2014; Mavondo & Rodrigo, 2001). Such bureaucracy poses pernicious influences upon SMEs because of their poor "guanxi" with local government officials. In this study similar challenges were frequently observed. For example, C2-PM revealed that the legal approval of their rollout of a new type of online taxi service when they were a business start-up usually took a long time due to many rounds of government departmental authorisation process. In other words, the government does not give priority to less competitive private enterprises as their nature of bureaucracy and entrenched mentality of pecking order (i.e. a latent hierarchy of competitiveness status amongst enterprises that are involved in government administration) allow them to be overly dependent upon large corporations who they build longstanding collaboration with to help them solve urban issues.

7.4.1.3 Less citizen-focused industry competition

Third, the 'pecking order' that exists in government administration gives rise to competition, with a plethora of private enterprises competing to pre-empt actions in order to gain contracts in both the design and implementation of government-led, large-scale and citywide smart transportation projects. However, such competition-driven urban governance is usually just a two-player game, with the emphasis on how the "integrated spectacular" – i.e. a form of capital accumulation, focusing upon urban actors competing within a global chain of city production other than long-term embodied vitality (Visser, 2019) – is critically anchored into the social fabric, without inviting in citizens who are actually at the bottom-end of such an integrated system. It is evident that competition in the transportation sector is especially tense due to the distinctive nature of the urban transportation system, which in many cases, is regarded as the driving force to wrench many cities from lower tiers onto higher levels so as to enhance economic competitiveness (EUSME, 2015). As such, expertise, experience and knowledge seem to be rather crucial in such a competitive economy. Both government and enterprise participants revealed that they regularly organise industry conferences, symposiums and summit forums to work collaboratively on new innovative solutions to further strengthen urban STS. Despite these endeavours, citizen or social community representatives have never appeared at such events. As hinted by participants, it just appears to be two bodies sitting together mediating a techno-utopian landscape of future citizen-centric STS, without really acknowledging what kind of solutions would deliver best value for their citizens - although they claim they do.

The challenge discussed above suggests a less integrated alliance between different stakeholders especially those with close-knit relationships with citizens. To be more summative, the government plays a top-down leading role within the entire co-creation process, whilst private enterprises just comply with political and regulatory rules, and citizens are even excluded from the co-design process. Nevertheless, this study reveals two potential opportunities with regards to the further development of government devolution and building frontline Special Purpose Entities (SPEs); participants claimed these opportunities are critical for the proposed data-integrated solution, which will be explored in the next sections.

7.4.1.4 Government devolution

The term of 'devolution' originates from the banking sector where top level management empowers lower level authorities with independent rights to make decisions and coordinate resources (Mujumdar, 2001; Sundar, 2001). Public administration and development literature suggest that the power of local governments is generated from economic and social reforms, and is the trigger of a shift towards government administration being decentralised (e.g. West & Wong, 1995; White, 1991). There have been a couple of spells over the past several decades where the Chinese central government advocated for a more transparent, dynamic, and decentralised form of urban governance and economy since the Reform and Opening-Up in 1978 (J. Y. Lin & Liu, 2000). However, the participants of this study revealed that the so-called 'decentralisation' only lasts for a certain period of time after every significant social and urban reform (such as the 'New-Type Urbanisation' agenda), and then goes back to how it used to be, which they believe is what the typical governmentality is in the contemporary Chinese growth-coalition regime. Different from previous social and economic reforms – refashioning of the social fabric from a macroeconomic perspective (Feltenstein & Iwata, 2005; Yusuf, 1994), the new urbanism is more focused upon a micro and regional level of transition and highlights the role of subordinate entities (Cheshmehzangi, 2016). As such, the role of government devolution becomes rather prominent in shaping sector integration. In the context of this study, the government participants maintained that government devolution does not only benefit lower level government authorities but also organisations in the business industry.

Despite the 'will of the leader' that consistently exists throughout the political regime, municipal governments have acknowledged the need to hand-down some of their power to the subordinate government agents and institutions. In the transportation sector, these organisations refer to Vehicle Administration Office, Traffic Congestion Governance Office, etc. These agents are delegated with executive force to directly communicate with local businesses; however, the current state of play is, as afore-discussed, they have no rights to make decisions for their higher level government - in a word, this is interpreted as large-scale administrative devolution with limited political influence (Bardhan & Mookherjee, 2006). The findings suggest that this devolution would be necessary for large-scale resource management. Whilst the new urbanism agenda emphasised the need to integrate urban resources, government participants expressed that, for cities to integrate data resources in particular, a systemic understanding of what each data resource means for the integration solution, would be required. Regular engagement with local private enterprises could enable these subordinate agents to exploit deeper interrelations between them and the government, especially in respect to the negotiation on a potential win-win scenario that reciprocally benefits each of them.

One thing that has been raised many times in this chapter is the role of citizens in shaping any integration process. In this sense, an opportunity for the data integration solution exists here, wherein participants speculated that government political devolution could enable more power of subordinate execution to coordinate data resources from various places. Participants revealed that such devolution is achieved by granting local community-based organisations, e.g. community committees, urban management offices and sub-district offices, with more incentives and executive rights through decentralisation. What is noticeable here is that rather than making decisions for the government, these organisations are incentivised and motivated to observe what citizens think of, and how they interact with, the actually existing smart city initiatives, as well as their thoughts and wishes regarding future solutions. Government participants argued that whilst these grassroot agents now remain inactive and obviously isolated from the government working system, they are increasingly being propelled by the pervasive new urbanism – establishing real citizen-focused and sustainable urbanisation. This argument is also reflected in the 'New-Type Urbanisation' literature (J. K.-S. Chan & Anderson, 2015; Cheshmehzangi, 2016). Moreover, what is critical here is synergistic communication vertically and horizontally across the organisation. This will be discussed in the next sub-section.

7.4.1.5 Building frontline Special Purpose Entities (SPEs)

The review of literature regarding the role of Chinese government in urban development suggests that many municipal governments would like to take drastic measures to, on the one hand sustain urban development, while on the other consolidate their political regime (M. Jiang & Xu, 2009). Put another way, whilst the government plays a leading role in coordinating resources from various places in response to a particular call for sustainability (e.g. low carbon transportation), they also leverage such an opportunity to strengthen their political influence and authority by cementing the government-led collaborative relationship with other parties. Herein, the question being discussed leads to the reflection upon the nature of the STS and the potential for data integration, and whether such nature, particularly in the Chinese context, leads to the need for the government to be placed as the leading protagonist within general data-driven STS initiatives. The current literature regarding Chinese smart city development places much attention on the interaction between data and diverse participants (e.g. EUSME, 2015; Ge et al., 2017; M. Guo et al., 2016; Y. Wu et al., 2018). For the proposed data integration scenario, this suggests a potential coordination mechanism through which data resources generated from various stakeholder sites are centralised into one place. Chourabi et al. (2012) argued that the failure of these kind of smart city projects is usually caused by the lack of alignment between different organisational goals or because multiple conflicting goals exist across stakeholder organisations. These contradictions are in most cases led by the complicatedness of multiple legal and regulatory processes, various management structures, organisational goals, technology sophistication, and the size of organisation (Gil-García & Pardo, 2005; Gil-Garcia et al., 2015). Chiming with the literature, the findings of this study suggested that it might be necessary to synthesise this range of organisational and managerial dynamics by a coordinator with legal and social power.

Building Special Purpose Entities (SPEs) was considered by government participants as an opportunity for organisations to consolidate both inter- and intra-agency communication. In particular, this might be able to benefit the government to more efficiently coordinate other stakeholders and their data resources, because SPEs are a government frontline office that represents government interests and political leadership (as SPEs are made up of technocrats and experienced government technical experts). SPEs also favour private sectors as government special funds and public assets are allocated to them in order to support the sector integration and partnerships. This nature of SPEs suggests that the government is seeking for a way to not only financially and infrastructurally undergird the coordination mechanisms but also leverage their political influences to direct the co-shaping of the data integration landscape (Ke et al., 2010). Furthermore, leaving aside the afore-discussed issue of taken-for-granted citizenship, which is what SPEs should in future address, the findings implied that such a temporary and coordination-based relationship between government and industry could create many more business opportunities for the current STS ecosystem.

7.4.2 Smart data governance

Whilst the last section discussed the major issues of coordination and collaboration with the focus upon building on sector integration and partnerships, this section shifts the focus towards more specific issues regarding the governance of various data resources and different practical challenges of data integration. Data governance has been depicted by the current literature as a set of technical and algorithmic ways of managing data sets. Kitchin (2016) argues that cities can be steered and controlled by algorithmic instruments, such as urban dashboards, city control rooms, pervasive surveillance and ubiquitous computing. Similarly, the findings suggested that on a daily basis, smart cities produce large troves of big data from various places, and in-turn these data serve the operation of city administration and functionality. The literature tells that some of these data are from sensor-enabled infrastructures, such as smart car parks wherein wireless sensor networks are considered as a fundamentally data-driven measure (Kianpisheh et al., 2012), while others are mainly generated from citizen end-user mobile devices, i.e. social networks data (Vakali et al., 2014). However, both the findings and literature claimed that many issues currently exist around the governance of these large data sets. Kitchin (2014b) lists six aspects of data issues and concerns (i.e. technical, organisational, ethical, political, social and legal) surrounding the revolution of big data in the digital era, and claims that these aspects as a whole and their interplays, unfold how big data reflect the world we know, in which we act, and why the sites of big data practice are where vested interests gain benefits from. This to some extent backs up the findings which suggested that acknowledging diverse structures of data, making sense as to why data are complicated, and taking significant measures to re-fashion the way in which big data are leveraged would be the smartmentality of big data governance. Just as Barnett (2013) connotes, such a multi-state of big data embraces interlocking issues, stakeholders and their interests that populate the socio-political playing field and economic scenery. However, it is argued that this obviously needs articulation upon revamping of data so as to re-shape current data practices as new developments with innovated usage scenarios.

7.4.2.1 Data standardisation

Another challenge that exists is the challenge of smart governance of data with various characteristics within the context of current data-driven smart transportation: information asymmetry due to a lack of political and financial underpinnings for unifying a considerable number of data structures and formats. Data with various structures and in different formats means that the information end-users receive varies, depending on where data come from and perhaps what devices they use to access the data service. Citizen participants of this study particularly highlighted their concern over this point – they are interacting with ubiquitously data-driven but discursively complicated data services. This is to say, citizens are confronting all types of data and data-driven services with various types of information about them feeding into their everyday life, which gives rise to complexities, contingencies and uncertainties of information dissemination and practices.

The findings revealed that there are both challenges and opportunities with regards to unifying data structures and formats. As the current literature suggests, despite many endeavours to establish data infrastructures and data consolidators in order to better integrate data resources, a plethora of big data in the transportation sector still remains in silos (An et al., 2016; Kitchin, 2014c). The findings indicated that this is not due to technological unsophistication, but because of significant financial and socio-political obstacles that hinder integration. It is interesting to point out here that almost all data technician participants in this study claimed that there are not technological stumbling blocks anymore that stand in the way of data integration practices, but barriers in relation to centralised data politics.

Herein, two interrelated issues were explored from the findings. Firstly, from a positive perspective, even though in the distinctive case of this study where data from all sub-systems and their applications were to be integrated, the integration mechanism looks to not anymore be a technological pessimism because the current technology is already sophisticated enough (referred to by enterprise participants). Rather, the defect is that the government has not established fundamental, and politically and financially imperative data standards and protocols, to unify all kinds of data resources from various organisations, especially large corporations like Didi and AutoNavi (both were merged by Alibaba) and transportation consortiums such as China Communications Constructions [1]and its branch firms. Although both central and municipal governments have provided many opportunities for industry data standardisation (An et al., 2016)， such as intelligent urban infrastructure that continuously collect and cluster datasets (Ming & Wang, 2013), open government data practices (F. Gao, 2016; X. Liu et al., 2015), and big data-led shared economy development (An, 2015), these practices – as similar in the neoliberal smart cities – could possibly have impacts upon vested interest groups who put forward market-led technological solutions based on their own interest i.e. profit-seeking. Although the government has much control, they need to depend on these giants to push urban and socio-spatial advancement. In other words, whilst it is possible in principle that the government harnesses coercion to standardise a large range of data sets, the reason why they have not done so is that they really need to weigh up whether it could pose a threat to the innovation productivity of these giant corporations as well as market dynamics from which citizens benefit. Nevertheless, government participants stated that what is positive is that a negotiation between government and industry in regard to the standardisation procedures has been undertaken.

7.4.2.2 Data authority and ownership

Whilst the last section was focused upon the macro level of data standardisation with an emphasis upon the complicatedness of data integration, this section shifts the focus towards the issue at micro level – data authority and ownership, namely the stipulation of data property (i.e. who owns, uses and reuses the data, and how data users and owners can be trusted by each other) (Kitchin, 2014b; X. Liu et al., 2015). Government participants stressed that this is a pre-condition of processing large data sets and setting industry standards in a centralised manner. An opportunity is that the current political legitimacy enhances trust across various stakeholders, including citizen end-users. However, they expressed that it is not clear at the moment which sets of data belong to which data owner sites. As such, to overcome this challenge, they noted that ownership would need to be legally stipulated.

Moreover, another opportunity this study explored is that the trust between stakeholders could enable differentiation of data users (i.e. who consumes data, such as citizen end-users,

[1] China Communications Constructions (CCC) is a state-owned transportation corporation directly supervised and administrated by State-owned Assets Supervision and Administration Commission of State Council - http://en.ccccltd.cn/

data brokers, other service-centric firms) and data owners (i.e. who owns and thus can manipulate data, such as data firms, databased platform vendors). For example, the findings revealed that the cooperative relationships between government and private enterprises could enable clear stipulation of the ways in which data are shared between each other; herein, data generated by one site and being re-used by another manifests the shift of data roles between them, and which is enabled by trust. However, enterprise participants pointed out that both government and private sectors would need to pay more attention to the legitimate outcome of data being used and re-used (particularly when data are mishandled, manipulated or inappropriately distributed) (Kitchin, 2014b), which they termed as 'data traceability'. This means that to make data traceable whatever their spatial-temporal conditions are, legal data authorisation protocols (Gope & Hwang, 2016; Kitchin, 2014b; Porambage et al., 2014) would need to be established to unravel where a particular set of data originates from and where it proceeds ahead to. For the proposed data integration scenario, understanding of these issues can be argued as necessary to delineate the clear trajectory of data flows and their legal attributes across stakeholder sites.

7.5 Socio-political shaping of smart economy

The last section discussed the potential challenges and opportunities regarding the system thinking of sector integration for initiating the proposed data-integrated STS applications. The primary line of argument shaped in the last section underlined the leading role of government (both at central and municipal levels) in coordinating transportation resources (especially data resources) and in moulding state-led socio-political dynamics of urbanism and smart city regime. The discussion therein revealed that the government intervenes in all urban sectors of innovation under the new urbanism with a technocratic vision to partially privatising public services with their political control. Proceeding a bit further, this section excavates another facet of the current govern- and smart-mentality – socio-political shaping of smart economy, in which both the challenges and opportunities to shape the data integration solution will be discussed.

7.5.1 State-steered technological determinism and corporatisation

It seems that the vast majority of global smart city scholars and practitioners claim that 'hardcore' ICT-driven smart innovations are what a genuine smart city should embrace. This has become a well-known, widely acknowledged rhetoric of sustainable and smart urbanism. Benchmarking and dominant smart city studies in academia especially echo such a smart bandwagon. For example, Hollands (2008) in his ground-breaking smart city paper '*Will the Real Smart City Please Stand Up'* explored the extent to which smart cities can be considered as a 'high-tech' variation of urban entrepreneurialism; Harrison et al., (2010) proposed that the foundation of a real smart city involves instrumentation, interconnection and intelligence, and to achieve this foundation relies upon fundamental ICT technology; Rob Kitchin in many of his smart city studies highlights that a smart city refers to the growing extent to which cities are infiltrated with pervasive and ubiquitous algorithms, computing, and digitally instrumented infrastructure which are generally regarded as being 'everyware' and commonsensical solutionism (e.g. Kitchin, 2014b, 2015a, 2015b, 2016); and furthermore, Chourabi et al. (2012) identifies 'smart technology' as the meta factor that influences the success of smart city initiatives.

Likewise, in China, from the top policy-making (such as the 'New-Type Urbanisation' policy) to the on-the-ground projects, the 'rich picture' of such an urban system seems to be pushed and pulled by ICTs as well. This is to say, both the neoliberal western and the Chinese smart cities have realised the importance of, and thus adopted, ICT-based technologies for smart city advancement. However, participants claimed that not all ICT solutions are beneficial; whether or not to utilise them depends on how they are gauged and scaled in a pilot locality before being widely implemented. However, the point here is that the findings of this research suggest an explicit difference between the neoliberal and the Chinese smart city contexts, in regard to who is actually holding such a 'technological determinism', and how this 'who' influences other aspects of smart city development - aspects as represented in Chourabi et al.'s (2012) Smart City Initiatives Framework, such as 'governance', 'people communities', 'economy', and so on.

This study suggests that, whilst in the Chinese context, the technological deterministic ideology is deeply grounded in government power – i.e. the current centralised political system, the review of literature indicated that in the global smart city context (particularly neoliberalism) this is more grounded in society through a new 'epistemic community' and 'advocacy coalition' (terms referred to by Kitchin, Coletta, Evans, et al., 2017) that are composed of a network of professionals or people from various sectors. This is to say, in China, it is the state that from time to time determines whether a particular smart technological solution needs to be rolled out, and as such the industry should 'follow the instructions' to put forward proposals for the solution. To be more specific, the findings suggested that the Chinese government usually 'glances' at what and how the dominant technology initiatives could benefit the society in the west, and therefore draws lessons from these western paragons and apply them to the Chinese context in their own way. Chiming with the argument in the section 7.3, the findings herein resonate that such technological determinism held by the government allows it to make huge efforts on expanding innovative businesses and entrepreneurship through propaganda and coercion. The literature suggests that this is aimed at the integration of isolated utilisable resources in order to make urban innovation development ultra-efficient and eco-friendly (Bakıcı et al., 2013; Deakin & Al Waer, 2011). Accompanied by potential business opportunities within the market, such political lever tips the balance in favour of the increasing growth of prioritisation and corporatisation.

However, hardly anyone has asked the question of 'why'? First, within the 'hard' Chinese political system i.e. top-down and centralised politics, why is technological determinism seen as an appropriate standard of urban development? In the context of this study, why might the proposed data-integrated STS application be seen as a potentially technological solution that can benefit urban transportation? Second, why is the government (with its political power) the main force that shapes such a technology-driven smart economy?

To answer these questions, it is necessary to firstly examine what the intrinsic driving force is for cities to harness ICTs to push urban development. To date, there are many smart city and STS related studies that have proposed different modelling, ranking and assessment frameworks. These tools are used by city administrators to more effectively set out strategic planning. Notwithstanding their differences, a shared motive of various types of measurements is the growing economic competitiveness. For example, Giffinger and Gudrun (2010) argue that smart transportation (as one of the six components/characteristics of the smart city) is the result of a complicated interplay of economic and socio-cultural conditions. Lombardi et al. (2012) proposed a revised 'triple helix' model, i.e. identified 'civil society' as the fourth actor) to examine knowledge-based innovation systems, and argued that amongst all four types of policy visions to which cities prioritise, ‘entrepreneurial city’ is the most prominent (the other three being ‘pioneer city’, ‘liveable city’ and ‘connected city’). All these studies indicated that technological reforms are a mirror of economic change. The latter is a result of the network nature of cities and its persistently entwined interrelations with different urban actors. These characteristics to some extent mark that technological advances are built upon the needs of the competitiveness-oriented and inclusive urban society, wherein social needs come from the entire society other than a particular individual or social group.

In China, things look slightly different. The economic transition (Reform and Opening-up) period that took place in 1978 led to a sudden shift of the economy from being overly reliant on the state towards an increasing pursuit of market forces. Such transformation resulted in growing economic inequality between different tiers of cities and even between different districts within a city. Thus, innovative improvement upon green and smart production becomes both socially and economically imperative (Y. Wu et al., 2018). In STS, such imperatives are referred to by participants as new energy and more integrated solutions which are all determined by relevant ICTs and are advocated by the state who are witnessing what is being achieved in developed countries regarding the huge potential of capital accumulation and ultra-efficiency that ICTs can bring to cities.

In the initial stage of this study, the proposed data-integrated STS is considered as an ICT-driven technological solution that some might expect to overcome the issues (e.g. ‘information islands’) that currently exist in Chinese urban transportation systems. However, by carrying out the research, it is evidenced that there are many complex socio-technical problems (especially non-technical issues) that cannot be addressed simply by such a technological solution. This is to say, the technological solutionism in Chinese smart cities should take the socio-technical system view into account.

For the data integration scenario, many changes led by technology (as interview participants suggested, e.g. refurbishing or upgrading urban transportation infrastructures, refashioning organisational administration, streamlining inter-departmental communications) are called for by government, sometimes with policies, and are enacted by the organisations that are actually controlled to a certain extent by the government (An et al., 2016). For example, participants revealed that there was a huge administrative change of government transportation resources in 2017. Many transportation relevant government agencies and offices were merged into a municipal transportation bureau, with the aim to augment government administration efficiency. Participants revealed that this can be achieved by establishing 'GovCloud' wherein relevant administrative transportation data are centralised for the purpose of unified governance. In other words, in China technological determinism is rooted in the urban political regime where government is the main force to push ahead the technology-driven economy.

7.5.1.1 Local characteristics and contingencies

Notwithstanding the changes stated above, a long-standing challenge exists; the study found that many STS initiatives in China are overly techno-political in nature and technologically optimistic, whilst often neglecting local cultural dynamics and contingencies. A noteworthy example is the enactment of license-plate based policy. This kind of policy has been used in myriads of cities around the world with the aim of reducing traffic congestion and air pollution (Viard & Fu, 2015). Similarly, over the last decade the Chinese central government has enacted this restriction as well in Beijing to reduce pollution caused by the smog by prohibiting drivers from using their vehicles on certain days in a week based on the last digits of their license plates (Zhang et al., 2017). High-definition and panoptic surveillance cameras were deployed to capture those who are would like to exploit the legal loophole. Since 2015, this policy has been enforced elsewhere in the north of China where the level of smog was marked as 'severe', such as in Shijiazhuang. However, the enforcement of this policy in Shijiazhuang has been bombarded with criticism from across the city, as people claimed that the cause of air pollution in Shijiazhuang is different from that in Beijing and such policy has caused significant inconvenience. Enterprise participants revealed that Shijiazhuang's air pollution is for the most part caused by industrial pollution from the agglomeration of factories rather than vehicle exhaust emissions. Many citizens have similar insights. For example, a car-user participant of this study complained that he just bought a new car because he did not want to bother with catching buses every day, but soon after he was prohibited from using the car on certain days. Other participants resonated that such restriction did not really improve the air quality. Having realised such an issue from the grassroot citizenry, the Shijiazhuang municipal government revised the policy alongside other attempts such as refashioning high-tech industrial zone by re-siting industrial factories. This is not an issue with just policy-making, but rather an ideology that resides in the governmentality; that is, the priority is uncritically given to technology and apparently it is regarded as the main component of the political-driven urban development programme. Meanwhile, the overlooking of local characteristics and contingencies could lead to the waste of resources and economic downside. Given the circumstance of STS data integration solution where there are many ICT-driven sub systems involved, technology would need to be given equal weight with other conditional factors in order to achieve the balance of a technology-driven smart economy.

7.5.1.2 Leveraging indigenous demonstration projects

Not only did the findings reveal potential challenges in the socio-political shaping of an STS economy, they also suggest opportunities for promoting the data integration solution within the design process. In exploring the current trends of smart city initiatives, Neirotti et al. (2014) emphasised that the advancement of a smart city as well as its digital path are contingent upon local contextual factors, such as demographic and geographic variables and economic development and structural urban dynamics. The findings that echo this point involve two potential opportunities. Firstly, although municipal governments usually neglect local contingencies and economic conditions to develop ICTs, they hold a positive and supportive view to invest in pilot and demonstration projects at the initial design stage. Government participant GP3 maintains that the aim of this is not only to examine whether a particular smart solution is considered as sustainable and benefitable, but also to expand the channels through which the government promotes social financing in order to raise funds (B. Hu & Chen, 2015).

Secondly, both government and enterprise participants asserted that there is a lack of professionalism amongst officials and experts from both industry and municipal and district governments, and thus cross-sectoral and intra-organisational special trainings become crucial. As the findings informed, the training sessions are usually led by state-authorised public institutes, co-organised with local IT corporations and targeted at entrepreneurs and management layers of the government agencies. The problem here which the findings connoted is that unprofessionalism could lead to inappropriate vision of top-level design and holistic thinking, planning, and decision-making in regard to the socio-political-economic configurations. This might be the reason why there is uncritical assimilation of neoliberal modes of smart city development from the west, and why the municipalities have an inappropriate understanding of how to properly anchor technology into smart cities (as discussed in the last section), which could result in unbalanced and inconsistent development across cities and regions.

7.5.2 State-steered marketisation and open-door economics

When discussing the current state of play of China's marketisation process under the banner of new urbanisation, it is worth mentioning the old economic development mode. The latter is overly reliant upon state-led population dividends, unscrupulous consumption of natural resources and a cheap labour force (W. Yu & Xu, 2018); these human activities resulted in a large range of socio-economic problems, such as unemployment, individual and regional disparities, and so on. In contrast, the ICT-driven smart city stresses the role of markets and value co-creation ecosystems (Letaifa, 2015), meaning that urban socio-economic development is not dependent upon state-led human activities anymore, but rather upon the all-societal clustered force of urban social and natural resources which are in turn exploited to benefit communities.

This means a more open market, a place where business opportunities occur and a competitive territory that private companies would like to exploit. As participants suggested, although the government has 'a big hand' to control the private sectors, the ICTs and related data-driven infrastructures are by-and-large innovated by big IT corporations. This relationship corresponds to a previous argument regarding the challenge against standardising all industry data resources as it might pose a threat to the vested interests which the government leans on to push smart city advancement (See section 7.2.2.1). As such, there is a growing tendency of smart city innovations towards large-scale privatisation of STS service delivery and marketisation of STS service use. Ever since the release of the 'New-Type Urbanisation' agenda, the central government has made public calls for "mass entrepreneurship and innovation" (J. K.-S. Chan & Anderson, 2015) and bottom-up and people-oriented ICT initiatives for smart city development (J. K.-S. Chan & Anderson, 2015; Sun et al., 2017).

In addition, human resources flow much faster than before, especially in the state-to-private orientation. For example, C1-PM, a project manager in the case private company 1, revealed that he and many of his current colleagues used to work in state-owned firms and government transportation agents, are now working in private sectors. Also, C2-SD, who used to work in the Hebei (Province) Transportation Bureau now works as a private firm's strategic director, suggested that many technocrat officials have a position in private enterprises, especially in those which are monopolistic in the market. This type of move could lead to a situation where the government instils the ideology of technocracy into the market field whilst the private sector still remains as corporatised and business-oriented. Therefore, such a bond between the government and the private sector allows private enterprises to on the one hand acknowledge how the state envisions future smart initiatives, and on the other, as is happening in the neoliberal smart cities, pursue technological solutionism through which urban issues can be visualised and addressed by ICT-enabled services, such as apps and dashboards (Cardullo & Kitchin, 2019b).

In other words, such relationship between the state and private sectors indicates a pervasively political orientation and a climate of 'state-steered' ethos within the market (D. Guo et al., 2014). This could be one of the reasons why the Chinese smart cities are tending to be neoliberalising and pro-business with advocation of corporatisation and entrepreneurship, and why the way in which they are governed is increasingly morphed into a techno-political, top-down in orientation, form of governmentality.

7.5.2.1 Innovation dilemma: business homogenisation

The analysis of the findings unfold that the growing extent of state-steered corporatisation and privatisation is a two-edged sword. From the positive perspective, participant GP3 stated: "*this is a win-win scenario: on the one hand, there seems to be many business opportunities in the market that could benefit private firms, and on the other, city administration and governance are no longer burdensome*." However, a challenge that currently exists reveals increasingly significant business homogenisation, particularly in cities like Shijiazhuang (referred to by enterprise participants), where SMEs and business start-ups endeavour to simulate dominant business paragon, namely they follow and copy what a prototype company is doing. In the business of transportation, for example, Didi and AutoNavi are regarded as an STS paragon and monopoly; their mobile apps are used nationally. Their business models are widely viewed as an excellent paradigm that other businesses harness and perhaps copy to innovate their own solutions.

Business homogenisation could further result in a waste of market resources and a large range of services that are not what citizens need but are instead profit-seeking. The analysis of the findings vis-à-vis the literature indicates that these non-innovative solutions are just the product of political economy, and thus business homogenisation is rooted in the pervasive 'pecking order' in Chinese society. The bureaucratic government and its highly centralised nature have recast the governmentality as a lever of political economy that nudges industry (Gandy Jr & Nemorin, 2019) in the direction of a "survival-of-the-fittest" form of competitive economy (referred to by GP1). Nevertheless, GP1 claimed that the purpose of this is not just for unjustified state control, but to encourage competitive corporations to uphold smart cities and in the meantime provide basic business conditions that can meet the demands of all SMEs and start-ups.

For large competitive corporations, the findings revealed that opportunities exist in government policy and financial support by providing special funds and promoting investments from around the city and elsewhere in China. This support originates from a call from the "New-Type Urbanisation" policy that advocates for the healthy long-term development of smart cities (M. Chen et al., 2018). Government participants revealed that over the past few years, the municipal government has launched countless open-tendering projects to industry in the transportation sector, thereby effectively stimulating the drastic growth of the competitive economy. Open-tendering practices were construed by GP4 as an embodiment of fair competition which offers a level playing field with good opportunities for various companies to boost their service. Therefore, many market-based investments, financing services and social utilisation of information resources have sprung up to stimulate diversified smart initiatives (J. K.-S. Chan & Anderson, 2015). As the previous literature suggested, factors such as a sustainable organisational structure and urban socio-cultural dynamics are stated as prominent to enhance economic competitiveness (Neirotti et al., 2014), hence leading to enterprises competing against one another in order to retain the superiority of their serviceability and win more market supremacy. Moreover, this form of market competition could enable an increasing extent of market-led but citizen-centric smart initiatives.

For SMEs and business start-ups, the findings suggested that municipal governments tend to offer entrepreneurial conditions and promote inward investments from other cities. As the previous literature indicated, many governments in the world have built a lot of innovation facilities and infrastructures in order to support open-door economics, such as research centres, start-up incubators and innovation parks (Appio et al., 2018). Likewise, in Shijiazhuang, many research and innovation bases have been built in the East economic development zone where the local municipal government underwrites large-scale scientific research and innovation pilot projects. These practices have generated many brand-new ventures which in return stimulate urban employment (Kongolo, 2010), and could possibly consolidate the industry coalition and the GPP.

So far, this discussion has unfolded two major issues around socio-technical shaping of STS development in Chinese new urbanism. Political legitimacy as a mega factor orients the development process towards being top-down in nature, politically centralised, techno-political deterministic, and pro-business. Whilst these characteristics primarily reflect the close relationships between government and enterprises, the next section will focus on how these two bodies interact with citizen end-users within the context of the proposed data-integrated STS scenario.

7.6 Limited citizen participation

As hinted in previous sections, smart city initiatives in the Chinese context are characterised as techno-political in nature and technologically deterministic; however, these characteristics could possibly contradict with what has always been proclaimed by the state, i.e. being citizen-centric. This is because smart city policies and initiatives with these traits could propose a question: is the wide civic society satisfied with these so-called ‘citizen-centric’ solutions?

In their smart city research, Kitchin et al. (2019) have attempted to reframe, refashion and re-imagine the smart city notion to regard smart city initiatives as an instrument to serve the interests of all citizens rather than just selected populations, such as vested interest groups (e.g. government officials, technocrats, transnationals, consortiums). Hollands (2008) also pointed out that many smart city initiatives in the UK (e.g. Southampton’s SmartCities project) are built upon a unified interface between citizens, commercial firms and government authorities. The “New-Type Urbanisation” agenda in China also highlights the imperative to make cities *“more ‘liveable’ and resilient and, hence, able to respond quicker* *to new challenges"* through *"citizen engagement"*. These citizen-centric discourses all underlined the necessity of building citizen interaction with other social bodies in the process of smart city construction. However, the differences between the two contexts are about to what extent citizens participate in co-creating the value that makes smart city initiatives more sustainable. This is more often the case when data generated from each of these social bodies are integrated.

Citizens would never be granted with rights and power without some form of official oversight. Kitchin et al. (2019) argue that for contemporary neoliberal cities to be smarter they need to conceptualise what smart city initiatives really consist of and how they can be operationalised to fundamentally transform the city, which is identified by other smart city researchers as a previously discussed shift of governance from governmentality to smartmentality (Vanolo, 2014). A distinctive argument drawn from the neoliberal smart city literature in regard to such transformation is that rather than being vested with various civil, legal, political and socio-cultural rights (which underscores individuals' membership in the urban regime), citizens are tending to be granted with individual autonomy, namely the freedom of 'choice' and individual responsibilities (i.e. 'consumerism' demonstrated in the Scaffold of Smart Citizen Participation (Cardullo & Kitchin, 2019a). In contrast, however, this study suggests that the extent to which citizens are truly free to choose is greatly contingent upon which phases of the smart city initiatives development they are involved in. Under the current settings of political legitimacy, the findings suggest that citizens are empowered with rights to have a say within the implementation process more than the design process. The following sub-sections will take a closer look at how citizens in Chinese smart cities participate specifically in STS, and how, and in what ways, their voices are heard now and might be heard in future given the proposed data integration scenario.

7.6.1 Where are citizens' voices?

There seems to be a controversial debate in smart city discourse in regard to who are included in digital and smart society within the new urbanism. For the STS, many scholars argue that in China everyone would need to be able to use STS services, including public applications (e.g. smart buses, shared bikes) and individual applications (e.g. smartphone apps, smart meters), and that government administrative procedures should be open to citizens via the internet, such as applying for driving licences, assessing legal counselling, accessing policy change, and so on. However, this was perceived by participants as a kind of utopian form of citizenship. In contrast, quite the opposite currently exists in terms of digital inclusion; the literature revealed the fact that not all citizens are digitally included, for instance those marginalised as urban poor (Cheng, Zhang & Shenggen, 2002; Nelson, 2017; Pucher et al., 2007) who have disabilities or barriers to access those applications. However, although these groups of citizens are not the majority of citizenry, their voices represent basic grassroot citizens' demands. The problem here now is obviously whether the government should listen to what they say?

It is said in the literature that in neoliberal smart cities there is an ideological shift that economic competitiveness is correlated to social well-being (i.e. improving the quality of life of citizens) in the smart city era (Hollands, 2008); however, the rapid proliferation of ICTs to some extent has resulted in a digital divide (Graham, 2002), and the effects of 'splintering urbanism' – social and economic fragmentation and polarisation of urban districts (Graham & Marvin, 2002) as well as its correlated effects, such as gentrification (Cardullo, 2018; Hollands, 2008) and ICT-enabled technological enclaves (Graham, 2002). This suggests that smart cities are also tending to be creative and trying to retain the 'creative classes' (i.e. people who engage in work are functioned to *create meaningful new forms)* as the skeleton members of the smart citizenry. In other words, it is by-and-large the pro-business nature of technological solutionism that results in the digital divide in the neoliberal smart cities. However, when discussing this issue with the data integration scenario in the Chinese smart city context, government participants believed that the case would be different given the political legitimacy setting in China and the demographically and geographically large urban society. More specifically, the end products of the technological solutionism (i.e. the proposed data-integrated application) are expected to equally serve all types of citizens; however, their voices would need to be critically heard when the application is to be designed. In a word, it would be the state that decides what kinds of citizens, by what means, and to what extent, can be selected to air their views.

Firstly, from the technical perspective, data integration initiatives in general are rather reliant upon the data generated from citizen end-users; there is no difference between the data coming from the affluent and socially well-privileged, and the urban poor or vulnerable groups in this sense (if they have access to the technologies). All citizens are enacted as data points or data products. In other words, citizens are being 'monitored'; information about themselves is constantly captured by ICT-driven cloud and big data computing (Cardullo & Kitchin, 2019a). Data generated from everybody is equally regarded as crucial.

Secondly, from the political perspective, this is because the municipal governments always need to embrace the sustainability vision – whether or not it is a good solution for a long-term effect, and take the majority view into account (which might vary differently in different circumstances), rather than do whatever citizens desire. Particularly, participants implied that such a majority view does not mean ignoring the marginalised or urban poor and only taking the needs of the privileged into account, but instead giving priority to making critical decisions and reasoned judgements in the best interests of the multitudes (which might include urban poor). An example from this study is citizen participants' desire regarding the implementation of real-time street-view video (which citizens desire to achieve through their mobile apps) which both enterprise and government participants deemed as unrealistic. In other words, this might not be an ideal solution to put forward when considering the interests of the majority of citizenry. The factors regarding the sustainability vision in this case include pragmatic implications, financial burdens, and consumption of resources. The issues in relation to the majority view include individual privacy, information security and vulnerabilities of mobile devices, etc. Pragmatically speaking, citizens' voices would need to be critically engaged with no matter who they are; the government would need to be critical when listening. Technological solutions should not be either biased, in favour of, or prejudiced against anybody.

However, the findings indicate a challenge that exists in the current state of play of digital inclusion and citizen participation. In the context of Chinese smart cities, although the government embraces the two principles stated above – sustainability vision and the majority rule – citizens are rarely invited to the planning and decision-making process (Huifeng Li & De Jong, 2017). Government participants reveal that they usually undertake post-event investigations of grassroot citizen demand, meaning that the government interacts with citizens in a number of ways (such as selective citizen interviews, open online discussion boards, mass media advertisement campaigns, government open days, and so on) to express their opinions about a particular initiative or policy after it has been implemented.

Moreover, these traditional measures were criticised by citizen participants as useless, again because of the problem with bureaucracy and ponderous administrative procedures (for example, they usually go to many places to get their application form to be approved) they have encountered. As such, there was a strong voice resonating amongst citizen participants. Citizens do not use, and hardly trust, the reporting mechanisms from government sites, but instead favour the solutions developed by the private enterprises, such as feedback and suggestion services on the smartphone apps. Further, resonating with the literature, technician participants hinted that the growing sophistication of user-generated content (UGC) technology would enable more precise capture of citizen demand in a technical manner (Daugherty et al., 2008). In order to address issues regarding data acquisition, information privacy and security, and citizens airing their views, advanced data infrastructures that are built upon UGC data would be required. They further hinted that leveraging UGC is how many IT firms have currently been collecting data. For the proposed data integration scenario, in regard to technically capturing citizen end-user data, this might be a useful approach for gathering data for centralised data processing and efficiently capturing citizens' demand without needing face-to-face conversation anymore.

Overall, leaving aside the reliance upon technical solutionists and such reflection of technological determinism, this study argues that citizens would need to be having a say at a much earlier stage of the value co-creation process of building data-driven smart initiatives if they are aimed at being genuinely citizen-centric. However, acknowledging the citizen voice does not mean their opinions are definitely taken into consideration; rather, the government would need to be critical in decision-making by thinking about the two principles stated above as frames of reference.

7.6.2 To achieve smart citizenship

Whilst citizens' rights and voices are quite limited in the design and decision-making process, the issue now is whether or not they have a big say in the implementation process? The findings from all three perspectives connoted that citizens have tended to be smart when a particular STS initiative is being implemented; in a word, the notion of smart citizenship only takes place within the implementation process wherein solutions, services and infrastructures have already been applied, but might need to further improve and refashion. Participants from all groups as a whole implied the ways in which citizens can be smart during the implementation process. Corresponding to what Kitchin (2014a) classified as two major types of individual data – *directed data* (e.g. collected via automated surveillance and digital devices) and *volunteered data* (e.g. collected via online transaction, social media self-monitoring devices) – the findings at this point similarly revealed two issues which illustrate that smart citizens would need to more effectively interact with their data. These issues include knowing about, and actively sharing, their data.

7.6.2.1 To be smart citizens: knowing about their data

In both focus groups and interviews, participants mentioned the role of surveillance systems adopted in STS. The analysis of the findings connotes that surveillance is always an indispensable functional aspect of STS initiatives and is usually carried out when a particular surveillance-embedded initiative has been implemented. While the literature has illustrated myriads of definitions and classifications of the surveillance system, the findings of this study particularly focus upon the physical form of surveillance infrastructures.

Government participants indicated that the abstract data embedded in, or generated from, surveillance cameras are usually not shareable to the private sector, including STS enterprises who are specialised in STS applications and may have collaboration with government (e.g. the GPP). Enterprise participants resonated that they have attempted, but failed, to acquire surveillance data with the aim to provide citizens with more responsive STS services and all-inclusive transportation information. Government participants explained that the reason behind this is the government's effort to protect citizens' privacy on the one hand, whilst on the other, to effectively monitor and control the public.

In terms of the former, the literature suggests that individual information privacy is usually violated when personal data are disclosed without permission and authorisation (Curzon et al., 2019; Smith et al., 1996). Government participants implied that if surveillance data are shareable and accessible, data such as biometric and genetic information could be manipulated by profit-seeking vested interests, which may result in a discursive form of data transmission across data sites without a proper mechanism to ensure information security. For the latter, both the findings and literature pointed out that the panoptical surveillance (e.g. CCTV) are used to identify geographical patterns of crimes and inappropriate behaviours, for instance, engaging in radical political protest (Lyon, 2005; Norris, 2005). Such purpose indicates that sharing these data with the public could provoke inefficiency of social control, which further suggests that such data sets are emblematic of the power of state control. In the context of transportation systems in Chinese cities, citizen traffic behaviours and mobility are being constantly monitored and sometimes policed by the local authority. For the above reasons, the proposed scenario of STS data integration could be valued as a means to better protect and govern civic society, rather than citizens' rights being subject to techno-political power and control. Figure 14 presents a photo taken by the researcher of the traffic control room in the *Traffic Management Bureau* in *Department of Public Security of Hebei Province* (*STMB)*. Participants demonstrated the Hawkeye surveillance system that has been pervasively deployed in cities and explained how the system operates to monitor and police the public.

Figure 14: A photo of the traffic control room in Shijiazhuang

Participants who work there, particularly stated that they target not only criminals but also citizens who break traffic rules and regulations, or those who attempt to exploit the traffic legal loophole (e.g. speeding on roads without clearly stipulated speed limits); all information about the person is displayed on the screens of the traffic control room.

The literature suggests that in neoliberal smart cities, directed surveillance data are manipulated by private enterprises to further stimulate volunteered data by citizens through crowdsourcing and social media platforms (Papadopoulou & Giaoutzi, 2019; Trottier, 2014). Whilst the above discussed issues in China reflect that the Chinese state deploys surveillance systems in order to protect citizens, and that the data from which should not be shared with private enterprises for commercial use. Notwithstanding this purpose, existing literature does not suggest what citizens think of both of these derived and volunteered datasets. But in this study, citizen participants argued for transparency. Firstly, they perceived that all types of transportation information could be made more transparent if data from various transportation systems were integrated because the attributes of data from different places would be seamlessly associated. Secondly, given the widespread use of surveillance devices in urban areas, rather than being granted access to the actual raw data of these surveillance infrastructures, they should instead know what particular surveillance infrastructure is being implemented, and for what purpose. What is more, citizens could make more flexible decisions if they know more information about their personal data collection and use. Furthermore, as De Lange and De Waal (2017) noted, technological infrastructures that capture citizen data usually neglect some of the basic components of what it means to live in a smart city (e.g. convenience, efficiency, transparency) and how citizens can contribute data to smart city initiatives.

7.6.2.2 To be smart citizens: actively contributing their data

Citizen science literature suggested smart citizenship requires the idea of engaging citizens in shaping their living environment. Typically, local residents expressed a desire to have a say in ‘making a place’ to live (Beyea, 2009); however, the extent to which such a ‘say’ is dominant in advancing living conditions varies across contexts and circumstances, and therefore the form of citizen participation in city development can be multi-fold (see Arnstein’s (1969) ladder of citizen participation, for instance). In the context of Chinese cities, the findings echoed and extended the literature in terms of citizen participation in Chinese smart cities. Whilst citizens were deemed as involved in the implementation process more than the design process (Huifeng Li & De Jong, 2017), the findings further hinted that citizens never have a say in decision-making when a particular initiative is being designed. Yet, they are allowed to raise their voices after the design process is finished (e.g. UGC-based applications developed by technical firms are used to capture citizens’ voice), but their voices are overly steered by the state in regard to the form and content of their voice.

It is evident from the findings that government has acknowledged the need to transform 'cookie-cutter' forms of citizen-centric smart city initiatives towards being customised and bespoke, for the purpose of smart citizenship. Representatives of these initiatives are smartphone applications (which allow end-users to personalise their transportation preferences) and personalised solutions for specific purposes (which offer different services to different groups of people). As a result, an increasing number of designated or self-designated customised STS initiatives have appeared on the market. As many enterprise and government participants claimed, these initiatives are rather reliant upon public participation; in a word, the efficacy of customisation is determined by whether citizen end-users effectively interact with these applications. Herein, the literature backs up such citizen interaction in terms of citizens being not merely consumers and data producers (who create self-generated data by all kinds of customised services produced from the market) (Brenner & Theodore, 2002; Cardullo & Kitchin, 2019a), but also as actors who provide feedback and suggestions (e.g. useful information, ideas, thoughts and opinions) (Seltzer & Mahmoudi, 2013) for the purpose of further improvement and refashioning.

However, contracting to how Cardullo and Kitchin (2019a) argue that feedback and suggestions usually take place in the design phase of a particular initiative, the findings of this study within the Chinese context indicated that these actions only occur when a problem exists. This depicts a kind of 'wise-after-the-event' ideology of active citizen engagement, where citizens are encouraged to contribute to refashioning already existing customised initiatives, rather than creating new solutions.

Here exist two extending and interrelated issues hidden behind such ideology. The first is whether these existing customised initiatives are truly what citizens demand? Enterprise and government participants both provided generally negative answers. Hemment and Townsend, (2013) argue that smart citizens need smart government. Likewise, the participants of this study hinted that in order to initiate a state-led data integration solution, citizens should be allowed to have expectations from the state and the latter would need to consider making remarkable changes to the existing initiatives according to citizen demand. The second issue is that many truly custom-built and citizen-centric initiatives, which are mainly developed by private enterprises, usually come up against government regulations because, as participants argued, there is a lack of a systemic governing mechanism that stipulates their legality, and lack of rudimentary data protection measures. Whilst many literatures have highlighted data vulnerability and insecurity as marked challenges to running big data-driven technological initiatives (Kitchin et al., 2015; Townsend, 2013), the findings indicated that purposive policy-making procedures might be able to undergird the efficacy of involved data sets. For particular types of custom-built initiatives, this suggests that it would be necessary to put forward a corresponding policy or legitimate government stipulation to specify how data should be handled, by what means, and in what transportation scenario should the services run.

7.7 The integrative framework: Successful design and implementation of data-integrated STS initiatives

Previous sections illustrated an in-depth discussion of the potential challenges and opportunities for initiating the proposed data-integrated STS application. Bearing out the key dynamics extracted from this discussion, this section presents a theoretical framework of this study (Figure 15). In this framework, a variety of factors that may influence successful design and implementation of such a data integration solution within the Chinese city context are identified. The study argues that these factors are what STS practitioners would need to acknowledge and manage for an increasing chance of successful design and implementation of data-integrated STS application.

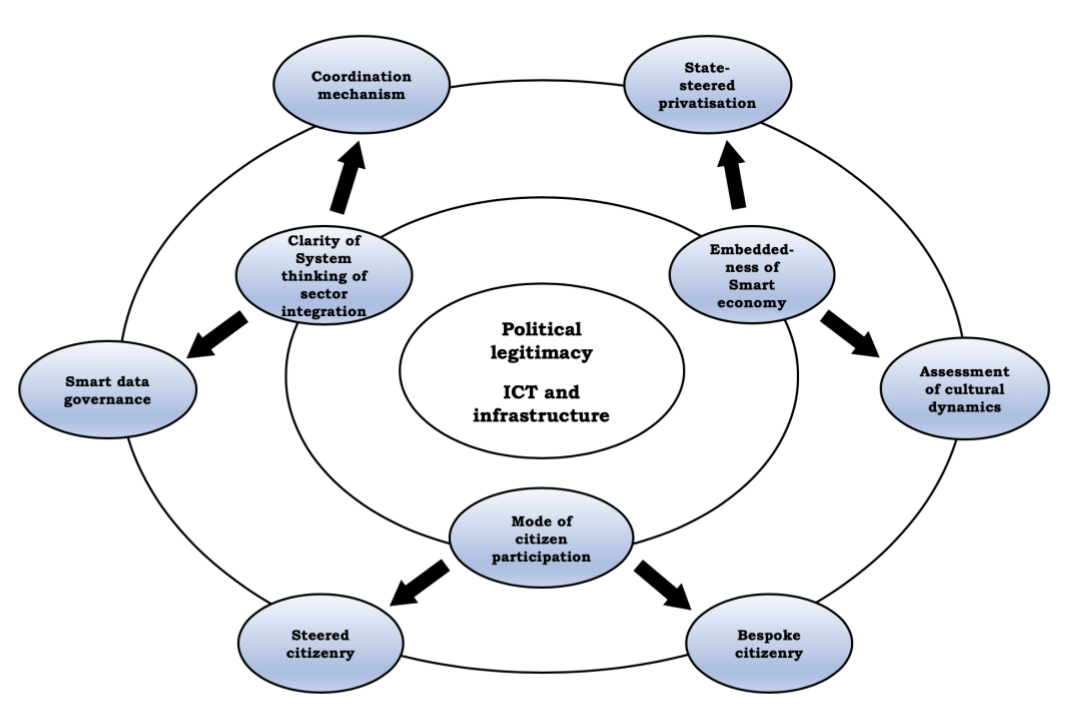

Figure 15: Factors influencing the successful design and implementation of future data-integrated STS initiatives in Chinese city context

7.7.1 Inner factors

One of the key arguments has been extracted from the previous sections is that the existing form of STS governmentality in Chinese cities is techno-political in nature and technologically deterministic. This suggests that the political legitimacy plays a dominant role in the process of initiating STS initiatives in Chinese cities. Herein, the discussion elaborated that this is a mega factor that exerts significant influence upon all the other factors of the data-integrated STS development. Moreover, both the smart city literature and the findings claimed that the proliferation of ICTs and widely embedded urban infrastructure are technically considered as crucial driver of smart city initiatives (e.g. Alawadhi et al., 2012; Chourabi et al., 2012; Giffinger et al., 2007; Harrison et al., 2010; Hollands, 2008). The top-down and centralised nature of smartmentality in Chinese cities would determine the ways in which such ICT and infrastructure-based initiatives are socio-technically designed and implemented, which is state-steered. Thus, ICT and infrastructure and political legitimacy are defined as two mega factors directly influencing successful design and implementation of the data-integrated STS application.

Furthermore, echoing the 'New-type Urbanisation' agenda (J. K.-S. Chan & Anderson, 2015; CNDRC, 2014), the findings of this study claims for the need to bring in various social actors to co-create the value that these initiatives would have, such as citizen end-users and private STS enterprises. The findings revealed that there are various potential challenges and opportunities that would emerge when the government interacts with these social actors. According to the discussion of synthesised insights from all three perspectives of the participants, three interrelated major factors and their associated sub-factors have been identified that are shaped and moulded by the current political legitimacy and the increasing development of ICT and infrastructures. More importantly, these factors are what both government and enterprises would need to acknowledge and manage in order for the successful design and implementation. Discussed in the following subsection, these factors are hence considered as the intermediate and outer factors respectively presented at the middle and outer layer of this framework.

7.7.2 Intermediate and outer factors

The three intermediate factors are defined as: clarity of system thinking of sectors integration, mode of citizen participation, and embeddedness of smart economy. Instead of saying they are independent factors, the study shows that these three interrelated factors respectively embody three key arguments distilled from this discussion. For each of these, outer factors have been identified; they represent more specific and on-the-ground dynamics that shape the peripheral components of the design and implementation of data-integrated STS applications. The following sub-sections will articulate these three key arguments with key considerations of the potential challenges and opportunities.

Firstly, the study argues that the current centralised, top-down political and legal systems determine that private sectors are constrained in co-creating STS initiatives with little self-autonomy under the partnership with government. Private STS enterprises are therefore facing many stumbling blocks that stand in the way of the value co-creation process, such as bureaucracy, pecking order, and business homogenisation. Nevertheless, some potential opportunities also exist to enhance organisational performance and their partnership with the government, which has been identified as a system thinking of sector integration. Herein, channels through which such integration can be achieved have been identified, for instance building coordination mechanisms with more transparent and efficient channels for collaboration, and refashioning existing organisational structure in both government and private sites to enable smarter data governance.

Coordination mechanisms in this study refer to the collaboration between all types of enterprises (i.e. industry coalition) and between the government and private enterprises (i.e. the GPP). The findings of this study suggested that continuing efforts in government devolution and building on Special Purpose Entities (SPE) could be effective measures that could augment the effectiveness of such mechanisms. These measures indicate the necessity of establishing specially purposed organisations which are empowered to coordinate resources from various sites. Moreover, as government always plays a leading role in these collaborations, it would be necessary for them to have a strategic and holistic vision of governing transportation data sets. The concept of smart data governance aroused from both enterprise and government perspectives, in which arguments are referred to as data industry standardisation and data authority and ownership. For various types of transportation data to be integrated into one system, the government needs to legally stipulate unified national data standards, carefully scrutinise data attributes, and distinguish between data owners and users. These legal governmental practices were considered as crucial in providing enterprises with a secure, healthy, and entrepreneurial environment.

Secondly, the study argues that the current state-of-play of the political regime again determines that although citizens as end-users are encouraged to participate in building future STS initiatives, they currently play a rather limited role in the initial decision-making and design process. However, citizens are greatly active, and have a big say in the implementation process. Government and enterprises herein should make concerted attempts to promote smart citizenship by endowing them with rights to speak, comment, suggest, and provide feedback etc. with regard to the effectiveness and performance of particular STS initiatives, and should really put these efforts into effect. For example, the grassroots cadres of government departments, e.g. Community Committees and Urban Management Offices, literally have direct communications with citizen representatives within certain districts but they fail to carefully listen to what they think about particular solutions for particular issues. Enterprises usually roll out corresponding platforms through which citizens can air their views. These practices have been claimed to be even more important to the proposed data-integrated solution of STS as participants stated that problems would increase and perhaps enlarge, when troves of data come to one place.

In this sense, citizens are actually defined as steered citizens – they are told and steered to provide their insights through a set of pre-set approaches of interaction only when a particular STS initiative is being implemented. In addition, participants also advocate for smart citizenry by providing customised STS services for citizen; this is claimed as a bespoke kind of citizenry. Although citizens have a certain degree of choice (i.e. as Cardullo and Kitchin (2019a) define citizens of this type as 'consumers'), they choose from a set of actually existing smart initiatives. Overall, these two types of citizenry reflect citizens' rights to have a say in the implementation process of STS initiatives, and suggest two implications for STS practitioners as a frame of reference. Firstly, although they are not really engaged in the decision-making and design phase, such a 'right to say' would bring about more responsive government. This responsiveness would create trust which would further enable more constructive 'right to say' and have more profound implications for everyone (Goldsmith & Crawford, 2014). Secondly, more citizen engagement in the design and decision-making would create more chances for successfully initiating citizen-centric and value co-created STS initiatives, and in particular, the data-integrated STS application.

Thirdly, the study argues that although the 'New-Type Urbanisation' plan promotes the increasing privatisation of pubic assets and resources, and the growing extent of capital accumulation through marketisation (J. K.-S. Chan & Anderson, 2015; Cheshmehzangi, 2016), the smart economy in general is significantly steered and intervened by the state which decides the direction of development. To some extent, a deep entrenched ideology of technological determinism has led to the government overly stressing the importance of technology, and overlooking local characteristics and contingencies, i.e. cultural dynamics. Participants hence claimed that it is necessary to take significant measures to enhance performance of local economic competitiveness. They extended that government have tended to draw their attention to improving local entrepreneurship conditions by offering special funds, and promoting both indigenous and foreign investments. Further, the open-tendering practices could enable growing market competition, with which a variety of private STS enterprises would become active and attempt to compete for more market supremacy. This is to say, the state-steered privatisation provides a level playing field for private enterprises, which as a whole, are identified as one of the main forces in co-creating the proposed data-integrated STS solution.

Furthermore, although the factors of the theoretical framework were drawn from the investigation of Shijiazhuang's STS, they represent the potential to initiate such a data-integrated application in the context of other Chinese cities in future. Tsang (2014) argues that the outcome of qualitative case studies can be both empirically and theoretically generalised to other contexts. For empirical generalisation, there must be some common values and features between the populations within two contexts, namely a kind of "empirical regularity" is established amongst them (p. 377). For theoretical generalisation, once existing theories are refined or new theoretical frameworks are developed based on empirical findings, the scope of generalisation could be dependent upon the basic populations and contextual settings, i.e. "mechanismic explanations of empirical phenomena" (Bunge, 1997, p. 440). These rationales suggest that the findings of a study are all what are needed in order to respond to the initial purpose of the research and they are also applicable in other places with similar contextual settings. However, the theoretical framework of this study depicts an open system with its factors being transferable rather than generalisable to other cities in China. This indicates that given the local socio-political-economic characteristics and variables, whilst the defined factors might play a crucial role, additional influences could also intervene in the shaping of a data-integrated STS application in another city.

7.8 Summary

This chapter synthesised insights from across the three findings chapters in terms of the key potential challenges and opportunities for initiating the proposed data-integrated STS application. The chapter firstly reiterated key findings drawn from each group of participants' points of view regarding their own concerns and perceptions (Section 7.2). The chapter then stepped into a close examination and comparison of the governmentality in both the Chinese and neoliberal smart city contexts, thereby articulating the shift of smart city development ideology from governmentality towards 'smartmentality' (Section 7.3). With such ideology throughout the discussion, the chapter then moved to a more in-depth exploration of a set of important dimensions of the potential to initiate the proposed data integration solution, with perceived challenges and opportunities identified (Sections 7.4-7.6). Finally, a theoretical framework was demonstrated based upon the discourses in the prior sections to visualise the defined key factors that may influence the success of designing and implementing data-integrated STS applications, as well as the interrelations between these factors (Section 7.8).

Chapter 8: Conclusion

8.1 Overview of the research

This thesis set out to explore **what would be the potential challenges and opportunities for initiating a data-integrated smart transportation system (STS) application in China's new-type urbanisation from a socio-technical perspective.** In order to answer to this question, the study aimed to address six objectives.

The first and second objectives concentrated on a literature investigation of smart city and STS in both the general and Chinese city contexts. As a significant domain of the smart city (Anthopoulos, 2015), STS initiatives gained traction amongst academic scholars, industry and governments, while many issues related to STS in particular, still remained unsolved, especially in regard to data integration. Firstly, although many dominant smart city literatures had evidenced the socio-technical system view of designing and implementing smart city initiatives in the general context (e.g. Alawadhi et al., 2012; Chourabi et al., 2012; Nam & Pardo, 2011b), there was a lack of exploration of how such a theoretical lens can specify the issues of STS initiatives in particular, within a specific context. Secondly, whilst the role of citizens and the ways in which they participate in building both western neoliberal and Chinese smart cities had been significantly studied and theoretical models established (Arnstein, 1969; Cardullo & Kitchin, 2019a; Huifeng Li & De Jong, 2017), questions of how citizens would engage in STS and how they might interact with local enterprises and government still remained unanswered. Thirdly, from the information system point of view, existing studies about data integration practices in the Chinese smart cities placed emphasis upon technical imperatives for realising the universal access of heterogenous STS data sources (An et al., 2016); there was even little focus upon the holistic socio-technical understanding of data being integrated within the urban transportation system.

In order to achieve the objectives 3-5, the overall strategy of this research, i.e. a single-case study (i.e. the case city of Shijiazhuang), was established to investigate multiple stakeholder perspectives (e.g. citizen end-users, STS enterprises and government) through undertaking different data collection methods – i.e. focus group discussions (with citizen end-user participants) and semi-structured, in-depth interviews (with STS enterprise and government participants). The collected empirical data that were thematically analysed and synthesised as the main part of this research have produced a variety of insights; these allow us to better understand a fundamental socio-technical shaping of the issue wherein various kinds of STS data were to be integrated and the dynamics that may influence the success of designing and implementing such proposal. A theoretical framework was developed at the end of this study to back up and visualise the analytical procedure of the synthesised findings and the reviewed literature, as a response to the sixth objective.

8.2 Empirical contribution

The study makes a significant contribution to our understanding of the socio-technical shaping of STS initiatives through a case study focusing on a data integration solution in the Chinese city context. This accomplishment was made through the application of Chourabi et al.'s (2012) socio-technical system view of smart city initiatives and the investigation of the mode of citizen participation in contemporary smart cities which offered a lens to guide the theoretical framing process for the research design, through to the subsequent collection and analysis of empirical data that was missing from prior knowledge and experience of the subject matter.

This research is interdisciplinary in nature and could be of interest to academic scholars from a variety of fields in the social science sphere, such as information systems, urban studies and political science. The thesis's contribution to information systems knowledge is mainly concerned with the Socio-technical System thinking for data-integrated STS rollouts in the Chinese city context. In particular, this study is the first to explore specific components of interrelated social and technical systems and the application of both in designing and implementing data-integrated STS initiatives in Chinese cities.

The empirical work carried out in this study contributed to the literature of the technical part of the Socio-technical System in terms of how STS practitioners technically manage data alongside the infrastructure from which they are generated. For example, the study observed the need to build information architecture with enhanced system capacity for the integration of data with various formats, structures and attributes, and to make great use of data standard systems, such as World Geodetic Systems 1984. The study also observed that transportation infrastructures and hardware components would need to be upgraded at three different levels: micro level (i.e. data acquisition and storage tools), medium level (i.e. road infrastructure deployment) and macro level (i.e. urban road planning). In terms of the thesis's contribution to the information system literature regarding the social part of the Socio-technical System, the study identified the main types of social actors involved in co-creating the data-integrated STS initiatives, i.e. citizen end-users, STS enterprises and government agencies, and observed a set of socio-political-economic components which these actors interact with. On the one hand, these social system components were drawn inductively from the empirical research on each of these three groups of actors, whilst on the other hand, each group of actors envisioned these components in their own way, and on their own behalf (i.e. as end-users, system developers and policy-makers). Synthesising as a whole these three perspectives on the same social phenomenon, makes an empirically contribution to the Socio-technical-System literature by offering a more integrative understanding of the system.

In terms of the thesis's contribution to the knowledge about urban studies, this is the first study to look at the differences between neoliberal smart urbanism and Chinese new urbanism in terms of the nature of ICT-driven smartmentality – i.e. the smart ethos of governmentality (Foucault, 1991; Vanolo, 2014), and how such differences are important in gaining a deeper understanding of the deeply entrenched urbanisation issues that may influence the success of initiating future STS solutions, e.g. data-integrated STS applications. For example, the techno-political nature of smartmentality within Chinese new urbanism produced technologically deterministic and corporate forms of urban governance and taken-for-granted smart citizenship.

Furthermore, in terms of the political science, the study contributes by unfolding the socio-political framing of STS initiatives through elaborating how the settings of the current political legitimacy – i.e. hierarchical, centralised and top-down in decision-making – would determine the initiation of the proposed data-integrated application in Chinese cities. For example, the research observed that government political power had already been intervening in the development of market innovations and citizen participation. Continuing effort by the state on such political devolution and building on Special Purpose Entities (SPEs) were hence perceived by participants as presenting crucial opportunities for the design and implementation of future STS initiatives that involve multiple stakeholders.

8.3 Theoretical contribution

The set of factors defined in Chourabi et al.’s (2012) integrative framework had contributed to the literature by providing an understanding of successful design and implementation of smart city initiatives in the general context for different purposes. In particular, this framework helped to understand the impacts of three crucial inner factors (i.e. technology, organisation and policy) and five outer factors (i.e. people communities, policy, economy, built infrastructure and natural environment). Chourabi et al. (2012) claim that firstly all these factors were contextualised, and secondly technology was particularly defined as the mega factor that exerts heavy influence upon each of the other factors.

The integrative framework for the successful design and implementation of data-integrated STS initiatives developed in this study (see Figure 15) resonated to some extent with Chourabi et al.’s (2012) framework, given it placed technology as a mega factor. However, based on the empirical work it was recognised that this was highly politically contextualised. Given the distinctive characteristics of China’s political and legal systems, political legitimacy was identified as another mega factor. These two mega factors as a whole are highly likely to impact significantly on the successful design and implementation of data-integrated STS applications.

Beyond the two mega factors, the three intermediate factors of the proposed integrative framework (i.e. clarity of system thinking of sector integration, embeddedness of smart economy, and mode of citizen participation) and each of their sub-level factors of the framework in this study contributed to the theoretical knowledge in two ways: addressing the importance of the socio-political-economic context of the research (i.e. the ‘New-Type Urbanisation’ agenda), and bringing in the angle of stakeholder relations to the theoretical framing of general smart city initiatives.

Firstly, these factors are interrelated and the meanings of them could be drawn on to achieve the goals of the new urbanism stated at the beginning of this study – i.e. technology-enabled, citizen-focused and sustainable urbanism (see Section 1.1) (CNDRC, 2014; De Jong et al., 2016; Griffiths & Schiavone, 2016; Huifeng Li & De Jong, 2017; Qian, 2014; D. Wang et al., 2015). To be more specific, these factors reflected the socio-political-economic commitments of the Chinese central government’s “New-Type Urbanisation” agenda in aspects of: the ways in which citizens can be empowered in building data-integrated STS initiatives and to what ends (namely that bespoke smart initiatives would enable smarter citizenry, and citizens can be more actively involved whilst maintaining the state's desire to steer the citizenry towards particular ends), the forms of organisational and managerial dynamics for enhancing overall innovative capacity and capabilities (i.e. coordination mechanism, smart data governance), and the political-driven and state-steered form of smart economy in stimulating entrepreneurial cities (i.e. state-steered privatisation, assessment of cultural dynamics).

Secondly, each of these three dimensions of factors and sub-factors represented a synthesis of the three stakeholder perspectives involved in this study. Respectively, the citizen end-user perspective reflected grassroots societal needs, the STS enterprise perspective indicated a more technical, organisational and managerial angle of view, and the government perspective suggested a more political and legal stipulation and enforcement. On the one hand, from a philosophical point of view, the roles of these stakeholders and their views backed up the nominalism assumption that emphasised that social reality is created by social actors and therefore never exists independently from human perceptions (Saunders et al., 2016). On the other hand, the interrelationships of those factors within which three perspectives were embedded, reflected the social constructivism position that illuminates constructed social reality to which people's daily interactions entitle the meaning (Mead et al., 1967). Therefore, these intermediate and outer factors of successfully designing implementing smart city initiatives contributed to the gap in smart city initiatives theory.

8.4 Methodological contribution

The methodology of this research was identified as a single-case study with triangulation of bottom-up qualitative data collection approaches (i.e. focus group discussions and semi-structured interviews) applied to investigate different social perspectives (i.e. citizen end-users, enterprises and the governments). Although many prior studies in general had explored smart city issues by adopting these two data collection approaches, and many had studied STS and its applications from these three social perspectives, little had combined both dimensions in the field of STS within the Chinese city context. Methodologically, this study therefore contributed to the knowledge by undertaking focus groups and semi-structured interviews with different social actors to explore data-driven STS initiatives within Chinese cities.

8.5 Practical implications

The socio-technical understanding of the opportunities and challenges of initiating a data-integrated STS solution in Chinese cities developed in this study, could offer practical implications for citizens, STS enterprises and municipal governments. The specific set of factors identified in the theoretical framework could be pragmatically taken by these bodies of stakeholders as a guide to more effectively engage in designing and implementing a data-integrated STS application, or similar initiative. Driven by the two mega factors (i.e. ICT and infrastructure, and political legitimacy), the study could offer a new frame of reference in initiating data-integrated STS solutions in a sense where these stakeholder actors could actually take further actions that are built on the governmentality and smartmentality.

8.5.1 Municipal governments

Whilst the governmentality observed in the study reflected the Chinese political and legal systems as an embodiment of the centralised and top-down form of the state's political regime, municipal governments, as the personification of such power, could in future shift their attention towards a more citizen-centric mode of smartmentality. A major practical implication arising from this pertains to the need to engage citizens in the decision-making and design stages of initiating a particular innovation, by allowing citizen representatives to propose ideas, suggest design scenarios and discuss potential issues with both enterprise delegates and government officials. In a word, the government should really take citizens' voice into account rather than do everything with a 'taken-for-granted' view of citizenship through a 'one-size-fits-all' solutionism. Municipal government agencies could achieve this by advocating more and more bespoke citizen-centric services. Yet, the extending of bespoke citizenry initiatives would need them to take a step back in terms of smart city governance by giving more self-autonomy to the private sectors, executing political devolution to a large extent, and promoting more freedom of markets.

8.5.2 STS enterprises

The thesis also has practical implications for STS enterprises that are considered as the system developers of STS initiative applications. In the sense of this study, they are defined as crucial vested interests and implementors of the proposed data-integrated solution. The findings indicated that STS enterprises could contribute to more effectively embedding data-related technology (e.g. cloud computing) and their resources into partnerships (i.e. industry coalition and government-private partnership) as technical underpinnings of the sector integration. Moreover, as the main collaborator of municipal governments, local STS enterprises could fully make use of the entrepreneurial opportunities provided by the state to improve serviceability and innovation capabilities for enhancing local economic competitiveness. Further, they could also contribute to always being proactive and taking the initiative to be the bridge which connects citizens with the government by virtue of building technical channels through which citizens more efficiently engage in the decision-making and design process of future STS initiatives.

8.5.3 Citizens

Finally, the findings regarding citizen participation could be of interest to citizens that have direct interactions with the end solution. The existing political and legal systems in China have contributed to the shaping of the 'taken-for-granted' and 'window-dressing' forms of citizenship. As the end-users and consumers, citizens would need to clearly understand the results of such modality of citizen participation, i.e. citizens believe what they have been offered is what they should be offered. However, the analytical discussion of this study concluded by rationalising the citizens' voices and the way in which they should participate in initiating the proposed integrated solution. Herein, alongside the practical implications for both the government and enterprises, what citizens could place attention on is the mentality of being smart, as the findings suggested, in a way of actively embracing the smart city ethos in their daily life as pursing 'high-quality' citizenry (e.g. citizens with decent traffic behaviours and smart city awareness), on the one hand. On the other, they should have awareness of fully engaging in problem-solving practices for a particular initiative from its initial decision-making and design stages. This is to say, although citizens in Chinese cities are to a large extent being steered by the state, they should be aware of the importance of being smart citizens to actively raise their concerns and be involved in taking effective measures to address them, with concerted efforts from enterprises and government.

8.6 Limitations and directions for future work

It should be acknowledged that the study has some limitations. Future research should avoid these limitations, and therefore corresponding directions for future work need to be identified.

The first limitation is in relation to the case study design. Firstly, the data collected from each perspective of the research participants was just a snapshot of the fieldwork. Each type of participant was only investigated once, and the overall procedure of the fieldwork started from the citizen end-user perspective, right through the STS enterprise perspective and ended with the government agency perspective. Also, the study applied a bottom-up inductive approach to explore relevant participants' perceptions upon a proposed technology initiative. However, given the rapid development of ICT-based emerging technologies in contemporary smart cities and the fast-changing urbanisation progress, there would have been a need to define this study as a longitudinal case study. It would be useful to carry out another round of data collection at a later date if the proposed data integration scenario were to be implemented in order to examine the 'misfit-fit' possibilities (Gresov, 1989). This means an exploration of the extent to which the perceived challenges identified in this study were to be tackled and new socio-technical considerations that could emerge by then (the time of the additional data collection).

Secondly, this research applied single-case study as the research strategy with the focus placed on the case city of Shijiazhuang – i.e. a Tier-2 city, also known as the capital city of Hebei province. As the Discussion Chapter suggested, although the integrative framework was defined as an open system that could be transferable to other Chinese city contexts, there are local contingencies and variables which would have led to a different research outcome. Thus, a comparative study in several other cities with distinctive local characteristics would be necessary to discover something only pertaining to these places; this would help to shape an even more in-depth and thorough understanding of the initiation of STS data integration solutions.

The second limitation is the fact that this study was focused upon citizen end-users, STS enterprises and government agencies perspectives. Although the study identified these three types of stakeholders as the main actors that perform in shaping the initiating of STS initiatives, it would also be useful to investigate other types of social actors, such as research institutes and academies, state technocrats, and state-owned enterprises, with the aim of unfolding an all-inclusive and more detailed analysis of the topic.

8.7 Concluding thoughts

"Building smart cities is going to take time. It will by necessity be a long, messy, incremental process." (Townsend, 2013, p. 11)

The citation above describes an arduous and time-consuming process of smart urbanism. Whilst the "New-Type Urbanisation" agenda set out to achieve smart city construction within six years (2014-2020), the study evidenced that, to a large extent, this is not an easy job. Not only are there many socio-technical facets that need to be taken into careful account in expanding smart city initiatives, various types of social actors also need to tie in with each other to co-create value for the evolution of new urbanism. Smart transportation as a prominent domain of smart city upholds urban mobility. Despite being increasingly technologically sophisticated, the 'smartness' label tells us that it is a far more complicated system, and that it requires us to undertake a more fine-grained critical analysis of the potential challenges and opportunities for initiating future scenarios. Smart transportation system initiatives require not simply technology, but also human beings and, as such, a collective mentality of being socially-driven, citizen-focused and sustainable – in other words, 'smart'.

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Appendix 1: Focus group questions

A. Questions about Shijiazhuang's transportation network in general

- Does such bad traffic condition really affect your life? Are you really bothered by this sort of things?
- What do you think could be the cause of that?

B. Questions about the problems of the current STS in Shijiazhuang

- What sort of things in urban transportation do you think are really well developed, e.g. transportation infrastructure, vehicles on the road, transportation-related policies, technologies etc.
- Also, what kind of problems have you ever met in the transportation?
- Do you know any relevant policies made regarding these problems?
- Were there some technologies applied?
- What specific kind of technologies do you know were best to address these problems?

C. Questions about 'applications'

- Were there any STS applications that made you not bothered with the problems anymore?
- What were the benefits/advantages of these applications?
- Do you think the current commonly used applications can more or less help address the problems you just mentioned?

- What STS applications have you tried before but stopped using later?
    - Why did you stop using it?
- What main functions of the application do you often use?
- Could you please give a bit more details – why do these functions really attract you?
- What would be the most benefits for you of using those applications?

- What are the weaknesses of the current STS applications?
- How would you think these applications to be functionally improved in future to meet your demand?"

D. Questions about 'integration' issue

- What sort of functions or services should further STS initiatives cover do you think?
- Do you use various applications/services in one journey for different purposes, say respectively acquiring different transportation services, to make your journey smarter? Or you only rely on single application/service for a particular purpose?"

- If there is an application in future that comprises all functions and information on the current applications to provide you a comprehensive set of services, would you be keen on using that every time you go out?
- What sort of things do you desire such a data-integrated application to have?
- In what respect would you think the integrated application is much better in use and performance than the current applications?
- Do you think it would make your journey easier and smarter or in the other way around?"
- What do you envision would be the possible benefits of such a data-integrated solution to be?
- What would be the potential disadvantages of using it?
- If such an integrated application were to be implemented in future, what do you think could be the potential obstacles?

E. Concluding questions

- Do you have anything to supplement?

Appendix 2: Interview questions (STS enterprises)

A. Background and context – opening words

B. Participants and their jobs

1. Could you please briefly introduce yourself and your job duties?
2. How long have you been a technical staff / project manager in this company?
3. Could you tell a bit specific projects or tasks of the apps in your team that you have accomplished in the past? What responsibilities did you take for the project?

C. The app(s) of the interview company

4. At initial stage of a project – a new app or a new feature added on the app, how did you come up with this idea?
   4.1 What motivated your team to do it?
5. What transportation-related issues do your app(s) aim to address? *(Here is followed by mentioning citizens' concerns about the current urban transportation, e.g. traffic pressure, time consuming)*
6. What are the main features of the app(s) you currently work on?
   6.1Which are the most characteristic ones that most of users use?
7. What are the advantages and disadvantages of the main features/functions on the app(s)?
8. What are the resources of your app data? Where do your data come from?
9. What sorts of technologies and architectures at the moment are applied to your app development in terms of data gathering and use?

D. Other apps in the market

General knowledge and environment

10. How is the general development of STS apps across different sectors of transportation?
    10.1 What are the main advantages and barriers of their development at the moment?
11. How do you compare the app(s) that you work on with those from other businesses within the same sector of transportation service? For example, how do you compare Baidu Map, Gaode Map and Google Map which are all sort of route planning apps?
12. There are also various apps providing distinct services within different sectors of transportation service. How do you think of their general operability when taking into account their capability of benefiting their users?

Data of these apps

13. What are the common characters of data needed by different apps?
14. What are the challenges for companies to collect and use their data?
15. What factors do you think are crucial to maintain both quality and quantity of app data?

E. Relationships between stakeholders

Participant company VS Citizen end-users

16. Do you normally carry out end-user investigation before developing a new app or a new feature on an app to investigate what end-users need and what they think of the apps?

    16.1 If you do, what sorts of views are more valuable to the development of the app? *(here is followed by mentioning some findings of focus groups – citizen opinions on the current issues of urban transportation, pros and cons of the existing apps and benefits of the proposed integrated apps.)*

17. Do you consider the categories of end-users, e.g. age, means of transportation? How is one type of users using the app different from one another?

Participant company VS Competitors

18. Do you do any market research or risk assessment in terms of competition from other companies within same sector of transportation services? *(here is followed by mentioning citizens' point of view on competition.)*
19. What do you think are the critical success factors of occupying market opportunities?

Participant company VS Government

20. When you develop applications, do you do any policy research from relevant government sectors in terms of resources, policies, technologies and their Smart City and Smart Transportation development plans? *(here is followed by mentioning citizens' views on government support)*

    20.1 Are there any other types of interaction with government people that facilitate developing your apps?

    20.2 Are there barriers involved in communication with government?

F. Data sharing and data integration

21. How do you understand the importance of data sharing between relevant transportation data-holders?
22. How is data shared between you and your users?
23. Do you share data with any organisations? For what purpose?

    23.1 Are they cooperative organisations?

24. Do you collect data from relevant government sectors/agencies?

    24.1 What is government data policy? What are the difficulties of data collection from government?

25. When you have collected a large range of data resources from different places, how is such amount of data stored?

    25.1 Do you integrate all these data to your app?

    25.2 Do you have previous projects about data integration? What did you do?

    25.3 What is your key concern of integrating data into your app?

G. Future improvement and data-integrated potential solution

26. What is your future development plan of the apps you work on?
27. Many people desired that future STS app can achieve accurate indoor positioning, real-time street views and more effective human-app interaction, etc. What do you think are crucial to achieve this? Any challenges?
28. There are various types of STS apps in the market providing different types of services. People have to download multiple apps in their mobile devices. If all

these services are provided by one app by integrating their data, technologies and other resources, what challenges do you think there would be?

28.1 If such an integrated app is a potential future STS initiative, what contribution do you think it can make to the city?

H. Concluding question

29. Do you have anything else relevant that you would like to say?

Appendix 3: Interview questions (government agencies)

A. Participants and their opinions on urban transportation status

1. Could you briefly introduce your job and your department?
2. How long have you been working in Shijiazhuang Transportation Bureau (SJZTB)?
3. What do you think of the transportation development over the past ten years in Shijiazhuang?
4. What do you think are important areas for development in relation to Smart City transportation services?
5. What are your views on the benefits of the current STS applications to the urban transportation system and our citizens in Shijiazhuang?
6. To develop a new Smart transportation service in Shijiazhuang in particular, e.g. smart car park, what resources are necessary to be involved?

B. Projects of SJZTB

7. Could you tell me about specific projects or tasks about urban transportation services/smart transportation initiatives that you have done in the past? What responsibilities did you take for the projects/tasks?
8. At the very beginning of these projects, how did your team come up with this idea?
9. What transportation issues did these projects aim to address?
10. How did the outcomes of these projects benefit the urban transportation and/or citizens?
11. What was the collaboration in these projects? What types of institutions were involved in implementation of these projects?

C. Government roles in STS application development

12. What are the relevant government policies related to STS initiatives? How do you think these policies impact on commercial companies developing their STS services?
13. What are the key factors shaping government decision-making in STS?
14. Are there any forms of data integration of STS applications that government would like to develop, or see developed?

D. Relationships between government and other stakeholders

a) Business collaboration (business-business relationship)

15. From government perspective, what are the barriers for a commercial STS application company to collaborate with other companies who do similar business?
16. What is your understanding of 'data sharing' between commercial STS application companies for any type of needs? What are your views on the current data sharing and/or data trading practices between STS businesses?

17. Are there any transportation-related government provisions/policies about commercial cooperation regarding data trading and sharing? How do government provisions/policies influence on data trading and sharing across different STS companies?

b) Government power (business-government relationship)

18. What are the typical forms of collaborations between commercial STS application companies and government agencies; how do companies whose main business is STS application collaborate with government agencies, for instance? Are there any data shared or traded to each other? What are they?
19. What is your opinion on the term 'information isolation' that points to relevant government transportation agencies not opening data for commercial re-use by businesses to develop their services? What kinds of data are they? Are there any reasons why these data have been 'isolated'?
20. To what extent do you believe that 'open data' – i.e. data that is freely available online for anyone to access and re-use - from government is useful for commercial companies to develop their transportation applications with the aim to benefit citizens and urban transportation? To what extent is this data currently open? What are the barriers to opening such data?
21. Are there any other powers of government that currently, or could in the future, direct the trend of STS application development?

c) Citizen participation (government-citizen relationship)

22. What is your understanding of 'citizen participation' in building Smart Cities?
23. To what extent do you think citizens in Shijiazhuang and other cities are currently engaged in informing and developing STS initiatives? How about specifically in relation to transportation information provision through mobile applications?
24. How do Shijiazhuang's Smart City/STS policies currently consider citizen interests?
25. How transparent and accessible do you think government owned transport data should be to citizens? Do you think the underlying data, or the information generated from it, is more important to citizens? What would be the difficulties in making government owned transport data more transparent to citizens?

E. Data integration

Coming back to the idea of data integration across STS applications…

26. To integrate transportation data from different data holders to develop, for example, an integrated data platform or an integrated mobile application, what do you think government should or could do to coordinate the integration of these resources from different sites? What are the difficulties to do so? What are the key successful factors you think there would be?
27. What are the political & government policy concerns of integrating transport data from different applications?
28. What are the commercial concerns of integrating transport data from different applications?
29. Were there any successful data-integration projects in the past that the government were involved in?
30. What is your envisagement of STS data-integration scenarios to be in future?

F. Future STS development

31. Basically, what to do to be a ‘smart government’ do you think?
32. What do you suppose to be the future trend of smart transportation?
33. Do you have anything else to add up to our conversation?

Appendix 4: Information Sheet

The University of Sheffield. Information School	An investigation of smart transportation system (STS) data integration within Chinese cities: A socio-technical system perspective

Researchers		
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Purpose of the research

This study aims to explore the potential challenges and opportunities for initiating the a data-integrated STS application in China's new-type urbanisation from a socio-technical perspective.

Who will be participating?

The research project involves 1) several groups of citizens who are end-users of and have different knowledge and experience of smart transportation systems; 2) three local transportation companies in the case city of Shijiazhuang; and 3) two local government agencies who administrate urban transportation.

What will you be asked to do?

For citizen end-user participants:
You will take part in a focus group discussion to provide your views on Shijiazhuang's STS in general, issues of the current Shijiazhuang's STS and its applications, and the potential to implement the proposed data-integrated scenario for the STS.

For local transportation companies:
You will take part in an individual interview. The purpose of this interview is to obtain your in-depth insights on the current STS and its applications in Shijiazhuang and your perceived socio-technical dynamics that might influence on successful design and implementation of the proposed data-integrated STS application.

For local transportation agencies:
You will take part in an individual interview. The purpose of this interview is to obtain your in-depth insights on the current STS and its applications in Shijiazhuang and your perceived socio-technical dynamics that might influence on successful design and implementation of the proposed data-integrated STS application.

What are the potential risks of participating?

Potential risks are same as those experienced in everyday life.

What data will we collect?

I will audio record all focus group discussions and interviews. No other types of data are needed.

What will we do with the data?

- The recordings will be transcribed into a Word document and fully anonymised - any reference to participants' real identity will be eliminated.
- All recordings will be stored in different encrypted places.
- The anonymised transcripts will be kept for possible reuse for future relevant projects.

Will my participation be confidential?

The researcher will treat your participation confidentially and your name will not appear in either the transcripts or the thesis. The researcher will ask other participants to keep the information confidential.

What will happen to the results of the research project?

The findings of this study will be presented in the Findings Chapters of the thesis. The findings produced from the study will be carefully stored and retained for re-use in future relevant projects or academic papers.

Appendix 5: Participant Consent Form

The University of Sheffield. Information School	An investigation of smart transportation system (STS) data integration within Chinese cities: A socio-technical system perspective

I confirm that I have read and understand the description of the research project, and that I have had an opportunity to ask questions about the project.

I understand that my participation is voluntary and that I am free to withdraw at any time without any negative consequences.

I understand that I may decline to answer any particular question or questions, or to do any of the activities. If I stop participating at all time, all of my data will be purged.

I understand that my responses will be kept strictly confidential, that my name or identity will not be linked to any research materials, and that I will not be identified or identifiable in any report or reports that result from the research.

I give permission for the research team members to have access to my anonymised responses.

I give permission for the research team to re-use my data for future research as specified above.

I agree to take part in the research project as described above.

______________________________ ______________________________

Participant Name (Please print) Participant Signature

______________________________ ______________________________

Researcher Name (Please print) Researcher Signature

Date ____

Note: If you have any difficulties with, or wish to voice concern about, any aspect of your participation in this study, please contact Dr. Angela Lin, Research Ethics Coordinator, Information School, The University of Sheffield (ischool_ethics@sheffield.ac.uk**), or to the University Registrar and Secretary.**

Appendix 6: Research Ethics Approval Letter

The University Of Sheffield.

Downloaded: 09/03/2020
Approved: 30/06/2017

Jun Zhang
Registration number: 150112569
Information School
Programme: PhD Information Studies

Dear Jun

PROJECT TITLE: A study based on the analysis of challenges, benefits and enablers of integrating a Smart Transportation System within the context of China
APPLICATION: Reference Number 011947

On behalf of the University ethics reviewers who reviewed your project, I am pleased to inform you that on 30/06/2017 the above-named project was **approved** on ethics grounds, on the basis that you will adhere to the following documentation that you submitted for ethics review:

- University research ethics application form 011947 (form submission date: 27/06/2017); (expected project end date: 01/01/2020).
- Participant information sheet 1024966 version 10 (01/06/2017).
- Participant consent form 1024967 version 3 (01/06/2017).

If during the course of the project you need to deviate significantly from the above-approved documentation please inform me since written approval will be required.

Your responsibilities in delivering this research project are set out at the end of this letter.

Yours sincerely

Larah Hogg
Ethics Administrator
Information School

Please note the following responsibilities of the researcher in delivering the research project:

- The project must abide by the University's Research Ethics Policy: https://www.sheffield.ac.uk/rs/ethicsandintegrity/ethicspolicy/approval-procedure
- The project must abide by the University's Good Research & Innovation Practices Policy: https://www.sheffield.ac.uk/polopoly_fs/1.671066!/file/GRIPPolicy.pdf
- The researcher must inform their supervisor (in the case of a student) or Ethics Administrator (in the case of a member of staff) of any significant changes to the project or the approved documentation.
- The researcher must comply with the requirements of the law and relevant guidelines relating to security and confidentiality of personal data.
- The researcher is responsible for effectively managing the data collected both during and after the end of the project in line with best practice, and any relevant legislative, regulatory or contractual requirements.