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# Shaping a Smart Transportation System for Sustainable Value Co-Creation

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## Abstract

The smart transportation system (STS) leverages ubiquitous and networked computing to improve the efficiency of urban mobility. Whilst existing IS work has explored various factors influencing STS development, there is a lack of consideration of how value can be created for building a more sustainable STS. Drawing upon the value co-creation theory and stakeholder theory, we seek to understand the socio-technical shaping of the STS ecosystem and how government, firms and citizens collaboratively create sustainable value for designing and implementing STS initiatives. To reach this aim, we carry out a longitudinal case study over 2016–2018 in Shijiazhuang, China. We offer both theoretical and practical explanations on (i) key value facets with regard to sustainable STS design and implementation; and (ii) a holistic view of iterative value co-creation process pushed by key stakeholders. This study makes particular contributions to the IS, marketing and transportation literature by offering a critical understanding of the social dynamics for shaping a big data-driven STS ecosystem.

**Keywords** Value co-creation · Smart transportation system · Data governance · Citizen participation · Sustainability

## 1 Introduction

As the United Nations (UN) predicts that 68% of the global population will live in cities by 2050 (United Nations (UN), 2018), together with an additional 2.9 billion vehicles using road networks (Djahel et al., 2018), cities are confronting unprecedented challenges to their long-term sustainable development. One of the challenges to transportation planners and policymakers is to sustain a transportation system that overcomes increasing demands for existing and future traffic whilst mitigates harmful carbon emissions from transportation sources for environmental sustainability purposes (Ismagilova et al., 2019). A citywide transportation system has to be built in a way that citizens can access the city using smart and eco-friendly transportation services, and by which public authorities and governments can achieve their sustainable development goals (Yan et al., 2018).

To address this challenge, researchers across many fields have endeavoured to explore the development of smart transportation systems (STS) (Boukerche & Coutinho, 2019; Cheng et al., 2020; Yan et al., 2018). The STS is defined as a comprehensive transportation system that leverages information and communication technologies (ICT) to realise ultra-efficient interactions between humans and vehicles, vehicles and vehicles, and humans and information, meanwhile enabling secure and sustainable urban transportation ecosystem (Boukerche & Coutinho, 2019; Yan et al., 2018). As a constitutive system of the smart city (Chourabi et al., 2012), the STS is inherently built up upon ubiquitous and pervasive computing through big data and business analytics tools (Kitchin, 2019), contributing to datafied urban transportation systems and re-defined business relationships between diverse stakeholders (Luque-Ayala & Marvin, 2020). Consequently, big data and business analytics have raised growing attention by scholars from management and information system (IS) fields to research organisational-level performance, such as decision-making (Duan et al., 2019), strategic competition (Manyika, 2011), and big data-driven business ecosystems and value chain (Pappas et al., 2018). The outcome of these practices aligns with the goal of high resilience of digital transformation for shaping the twenty-first Century sustainable society (Pappas et al., 2019). For the STS, this means a healthy, green and more human-centric mode of transformation. The STS in the city can thus help local citizens more efficiently and effectively engage with big data-integrated

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transportation systems (Akande et al., 2019; Cheng et al., 2020).

Whilst the STS develops as a socio-technical initiative, it is also considered a political and economic by-product in many countries, hence requiring encompassing consideration of governance and management. In management and IS research, recent studies demonstrate intensive efforts in developing regulatory frameworks for control management and standardisation (Vitunskaite et al., 2019), conceptualising the ways in which data are used for different purposes such as open data governance (Pereira et al., 2017) and privacy and security mechanisms of data handling (Ismagilova et al., 2020), and system and service integration (Schulz et al., 2020). Studies with a greater socio-technical emphasis have explored the variegated dynamics of governing smart mobility (Lin et al., 2017) and sustainable transitions (Becker et al., 2021).

However, building the STS is a challenging task and requires a holistic and ecosystem view that involves multi-scalar participation to addressing the heterogenous nature of governance in a concerted effort. An ecosystem addresses not simply technological but also managerial issues, and different stakeholders, such as government, industry and citizens, interact within the design and implementation process of the system (Kar et al., 2019). Backed up by this conceptual angle, this study is focused upon the form of sustainable value cocreation of the STS. Specifically, this study seeks to answer the following research question: *How can the government, STS firms and citizens collaboratively create sustainable value in developing smart transportation systems?*

To answer the above question, we draw upon the concepts of value co-creation and stakeholder from marketing, IS and transportation literature. In the marketing literature, it has been acknowledged that value can be generated in the co-creation, co-design, and co-development processes wherein customers shift to play an active role (Lacoste, 2016; Vargo & Lusch, 2004). Recent literature regarding big data and business analytics ecosystems has placed emphasis on different facets of value which can be co-created through the interactions among users, technological resources, and business processes (Mikalef et al., 2020; Sarker et al., 2012). For example, Li and De Jong (2017) argue that a smart ecosystem would need empowering citizens to participate in rudimentary design of smart systems. To some extent, this would also require public institutions and private firms to sharpen their serviceability (De Jong et al., 2016). Further, government bodies advocate technocratic initiatives and legitimise the use of technology (Griffiths & Schiavone, 2016). In STS, value has its comprehensive form of presence, but it also faces problems with poor data governance and lacks effective coordination of multiple stakeholders (Silva et al., 2018). We investigate such challenges of value co-creation process by specifically focusing on the transportation domain. By integrating the notion of value co-creation in STS, we conduct a longitudinal case study in the city of Shijiazhuang in China spanning three years since 2016. We explore how the STS is designed and implemented by local government and firms, and how citizens play a role within.

This study makes important contributions to the IS, transportation and marketing literature. Firstly, this study builds up the socio-technical discourse by untangling at great length both the technical components of STS innovations and social dynamism of STS governance. This socio-technical nexus conjures up technology-driven and citizen-centric designs and implementation. Secondly, we identify a set of key factors that lead to successful STS design and implementation. Thirdly, we contribute to the value co-creation and the stakeholder theory rationales by unravelling how a big data-driven STS ecosystem runs in the situation where different stakeholders play a distinctive role and closely interact with each other. Sustainable value facets emerge and are continuously shaped by these interactive processes.

## 2 Smart Transportation System

Urban transportation is a source of energy consumption, a cause of air pollution, a driver of urban economics and social development; a myriad of measures have therefore been taken to manage all types of transportation resources and balance its opportunities and perils in order to achieve sustainability (Sayyadi & Awasthi, 2017). Making sense of the 'smart' labelling of technology-driven transportation systems has become critical to smart city researchers today. For example, Alter (2019) identifies a number of principles to define smartness; two important ones are the socio-technical nature and intensive involvement of users (i.e. citizen-qua-users in this study) as participants. However, these two points do not differ 'smart' and 'intelligent'. In the current literature, intelligent transportation system (ITS) studies tend to focus on infrastructural design and connectivity (Ganin et al., 2019; Wang et al., 2019), whereas STS research emphasises the interconnectivity in service provision and the extent of data sharing practices between human and associated transportation applications, with substantial involvement of ubiquitous computing and human-computer interactions (Kitchin, 2015). Such interconnectivity and data sharing practices in STS are supported by intensive use of networked computing and business models such as big data analytics, sensing, task automation and coordination.

The development of STS initiatives in China over the past decade has consolidated the idea of being interconnected, shared and networked. For example, many municipal governments across the country tend to promote 'one-stop service' based on cross-departmental collaborations to many smart city systems (Liu & Zheng, 2018). Meanwhile, a myriad of

**Table 1** Shijiazhuang STS components and functionalities (Wu, 2017)

| STS Sub-systems | STS Functionalities | Key instances |
|---|---|---|
| Traffic Information System | • Video image traffic information<br>• Real-time traffic information<br>• Practice information<br>• Traffic guidance | • CCTV cameras<br>• Detecting sensors<br>• Inductive loops<br>• GPS-embedded mobile devices |
| Inquiry Service System | • End-user and driver information<br>• Motor vehicle information<br>• Traffic accidents information | • Government smartphone apps<br>• Websites<br>• Frontline office of Traffic Management Bureau |
| Traffic Safety System | • Emergency command<br>• Infrastructure parameters | • Incident detection<br>• Ultrasonic sensors<br>• Magnetometer sensors |
| Service Guide System | • Web-based graphics and text information maintenance<br>• Traffic signposts deployment | • Social media posts<br>• Smartphone apps<br>• Websites<br>• Urban traffic dashboards<br>• Information centres |
| Customised Service System | • Vehicle information binding<br>• Driving licence binding<br>• System information reminding<br>• Individual information maintenance<br>• Traffic recommendation | • Smartphone apps<br>• Customised public means of transports (e.g. customised buses)<br>• Online car-hailing/−sharing services<br>• Phone appointment system<br>• Smart car-parking service |

smartphone applications provide app-based ride-hailing services (Tang et al., 2020; Wang et al., 2019) and customised information (Di Pietro et al., 2015) and the like. Provided that China is huge geographically and demographically, the objectives of STS development shift towards 'zero distance change' (Geng, 2012), namely ultra-efficiency and super convenience.

Amongst many municipalities, the city of Shijiazhuang, as the province of Hebei Province, is one of the state's transportation hubs in China. According to the government work report of Hebei Transportation Bureau (http://jtt.hebei.gov.cn/), the local government has made huge financial investment in building networked STS services and initiating integrated transportation resources as a top priority. In particular, the Shijiazhuang municipal government has applied big data, sensor technology and ubiquitous computing to manage the transportation network since 2014. Compared to old-fashioned telecommunication-based traffic management, the current system leverages cloud platforms to gather data from different places to facilitate decision-making.[1] Shijiazhuang's STS consists of five sub-systems (Wu, 2017). Table 1 presents these sub-systems and their associated functionalities and key instances. Each subsystem contains a variety of transport data which are created and used for various purposes. Technically, some key instances can be fallen into different sub-systems. For example, data captured by inductive loops can be converted into traffic information meanwhile used to traffic safety conditions.

Whilst these sub-systems are considered technical configurations and, as a whole, shape a networked, interconnected, and data-driven STS, a number of specific applications developed for the managerial and governing purpose. For example, from the policy making perspective, the enactment of Restriction of Vehicle Licence Plate[2] increases urban road capacity and thus enhances the efficiency of the public transportation system because free buses are available during this restriction period. With regard to management, traffic control rooms garner real-time traffic data collected by sensor networks for coordination and emergency control. From the perspective of data governance, the local STS firm, HEBITT, who works in concert with Traffic Management Bureau, develops the one-card system to cover all means of transportation.[3] Further, Alpark is focused on big data-enabled smart parking, implementing high-definition cameras and facial recognition technologies, so many idle urban spaces are converted into public parking lots.[4] The design and implementation of above sub-systems and applications rely heavily on

[1] Available at http://www.cac.gov.cn/2017-06/14/c_1121142936.htm

[2] The Restriction of Vehicle Licence Plate policy is released by Shijiazhuang Municipal Government. Available at http://www.sjz.gov.cn/english/

[3] HEBITT: a local STS firm in Shijiazhuang specialising in public transportation. Available at: http://www.hebitt.com/

[4] Retrieved from *Alpark City: starts a new era of intelligent parking*. Available at: http://en.aipark.com/Archives/IndexArctype/index/t_id/10.html

collaborations across many sites of data practice, including the municipal government transportation department (*government* hereafter), state-owned firms, public institutions, local private firms, and citizens. For the case of Shijiazhuang, we primarily focus on government, private firms and citizens which are the most three dominant actors.

## 3 Theoretical Background

To investigate how value can be created and sustained among various stakeholders in the STS, we draw upon two main bodies of research on i) value co-creation and ii) stakeholder theory, and relate them to the information system (IS) literature and transportation literature. The two theories provide a theoretical lens in examining collaboration and arrangements among STS participants including governmental bodies, commercial companies, and citizens. The IS and transportation literature contributes to understand how the STS can help to facilitate and enable such collaboration.

### 3.1 Value Co-Creation in STS

Value co-creation theory describes collaboration between multiple stakeholders and suggests that the value of a particular product is not generated merely by its producing firm, but co-created by the firm together with its primary stakeholders (Galvagno & Dalli, 2014). Co-creation occurs when two or more groups of members actively interact with and affect each other (Rahman et al., 2019). Most studies discuss value co-creation in an organisational context such as business-to-business (B2B) marketing (e.g. Breidbach & Maglio, 2016), consumer and enterprise interaction (e.g. Smedlund, 2012), and strategic alliances between social networking sites and firms (e.g. See-To & Ho, 2014). One of important research streams from these studies is ICT-based value (co-)creation that has been extensively rationalised in the IS literature. Whilst acknowledging financial, intermediate and affective benefits of value co-creation through ICT (Cheng et al., 2020; Huber et al., 2017), attentions are required in the technology-related considerations in the application of value co-creation theory (Sarker et al., 2012; Yu et al., 2019). Besides, it is also important to assess intangible value that is being generated throughout the development process and application. As suggested by Sarker et al. (2012), in the context of alliance relationship and joint partnership, value is multi-faceted in nature in that it has different dimensions and elements viewed by stakeholders or participants.

For the STS, Schulz et al. (2020) identify a number of inhibitors of mobility value co-creation that are deemed crucial to resource integration and service interchange by mobility providers. Yin et al. (2019) analyse in depth how users participate in co-creating value for the bike-sharing system in Chinese cities, classify value into a set of customer and firm resources, and examine the side effect of resource mis-integration and non-integration. Such a comparing view of value co-creation and co-destruction in the transportation domain is placed in a critical position of collaborative transportation management (Okdinawati et al., 2017), a multi-agent model of planning, execution and prediction. In a nutshell, STS value co-creation is in some way built up upon a data integrated view of governing on the one hand – easy control and management – and on the other hand is aimed at making transportation information more accessible and adjustable by the public, allowing for commercial and business-led transformations.

From the socio-technical perspective, it is argued that STS value co-creation should focus on the entire service system instead of a particular business or organisation (Breidbach & Maglio, 2016) and on the means of resource exchange between actors within a certain economic relationship, i.e. connectivity in service systems (Breidbach et al., 2013). This suggests that STS service systems constitute a variety of actions, business processes, human relations, and human perceptions that would need to be considered. The existing literature lacks a comprehensive discussion about how these very aspects work in parallel in order to sustain value. We argue the literature can be enriched by unpacking key value facets of the development of STS initiatives with a particular focus placed upon the entire STS ecosystem, a service system that incorporates different stakeholders into the design and implementation process.

### 3.2 Stakeholders in STS

Stakeholders are identified as a cluster of individuals or groups who have interplay with actions connected to the value creation and transactions (Freeman et al., 2010). Stakeholder theory refers to the way in which organisations identify and organise critical information that emerges from strategic organisational planning (Freeman et al., 2010), with the aim to make business policy and strategy more effective (Freeman et al., 2020). Despite its development as a response to the needs of profit-organisations, the nature of stakeholder theory allows wider application to other settings as it describes and analyses the context-specific behaviours of participants (Flak & Dertz, 2005). In the co-creation of value with multiple stakeholders involved, stakeholder theory assists in shaping understanding of relationships between various stakeholders and relevant organisations in order to achieve the shared organisational goals (Jones et al., 2018).

There is a general consensus that in contexts beyond organisations and which involve broader public attendance, such as in city and STS settings, there consists of a variety of stakeholders with potentially diverging goals (Flak & Dertz, 2005). In city transportation, to carry out efficient STS related strategies and processes, the goals and objectives of different stakeholder groups should be attended to. Stakeholders involved in this study include citizen as end-users, IT enterprises as system developers, and government as policy makers. Driven by the existing data-enabled STS and the fact that data from different sub-system sites of practice are remained in silos and hard to integrate, data sharing and exchange is thus considered as the momentum for various stakeholders to interact and collaborate for an integrated solution.

One of the popular conceptual framings of stakeholder theory comes from the three distinctive aspects identified by Donaldson and Preston (1995) who argue that stakeholder theory in philosophical assumptions is depicted as being *descriptive*, *instrumental,* and *normative.* The ways in which these bases of the theory are drawn upon vary across studies. This research examines the nature of the value co-creation process from its beginning to the end with the goal of achieving sustainability. Hence, this study explores each of these characteristics as frames of reference, which is considered as a theoretical guidance for us to coherently combine all three perspectives. Donaldson and Preston (1995) argue that the stakeholder theory being *descriptive* is when it depicts the nature, fundamental characteristics and behaviours, and strategic management of organisations. For an STS, value co-creation by various beneficiaries and vested interests is considered as an assemblage of multi-stakeholder cooperative and competitive interests in which intrinsic value is rooted (Donaldson & Preston, 1995), hinting at the need to establish alliances and channels through which data transfers across various sites. Next, the stakeholder theory being *instrumental* enables a closer examination of the co-creation process of value that is built upon the descriptive base of the theory, namely how the perceived value can actually be dug out (Donaldson & Preston, 1995). For STS stakeholders, this implies being critical to the key resources that reside in various stakeholder sites and practicing effective stakeholder management with the goal of maximising value, such as profitability, competitiveness, data standardisation, and citizen participation. Furthermore, the *normative* tenet of the stakeholder theory emphasises upon the balance between stakeholders and their resources, indicating to seek for balance of all involved stakeholders' interests to achieve real sustainability (Jones & Wicks, 1999). In the context of STS, this indicates the necessity of balanced and sustainable value co-creation process in which three different stakeholder groups reach the shared goals of developing transportation solutions.

# 4 Research Methodology

## 4.1 Research Method and Setting

This research aims to identify the process of co-creating value among different stakeholders through the design and implementation of STS. Given its complex and qualitative nature, we adopt a longitudinal case study methodology. Case study facilitates in-depth exploration and perceptions into the context and phenomenon (Ritchie et al., 2013) and therefore enables the investigation of value co-creation achievement within a specific STS setting. A case city having adopted STS technologies between multiple stakeholders is an ideal context, as it illustrates insights of interactions, co-creation and dynamic flow of STS design, and its implementation in achieving sustainability between levels of citizens, organisations and government.

Shijiazhuang (as mentioned in Section 2) is chosen as the case city. Three different units of stakeholders were selected - citizens, organisations and the government - in order to understand the data flow between these three levels of entities and the co-creation of value by adopting new technologies across these three groups. The first unit of citizens consists of both car users and those who primarily use public transports. The purpose of this is to gain different insights about their opinions, thoughts and perceptions of interacting with STS and their perceived ideas of building integrated STS. The second unit includes three companies: Alpark, Mobike (Shijiazhuang branch),[5] and Union & Creative.[6] The purpose of their business is to design and apply STS applications to different scenes of urban transportation, and to function these roles in order to connect citizens and urban transportation administration. The last unit is two government transportation agencies - Shijiazhuang Traffic Management Bureau and Hebei Transportation Bureau - both of which have long-term coordination with the three case companies in regard to data-sharing practices and co-designing innovative solutions. These two agencies have enacted many STS policies and created project-led business opportunities for developing sustainable transportation initiatives, most of which are aimed at the services for a particular scene of transportation and within particular urban areas. For example, the bike-sharing service of Mobike is only available to use within the second ring road in Shijiazhuang. In addition, they have also promoted many co-creating initiatives aiming for sustainability by engaging grassroot citizens especially senior citizens who are marginalised to smart urban transportation.

## 4.2 Longitudinal Data Collection

Following case study method, 30 interviews and 6 focus groups (5 participants in each group) were conducted throughout a longitudinal period of 3 years from 2016 to 2018. Specifically, this includes 20 semi-structured interviews with

[5] Mobike is a Chinese bike-sharing firm, providing bike-sharing services to general citizens and location-based services to local government administration (https://mobike.com/cn/)

[6] Union & Creative is a Shijiazhuang local STS transportation infrastructure and sensor-enabled service provider (http://www.uchuang.com/)

project managers, C-level executives and data scientists from 3 different technology companies; 10 semi-structured interviews with governmental bodies in the Transportation Bureau and Traffic Management Bureau (the leading governmental agencies for sustainable and smart city development); 6 focus groups (each group consisting of 5 participants) with citizens from various backgrounds and who rely on STS technology in daily activities. Purposive sampling strategy was used for the interviews and snowball-sampling method was selected for the focus groups. Table 2 illustrates the profile of participants and the breakdown of timing for data collection.

Focus group interview with citizens consists of four sections including their general knowledge of smart transportation, insights of the pros and cons of existing STS applications, discussion of issues around data practice, and perceived future STS development. For companies, interview questions were elaborated with the objective of acquiring experience in their STS design and implementation practice. Therefore, interview with companies was structured into three sections including: their past project accomplishments, data related issues, and collaboration issues. Questions with the government department were structured in four sections, including opinions on urban transportation status, past project accomplishments, government roles in STS, and relationships between government and other stakeholders. The length of each interview varied between 45 min and 1.5 h. All interviews were recorded through a digital recorder and then transcribed into text and saved in a Microsoft Word document. 751 pages of transcripts were obtained from the interviews. Interviews with the governmental bodies were particularly relevant for this research as they acted the role of coordinator in extending STS technologies and in the promotion of value co-creation within the city context. Interviews with different companies also form important aspects especially the combination of collaboration and tension between corporations and government in facilitating STS. Citizens provide insights towards end-user experience and participation in the dynamic value co-creation cycle.

Secondary data based on 12 governmental documents and approximately 300 pages were also collected as supplements of the primary data. These include: New-Type Urbanisation Policy, the 13th Five-Year Plan, and multiple government work reports from 2014 (the time from which STS and sustainable smart city concepts were adopted by the government) to 2020 (when the development of STS has achieved an initial satisfactory stage).

### 4.3 Thematic Analysis

The research data was analysed following a thematic analysis approach (Boyatzis, 1998) through which data is coded and then derived into patterns, sub-themes and themes. The analysis procedure began with 'contextualisation' and 'familiarisation' i.e. recursively reading and re-reading the data, the following summaries and self-memos which were generated during the data collection stage (Ritchie et al., 2013). In this stage, an initial understanding of different stakeholders and narratives of the value co-creation process were obtained. The second stage started by comparing and theorising each incident from the data into codes (Tuckett, 2005). We systematically and constantly examined the transcribed texts, and an emerging list of codes was generated. Besides, insights regarding potential relationships among the codes, and collaborations between stakeholders in the value co-creation process were also recorded in memos. With an increasing number of codes and relationships between codes, we started to capture the emergence of structure within the data, i.e. generation of themes.

In the third stage, as main categories and relationships emerged, we further compared and explored the underlying meanings in terms of what the categories and relationships imply, what composes them and how they affect the value co-creation process. Finally, after all codes emerged from the data and categorised into sub-themes and themes, researchers followed the principle of 'suspicion' (Bernardi et al., 2019) in order to persist cautiousness towards possible biases of the narratives and make sure the label for concepts, sub-themes and themes are consistent. We reached data saturation by following and checking the conditions that 1) no open codes emerged from the data; 2) all concepts and

**Table 2** Summary of interviews and focus groups

| Participants | Roles | 2016 | 2017 | 2018 | Total |
|---|---|---|---|---|---|
| Citizens | | 30 (6 focus groups) | | | 30 |
| IT companies | Project managers | 2 | 5 | | 7 |
| | C-level executives | 1 | 3 | 2 | 6 |
| | Data scientists | 2 | 5 | | 7 |
| Local government | Directors of transportation bureau | 2 | | 2 | 4 |
| | Directors of traffic management bureau | 2 | | 2 | 4 |
| | Data scientists | 1 | | 1 | 2 |
| Total | | 40 | 13 | 7 | 60 |

categories were well established with no further possibility of generating new concepts or categories; 3) relationships between subcategories and categories, as well as the relationships among categories were well established (Fusch & Ness, 2015). Appendix 1 demonstrates examples of the analysis process of coding, generating themes and relationships, and refining and finalising themes.

## 5 Findings Interpretation and Theoretical Framing

Our systemic thematic analysis identified five key value facets which are discussed in this section against relevant literature in the field of smart city and STS. In light of our current understanding of sustainable value cocreation in building STS in both the general and Chinese contexts, our findings around these value facets, and our theoretical framework upon which our key propositions are based, will be outlined in order to explicitly underline how different social stakeholders interplay to cocreate value in sustainable STS.

### 5.1 Key Value Facets

#### 5.1.1 Data Governance

The 'New-Type Urbanisation' agenda, released by the central Chinese government, places significant emphasis on leveraging ICTs to promote smart information service delivery to society (CNDRC, 2014). Keywords involved herein chime with what the enterprise participants highlighted as imperative to develop an integrated STS – which relies on the integration of data produced from various places – i.e. sustainable development of data infrastructure and management information. Initiating data-integrated STS solutions necessitates system capacity that enables data with various formats and structures, from a variety of sites of data practice, to be technically integrated into one place. From the technology point of view, the building of data infrastructures means embedding sensor-enabled technologies into the fabric of smart society, and which is clearly propelled by enterprises that are considered as system developers.

In the STS, these data infrastructures include such as smart inductive loops, video vehicle detection, ultrasonic sensors, urban traffic control rooms and STS cloud platforms, to handle troves of big data with aim to transform cities towards being data-driven and networked (Manyika, 2011). However, data infrastructure needs data governance which corral data and databases into a complicated socio-technical structure (Kitchin, 2014). Participants of C-level executive suggested that data infrastructures are not simply technical imperatives; while STS practitioners need to embrace a systematic and integrative view of data, with managerial considerations of coordinating data sources and establishing industry data standards. Whilst enterprises actively engage in making concerted efforts in formulating the standard, this nationwide industrial normalisation is initiated by the government who play a leading role in coordinating various transportation sources.

#### 5.1.2 Coordination Mechanisms

Coordination mechanism is well associated with the concept of smart governance in the smart city discourse; the latter was identified as ICT-driven collaboration and interaction between citizens (and/or wider communities) and government administrations in regard to efficient and effective public service delivery and information dissemination (Chourabi et al., 2012; Tomor et al., 2019). Echoing the criticism by Harvey (1989) who stresses 'governance' is not an issue that simplistically amounts to the matters of the 'government', our evidence shifts the emphasis towards a more specific mindset – a coordination mechanism that relies on synergistic cooperation of various stakeholders, within which STS enterprises act as key stakeholders who are involved in both the design and implementation of sustainable value cocreation, though the government, from time to time, exerts political intervention into the design phase.

Our distinctive findings in regard to coordination mechanisms have two-fold implications. First of all, building strategic alliances across enterprises as a form of industry coalition is a propulsion for smooth information communications and data sharing that would enable the integrating of large troves of data. In addition, we found that across these sites there necessitates an integrated system undergirded by GIS platform vendors. They are intensively involved in building governmental initiatives that incorporate both technical (e.g. system configurations, data protocols, data structures) and social parameters (e.g. political dynamics, organisational structures). Data and system practices amongst different interested groups require such a socio-technical way of thinking, particularly when it comes to interactions and contradictions (Fischer & Herrmann, 2011). Moreover, a long-term span of government-private partnerships (GPP) is established due to the cosy symbiosis of data exchange operations between government and enterprises; data generated from either site are generated with utilisable attributes that the other would like to acquire.

Secondly, as remarked by the socio-technical ecosystem discourse (McKelvey et al., 2016), coordination mechanisms extend beyond technical dimension of governing built ICTs and infrastructures, and raise practitioners' attention to the organisational and social dynamics of cooperation, management and governance. Coordination mechanisms of smart governance resembles e-governance practices (Chourabi et al., 2012), with both emphasising streamlining organisational structure and administrative procedures, and coordinating both public and private resources in an integrated form (Söderström et al., 2014). According to our longitudinal investigation into organisational changes, we identify the need to build Special Purpose Entities (SPEs) as the frontline organisations that are specialised in developing particular sustainable STS initiatives and to structurally enhance intra-agency synergistic cooperation to strengthen overall coordination performance.

#### 5.1.3 Socio-Economic Dynamics

Embedding coordination mechanisms requires wider contextual dynamics in both designing and implementing the value cocreation ecosystem. We leverage the concept of smart economy to this value facet as a socio-economic position that shapes the societal context in China. It has gained traction amongst smart city practitioners to refer to economic competitiveness, service employment and human resources, entrepreneurship, and markets and competitions within general smart urbanism settings (Neirotti et al., 2014). These market-driven practices in most cases embrace the neoliberal ethos that claims smart initiatives as being pro-business and market-driven through practices of privatisation and marketisation (Hollands, 2008; Kitchin, 2015).

Bearing a resemblance to such a neoliberal banner of smart economy, Chinese smart economy manifests critical evaluation of the power of multi-stakeholder interests. For STS, this means that whilst the government tends to privatise partial state assets onto private places, municipal government retains control over the market field to ensure that the private give way to the state-owned. For instance, the top government sets underlying market rules (i.e. regulatory oversight to the borderline of the public and private), following a top-down trajectory of promulgation and circulation to subordinate institutions and the market, whilst on the other hand they provide many business opportunities (e.g. through open-tendering practices), with the purpose to balance the two sectors. Suffice to say that socio-economic dynamics of Chinese STS development, though with certain extent of political devolution to market forces, are circumscribed by legitimacy, within the boundary of which the government steers the design of specific STS initiatives towards the orientation of competitive economy.

#### 5.1.4 Political Legitimacy

Whilst the previous three value facets are represented by enterprise actors in both designing and implementing the STS with government intervention, mainly in the design phase, political legitimacy is identified as a conditional value facet that sets a political backdrop and pre-requisites for expanding STS initiatives and steers the orientation of development. This means that although the way of implementation of STS initiatives is multi-faced with the involvement of various stakeholders, it is corralled into legal and political arrangements in the first place before a formal course of action. Thus, we claim that political legitimacy works substantially in the design process of sustainable value cocreation. This is specified in two aspects. Firstly, municipal governments enact regulatory oversight to the private sectors. Enterprise participants depicted the role of government as "*a big hand that controls everything*" which is construed as a mindset of centralisation. Private enterprises need to showcase their previous accomplishments in order to justify that they are capable of helping the government address urban transportation issues and co-creating sustainable STS. Government, within the GPP, leverages their centralised politics to making standards of STS initiatives, including open data conversion protocols, market rules and regulations, and purposive policy-making and legislation (Pereira et al., 2017).

Secondly, we found that the trust of data is crucial in sustainable value cocreation, in particular the role of trust mechanisms to specify data ownership, copyright and credibility within the existing settings of political legitimacy. Our findings suggest that STS practitioners should raise their attention to the legitimate outcome of data being used and re-used (particularly when data are mishandled, manipulated or inappropriately distributed) (Kitchin, 2014), which we termed as 'data traceability', meaning that legal data authorisation protocols (Gope & Hwang, 2016) should be established to unravel where a particular set of data originates from and proceeds to. Given the cross-sector data practices, this is imperative to the building of coordination mechanisms for sustaining STS initiatives as it involves various socio-material dynamics that impact on the constitution of different data sources and assemblages, and determine how data move through spatial and temporal dimensions of stakeholder sites of practice.

#### 5.1.5 Citizen Participation

In our context, political legitimacy sets legal and regulatory framework within which STS development is conducted on a basis of concerted effort amongst government and various enterprises. Further beyond this stands a socio-technical framing of citizen participation; whilst urban initiatives enable a market-oriented form of governance under corporatisation and entrepreneurship, the idea of 'being smart' is concerned with ownership, namely those who inhabit smart cities and are involved in using smart services (de Lange & de Waal, 2013). Notably, we found that citizens can exert significantly more influence upon the value co-creation process in the implementation stage compared to the design process. Drawing upon the insights from the "New-Type Urbanisation" agenda concerning the promotion of citizen-centric urban system (Chan & Anderson, 2015; CNDRC, 2014; Li & De Jong, 2017), existing literature about smart citizen participation modality in smart city initiatives (Cardullo & Kitchin, 2019; Li & De Jong, 2017), and the ideas garnered from our participants with regard to the ways in which their voices were heard by local governments and enterprise developers, we identify citizens as being productive and proactive in co-shaping STS initiatives. We will explore these two types of roles alongside other value facets in 5.2.

Whilst the above defined value facets delineate a trajectory of socio-technical dynamics that are crucial to sustainable value cocreation, they are also evident in representing a number of interactions that demonstrate how these value facets interplay in the various stages of STS development, and by whom. Evidenced by the findings above, we claim that the first three value facets – data governance, coordination mechanisms and socio-economic dynamics – are enacted throughout the value cocreation process, whereas the other two (i.e. political legitimacy and citizen participation) are positioned as conditional value facets and casted primarily by the government (in the design phase) and citizens (in the implementation phase) respectively. Figure 1 visualises these value facets, the phases in which they are leveraged, and the key actors who make primary contributions to each. Apart from these, we have also raised five propositions about the interrelations across the value facets, which are discussed in the next section.

### 5.2 Propositions

The above-discussed facets of value are not actually independent from one another; rather, they represent distinctive qualitative patterns along with their interrelations. Our longitudinal case study particularly exemplified these interactions by identifying some underlying changes which emerged from the developing process of urban transportation initiatives in Shijiazhuang (e.g. retrofitting high-tech transportation infrastructure, enacting new policies and regulations) during the period of our fieldwork. These underlying changes shape our understanding of how value facets interplay with one

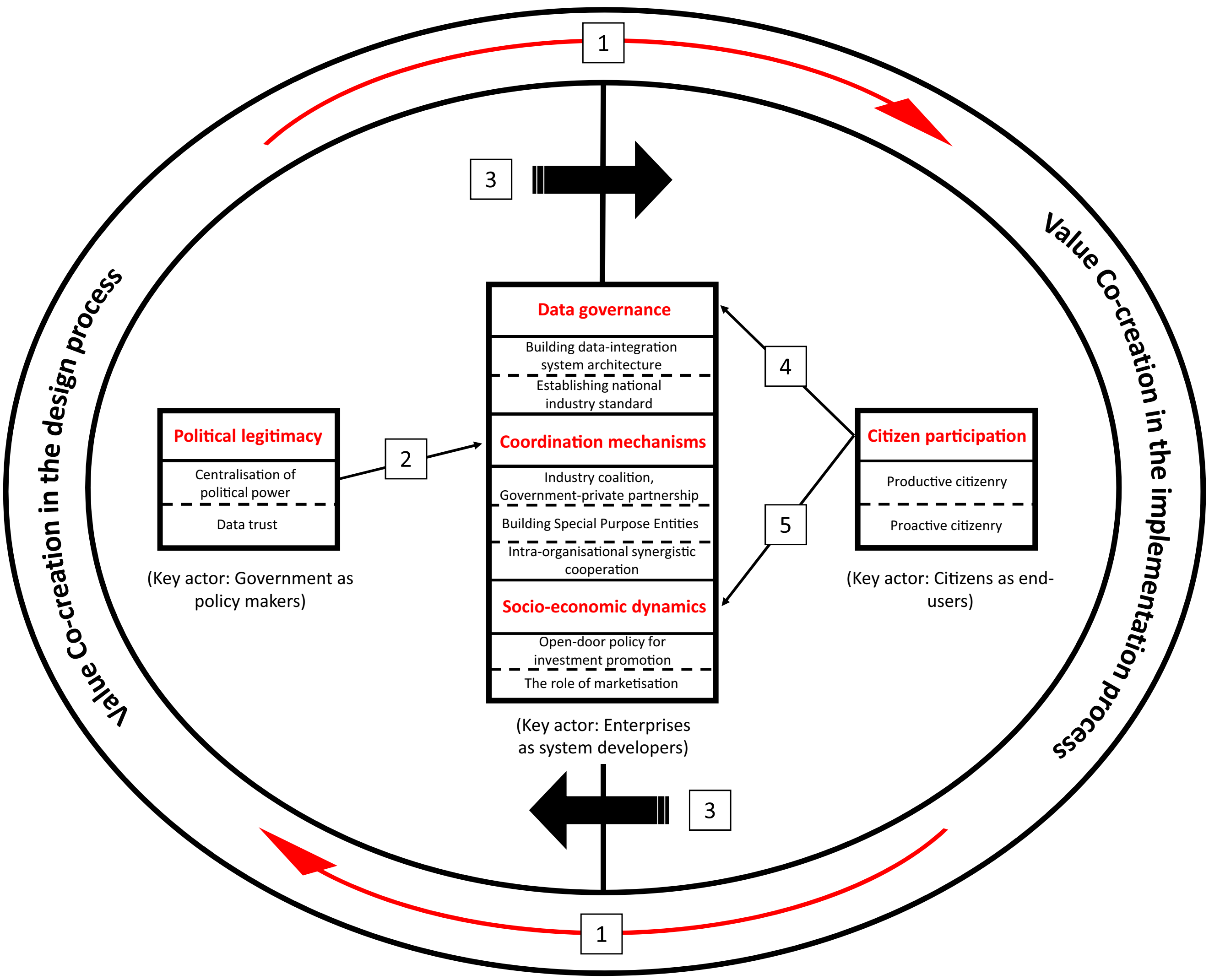


**Fig. 1** Value co-creation process of STS initiatives

another. Consequently, we have derived five key propositions which we argue are crucial in the sustainable value co-creation process of STS initiatives. Appendix 2 presents our propositions and supporting quotations as well as the role of participants.

He and Wu (2009) argue that China learns from the experience of neoliberal urbanism in a way of embracing open market and entrepreneurship (Hollands, 2008, 2015). Many urban initiatives like the "New-Type Urbanisation" agenda (Chan & Anderson, 2015) sprout up to legally support sustainable development of smart cities. This incorporates smart transportation into nationwide objectives. Accordingly, municipal governments have enacted STS-related policies and put forward myriad innovative projects, such as living labs, industry park, and big data centres. Arguably, these projects provide cities with generative conditions for promoting STS innovations. However, our analytical results manifest that the government is dedicated to making iterative and ongoing adjustments to existing STS innovations, rather than simply emphasising quantity (i.e. the more, the smarter, the more sustainable). In so doing, they upgrade existing infrastructural networks and technologies and hardware, revising policies, and rolling out the solution from one particular locality to a larger scale. In response to the rapid change of social and managerial dynamics of urban transportation systems, these approaches mark a striking feature of sustainable development – stability and vitality – manifesting the way in which value is created by different stakeholders in a concerted and persistent manner. For example, the promulgation of the 'give way to pedestrian' regulation by the Traffic Management Bureau of the Shijiazhuang government experienced many rounds of deliberation and negotiation. Experts from industry were invited to use big data analytics to analyse citizens' driving behaviours, mobility patterns, and critical localities of traffic accidents and congestions. Amongst them, business partners, alongside considering how innovations they develop like smartphone apps of transportation, also seek to reach a balance between regulations and their business. The notion of sustainability herein conjures up a symbiotic and goal-driven form of stakeholder relationship.

Another crucial dimension of sustainable value cocreation is evolutionary development. Many STS initiatives are not one-off experiments and do not serve for people in certain places. Instead, they start off as a pilot project in one place and will be leveraged elsewhere later if they are successful. A notable piece of evidence drawn from our study is what enterprise participants refer to – STS demonstration projects. Private firms seek to promote their technologies and business by collaborating with the local government; the outcome can be pioneering solutions, regarded as demonstration of technological sophistication (e.g. tidal flow lanes, sensor-enabled public transports) from which local citizens benefit. Value can be cocreated and sustained by a continuing effort of proliferation for wider presence. Such virtuous circle of the STS development is hence evidenced as a crucial characteristic of sustainable value cocreation that goes beyond geographical borders across cities, with the goal of achieving revolutionary urban transformation.

> ***Proposition 1:*** *The Value co-creation process is iterative and transformative; sustainable value is created on the basis of continual design and implementation of STS initiatives.*

Globally, the rapid development of big data analytics along with the neoliberal urbanism has changed the way in which technologies develop. Trusted international organisations, such as International Organisation for Standardisation (ISO), large technology companies like IBM, Cisco, Siemens, and quasi-governmental organisations like European Commissions, play a crucial role in formulating smart city rules and underwrite smart city projects. This shapes a technocratic vision of the contemporary smart city (Hollands, 2015), which challenges radical advocates who believe many existing solutions, visions and approaches are apolitical and scientific. In other words, the above organisations are authorities who are mandated with power to normalise and standardise the development process. Nevertheless, as Kitchin (2015) argues, more critical reflections upon the socio-political progress of sustainable urban transformation, through in-depth case studies and comparative research, are needed to contextualise geopolitical conditions. This study backs up Kitchin's point by highlighting the critical role of the steering state in China. And that is, despite privatisation and marketisation of STS services, the transportation industry is steered by the government who determines the way in which STS services are delivered and the extent to which private transportation resources are harnessed for public use. This forms a kind of contradiction between the market-driven STS and the top-down, state-steered political legitimacy, manifesting the steering position of government in creating value for the STS and balancing the market and citizen end-users.

The governance of a smart city ecosystem is not a government monodrama but rather a problem of socially collective action (Harvey, 1989). Echoing this view, we extend the argument that the Chinese government play a crucial role in coordinating STS resources and stakeholders from various sites of practice by exerting political interventions within the GPP. Amongst many different ways of coordination, one noticeable approach is through the government's control of data, particularly in the design stage of STS development. Value would emerge when data produced and captured from both private firms and state-owned organisations, are integrated and being used for comprehensive information processing by the government. Arguably, government transportation data are, in terms of both structure and format, standard and normalised, usually with high-quality and pure content but less up-to-date in nature. However, these data are mostly related to infrastructural assemblages, such as traffic lights, surveillance systems, and so on. In contrast, private data sources are more citizen-centric (e.g. end-user historical data) and are utilisable in a timely manner (real-time data acquisition). Data of both sides are reciprocally beneficiary. Government needs data from private firms for more effective social control via surveillance and sustainable STS development, whilst private firms would need government data to enhance their serviceability and consolidate customer relationships.

However, this reciprocal relationship is not equal, but rather it tips the balance in the government favour (Yu & Xu, 2018). Government enacts special policies and legal stipulations to dominate the collaboration. For example, the Standing Committee of the National People's Congress of China (SCNPCC) enacted the Cybersecurity Law in 2016 to protect cyberspace and the information network from being hacked in city cyberattacks.[7] When this law was first enacted, many key private transportation firms were asked for handing their data over to relevant government departments for the purpose of central management. Two years after, municipal and provincial governments constituted frontline big data centres termed as 'Special Purpose Entities (SPEs)' to collect and manage data from private firms and public institutions. As a means of governance through big data analytics, SPE is a kind of socio-technical infrastructure system (Hodson & Marvin, 2010) that involves not simply data per se but also financial, political and regulatory practices into the design process of STS innovations. STS experts, technocrats and skeleton staff from public bodies temporarily worked together in the SPEs. They were granted with non-restrictive access to the shared data sources and mandated with decision-making rights (Zang & Musheno, 2017). They also undertook regulatory oversight (Yee & Liu, 2019) throughout the duration of the project. The likes of the SPE and its political practices indicate the transformation of the stakeholder relation towards being shaped by the central state and steered by municipal governments. In a nutshell, just as big international organisations set the rules and usher smart city development from across the globe, government and its political legitimacy in China are in a critical position to steer the design of smart initiatives.

> ***Proposition 2:*** *STS development is led by powerful organisations, as those who standardise and normalise the design process. In China, the government with its political legitimacy play a steering role in coordinating and integrating data sources from various sites of data practice, within the process of which value of design for the STS is created.*

Whilst value is co-created by government and STS firms in the design process, the longitudinal study suggests that citizens step in the implementation stage and play a more active role within, and political legitimacy has some extent of influence upon citizen roles in shaping the STS. Rather than unquestionably promoting the neoliberal smart citizen advocacy that is generalised to many parts of the world and that embraces posthuman assumptions - citizens are entitled to choose or reject services (Visser, 2019), we instead more critically assess the role of smart citizens in sustaining value and how their roles interact with actually existing political legitimacy in the Chinese city.

The concept of smart city ecosystem – incorporating citizens, government and firms – has been considered crucial to sustainable governance (Ju et al., 2019). Despite steering roles of government in the design process, many smart systems have shifted their focus towards end-user services. Kitchin et al. (2019) argue that the smart city and its subsystems should serve the interests of all citizens rather than just selected populations, and mostly so-called citizen-centric initiatives are rooted in civic paternalism ("*deciding what is best for citizens*") and stewardship ("*delivering services on behalf of citizens*"). From this view, decisions are made by many stakeholders involved in discussion, suggestion and negotiation, and citizens are able to have certain degree of influence on this process. However, our longitudinal study suggests that government and industry determine the way in which services are delivered to citizens, namely citizens have no say in making decisions and designing the services.

Citizens see themselves as 'data users' or 'data consumers' entitled with basic rights in the contemporary smart city. Cardullo and Kitchin (2019) define such a role as 'consumerism' which suggests that citizens are allowed to browse, consume and make choices from existing offerings. Such consumerism is a striking feature of the western neoliberal context. However, in the Chinese smart urbanism, whilst the government leverages technology to promote big data-driven and networked urbanism (e.g. shared economy), citizens tend to shift their roles towards 'data producers', as what we argue as being productive citizenry. Productive citizens can offer not only data points which are used by the government for legal purposes, but also meaningful end-user patterns (e.g. mobility patterns to predict future traffic status) which STS firms make use of to develop more citizen-centric solutions. In a nutshell, STS firms bridge the government and citizens by reproducing citizen data for improvement of existing services and development of new solutions. Value is thus sustainably co-created insofar as data repeatedly journey across different stakeholder sites of practice.

In addition to being data producers, citizens are also particularly regarded as proactive citizenry in the implementation stage of STS development. This refers to citizens' awareness of being 'smart' (i.e. propensity to use innovative

[7] SCNPCC: Available at http://www.npc.gov.cn/englishnpc/index.shtml

applications) and their innate smart mindset (i.e. conformity with smart and sustainable ethos). There has been a transformation of the way in which the government deal with what participants referred to as 'undisciplined citizens' who try to exploit the legal loophole (e.g. over speeding, jumping the red light. Government works in concerted effort with STS firms to come up with solutions that allow citizens to proactively suggest, report, comment and complain about the problems they encounter through either the online discussion boards on the government website, reporting channels via smartphone applications, and so on. In a word, value co-creation takes place as STS firms and government work together to build up the channels through which citizens proactively step in for improvement.

> ***Proposition 3:*** *Value cocreation is driven by smart citizens producing data sources and proactively engaging in ameliorating services during the implementation process; this value is leveraged by the government and STS firms to design new solutions for sustainable STS development.*

Citizen participants expressed positive opinions regarding the performance of existing STS solutions, especially those used in traffic prediction, journey planning, and online taxi hailing services such as route guidance screens and GPS navigation devices. Enterprise and government participants, however, suggested that these are independent systems with data from one application not able to be shared with other applications. Whilst existing STS technologies, in principle, are competent to integrate data from various sites of applications, socio-political barriers stand in the way of such an integration process, including privacy concerns (Cottrill, 2020), issues of organisational boundaries (Goble & Stevens, 2008), data security (An et al., 2016), and so on. Some of these issues, like those related to privacy and security, need more user-centric data infrastructures that are built upon citizen end-user datasets and are not only reliant on conventional GPS approaches anymore. Integrating data in this sense indicates the need for refashioning data governance strategy such as upgrading data gathering and analytics technologies, and data infrastructures (e.g. building highly integrated system architecture and hardware configuration), with high system capacity to integrate data from various types of existing applications with different types of end-users.

The refashioning of data governance strategy actually reflects another two issues herein – why are citizen end-user data important, and how do citizens potentially push IT enterprises to upgrade technology for the design and implementation of new innovations? Our investigations revealed that many tailored STS solutions are derived from citizens, not simply by listening to their opinions, but instead by predictive profiling through big data analytics and by engaging end-user representatives in thought experiments and crowdsourcing and brainstorming exercises. A typical example in our study is the custom-built smart bike service developed by one of our case firms. They released the 'location sharing' service on the app particularly for young parents to track the location of their kids in a timely manner. Despite some potential ethical concerns perhaps regarding privacy, this idea was derived purely from citizen end-users: when many parents expressed their concerns over safety and security issues, they drew the firm's attention. They are invited to a thought experiment to envision possible scenarios that address their concerns.

Such a technical amelioration indicates the opening of data release protocol to end-users and the upgrading of sensors embedded in the bikes. Hence, the question we asked above seems not to be an issue of just interactions between citizens and IT enterprises at surface level, but rather a smart city rhetoric that reflects the mainstream smart city ideology which is deeply entrenched in myriads of designated commercial initiatives: citizen-centric form of smart governance (Hollands, 2015; Kitchin, 2015; Söderström et al., 2014). When citizens do have a say, IT enterprises tend to leverage technology to placate. Instead of simply providing feedback, citizens are able to suggest alternatives or express their opinions concerning deep-rooted urban pathologies (Cardullo & Kitchin, 2019). However, the challenge is still the same issue – centralised political constraints, with which citizens can only raise their voice when they are needed and when particular solutions are being implemented.

> ***Proposition 4:*** *STS technologies and data infrastructures are designed to benefit citizens but implemented on the basis of citizens.*

The prior propositions revealed three main characteristics of value co-creation in initiating data-integrated STS solutions: government-steered in nature, techno-corporate in form, and limited citizen participation and engagement in approach. We now claim that citizen participation, though limited, is the driving force in shaping socio-economic dynamics; measures taken to stimulate economic competitiveness would further encourage more citizens to participate in sustainable value cocreation. Rather than simply promoting the proverbial pro-business and profit-seeking kind of marketisation, government participants in our last-round of interviews suggested that sustainable STS would be banked on a level playing field where various enterprises compete to innovate smart solutions that serve multi-stakeholder interests.

For this reason, our findings suggest the necessity of leveraging the government's open-tendering practices as an instrument to effectively promote potential STS investments. This is usually undertaken through the aforementioned GPP. These open-tendering practices, as a matter of course, lead to fierce market competition amongst private firms - in other words are comprehended as competitive tendering (Hansen, 2010; Mouwen & Rietveld, 2013). Meanwhile, the C-level executives of the enterprise participants maintained that market competition is a trigger of the emergence of differentiated services. To this extent, contingencies do exist and vary in different places, and thus it seems prominent that private firms exercise all-inclusive planning in harnessing local market and innovation conditions and holistic vision of market analysis in order to enhance serviceability.

Many pre-existing smart initiatives derived from the market overlook the role of citizens and end objectives, serving the long-term interests of mass citizenship instead. On the one hand, such requirement elicitation seems to be quite radical in that firms place over emphasis upon the requirement of the 'market' instead of 'citizens', which echoes what we previously held that smart initiatives are in nature set out to pursue business profits and market supremacy other than to promote social well-being. On the other hand, our empirical evidence indicates that various socio-economic forces (e.g. SMEs, public institutions, local community committees, small retailers) have been mobilised by local government to collaboratively build participatory communities. It is manifested that government-led multi-scalar planning and holistic strategy of top-down resource distribution for this citizen-centric urban initiative, needs requirement elicitation that is built on the identification of potential socio-economic uncertainties, and more importantly, citizen desires. Whilst these are said to be achieved by consulting citizens about what services they wish to have and what they perceive a particular service to be for implementation, it is contended that, in the future, preliminary citizen-sourcing practices should come earlier to the design phase of service development.

> ***Proposition 5:*** *Whilst limited citizen participation leads to numerous profit-seeking other than citizen-centric innovations, various socio-economic forces are mobilised and coordinated by the government veering onto the building of citizen-consulted initiatives.*

# 6 Implications and Conclusion

## 6.1 Theoretical Implications

In this study, we investigated the design and implementation of STS with respect to how value is co-created by government, STS firms and citizens. This study has several important theoretical implications. Firstly, it contributes to the IS literature by offering new insights on big data-driven STS initiatives and identifying key factors that influence successful design and implementation. Extending from current STS studies which are mostly technology-centric, we brought in the socio-technical system view by demonstrating technically interconnected and networked components of the STS and how they interact with social dynamics of the system throughout the design and implementation phases.

Secondly, we contribute to research on 'value co-creation' in the STS context. Existing literature provides a market view of developing STS smartphone apps and business relationship between service providers and third-party agents (Schulz et al., 2020). Other studies research value co-creation in the sharing economy of public transportation (e.g. Ma et al., 2019) and with particular emphasis upon customer engagement in organisational practices (Jaakkola & Alexander, 2014; Nadeem et al., 2020). We take the STS as an entire ecosystem and we contribute to the literature by unpacking a set of value facets in STS development and how these facets lie with key stakeholders. Particularly, the study addresses this gap by theoretically framing the value co-creation process in STS.

The third contribution is the big data integration perspective of STS governance. Building upon a holistic understanding of the political-economic setting, the longitudinal case study contributes to the understanding of how data derived from one site of practice are re-used by another and how this dynamic shape the way in which citizens as users participate in extending STS initiatives.

## 6.2 Practical Implications

By providing an empirical investigation into the STS in Shijiazhuang city context, our results provide useful guidance for transportation planners and city policymakers through specifying the role of political legitimacy, data-driven and networked technology, STS governance, socio-economic dynamics, and citizen participation. The success of developing and deploying an STS is often associated with the local governmental goals and the intense collaboration and commitment of all stakeholders. The abstraction of relationships among participants (as discussed in the five propositions) emerging from this research are likely to provide guidance to other similar contexts.

As a longitudinal study, one particular practical guidance is that in the early stage of implementing an STS, the government pursued the usage of high technologies in the city and organisations pursued the ultimate goal of profits, and thus citizens merely participated in the implementation stage. This resulted in low participation and efficiency of the system. Comparably, in the later stage where citizens started to be involved in the decision-making process, some efficiency and participation problems started to disappear. Therefore, in STS practice, citizens as end users should be encouraged to be involved in the early decision-making process.

Finally, the narrative of the STS case in Shijiazhuang is considered an important contribution to praxis, as this serves as a consultable record. The theoretical framework developed in this study can be used as a practical guide to building future STS initiatives, wherein several important stages and interactions among key actors and stakeholders are highlighted. The framework can be useful and applicable in the similar context. More specifically, the three main processes with each key actor discovered in this study could provide government and firms with conceptual clarity and specific guidance to extending STS projects. Provided that achieving sustainability by big data-enabled technology has gained growing traction amongst government and firms, the study offers a strategic overview of designing and implementing STS initiatives.

### 6.3 Limitation and Future Research

Whilst our findings revealed a systemic understanding of sustainable value cocreation for STS development, the study nevertheless has limitations. Firstly, the value facets, and the propositions built upon which, are derived from our research undertaken in a Tier-2 city context in China; the outcome is highly contextualised to the geo-political settings therein. Given the differences of local contingencies and socio-political-cultural characteristics between cities at different administrative levels, a comparative study that places focus upon both higher and lower tier cities would offer more holistic evidence that illustrates a whole gamut of socio-technical dynamics that work in Chinese cities. Moreover, this study involves three main stakeholders – the government, private enterprises and citizens – who are defined as key actors in the interaction with certain value facets. However, it might be interesting to also investigate other types of social groups such as research institutions and state organisations that play different roles in these value facets.

## Supplementary Information



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