MASTER THESIS

Traffic Congestion Reduction and Smart City Strategy

- A Case Study in Shenzhen, China

Linlin Zhang (s 2108879)

Project Supervisors:

Dr. Laura Franco

Dr. Victoria Daskalova

MASTER OF ENVIRONMENTAL & ENERGY MANAGEMENT

UNIVERSITY OF TWENTE

2018/19

Abstract

China is currently going through a fast urban transition which pace has triggered a plethora of serious social problems, for instance an increasing amount of traffic congestions. The government has been working on the dilution of the traffic congestion problem in diverse ways and Smart City (SC) strategy is emerging as a new potential solution. The ability of technology is one of the important preconditions for the strategy. There's no doubt that Shenzhen is the center of advanced information communication technology (ICT) in China, with a large number of leading ICT firms, such as Huawei, Tencent , Ping an Technology etc. Moreover, innovative government and open-minded citizens can also contribute to transform Shenzhen into a "role" model due to its SC strategy. Without a doubt, public transportation companies are key stakeholders for effectively reducing traffic congestion and needs to be engaged in the urban transition through SC principles. Hence, this research was focused on finding out how the SC strategy can contribute to reduce the traffic congestion in Shenzhen. In order to address this question, multiple methods where applied, i.e. literature review and interviews with semi-structured questionnaires. Some of the findings of the interviews with relevant stakeholders (i.e. government, ICT firms, citizens), showed that it is not evident for them to relate SC and Intelligent Transportation System (ITS) with its potential to reduce traffic congestions. The interviewees expressed unawareness of the meaning of those terms. Even further, end-users (regular citizens) haven't even heard about SCs. The other challenges involved in the key stakeholders are related to the low motivation of the citizens, insufficient official platforms and harsh rules for participation, municipality planning chaos, low moral quality of some citizens, immature of current ITS and long-term testing period of ITS application, among others. The strategies against these challenges that have been suggested were derived from conversations with key stakeholders, from desk research and independent thinking. The most relevant suggested strategies are: 1) carrying out promotional activities in grassroot communities and promote the use of ITS related applications; 2) establishing a specified department to collect feedbacks from citizens; 3) ICT firms should actively join the governmental projects for ITS and acquire open minded suggestions or complains from the citizens, and; 4) ICT firms should understand the demand of customers, updating and upgrading their application timely to make these services customer friendly. As a general conclusion, it can be said that the SC strategy in Shenzhen requires collaboration among different groups: multi-governmental level, multi-sector and multi-actor (e.g. government, ICT firms, citizens etc.). Meanwhile, new types of ITS model are also needed to develop in order to accommodate the changing requirements from the customers and increasingly serious traffic congestion in Shenzhen. Ultimately, the report provides suggestions for stakeholders, as well as ideas for future study on the topic which might be beneficial for reducing the traffic congestion with the SC strategy.

Table of Contents

List of Figures and Tables

List of Abbreviations

SC – Smart City

ICT – Information and Community Technology

SPZ – Special Economic Zone

CHTF – China High-Tech Fair

NDRC – National Development and Reform Commission

DRCSM- Development and Reform Commission of Shenzhen Municipality

ITS – Intelligent Transportation System

MPS – Ministry of Public Security

ISO – International Standardization Organization

Index 2016 – smart city evaluation index (2016)

Index 2018 – smart city evaluation index (2018)

CCAC – Central Cyberspace Affairs Commission

MIIT – Ministry of Industry and Information Technology

IoT – Internet of things

AI – Artificial Intelligence

MNR – Ministry of Natural Resources

CIT – Contextual Interaction Theory

Chapter 1: Introduction

In this chapter four sections are introduced: background, problem statement, research objective and research outline. It begins with the background of the Smart City (SC) strategy, and the problem of current traffic congestion issue. Subsequently, it presents the goals that the researcher aims to achieve in this case study. Finally, it briefly introduces the contents in each chapter which will provide an overview of the whole report.

1.1 Background

Urbanization is considered as the major access to modernization, and has been becoming a general trend of economic and social development around the world (Wu et al., 2017). The rapid population expansion in major cities has brought the significant contradiction between urban traffic supply and demand (CHINACITY, 2010). Many studies have demonstrated that as the urbanization process in China continues to accelerate, the urban traffic congestion issue will experience severe increase (Yao, 2018). A series of negative effects has been triggered by urban traffic congestion, such as inconvenience and concern to commuting, severe air contamination and impacting the choice of travel modes (Yao, 2018), which will result in the decrease of life quality, urban chaos and even hamper the sustainable growth of cities (Shen et al., 2018).

As the fast modern technological development, especially innovative technology, such as information and communication technologies (ICT), SC has become an emerging strategy to face urban problems and create the development for inhabitants and firms (Dameri et al., 2018), which is crucial for achieving SDG[1] 11 (Make cities inclusive, safe, resilient and sustainable). The Chinese government has devoted great efforts for the promotion of SC nationwide. From

---

[1] The world's sustainable development goals (https://sustainabledevelopment.un.org/sdgs)

2012 to 2017, China has successively issued more than ten policies concerning smart city construction plans and evaluation systems at national level. While at local level, 95% of sub-provincial cities and 83% of prefecture-level cities (more than 500 cities in total) have proposed the construction of smart cities in the local government work plan (ISTIS, 2018).

As part of the urban construction, traffic is the artery of economic development, and smart traffic is an important part of SC construction (People, 2018). In the Overall Scheme of New Smart City issued by Shenzhen Municipality, smart transportation service is considered as a key element for public services and urban governance (SHENZHEN CHINA, 2018). According to China Daily (2019), Shenzhen is now ahead of Beijing, Shanghai and Hong Kong, and it has been the best-performing city in China with the deployment of intelligent traffic system (ITS). As part of the SC strategy, ICT has been widely applied in transportation service in Shenzhen. Artificial intelligence (AI) and big data technology have been used for improving road safety, communications and peer efficiency. Such technologies can identify image of traffic violators with very high accurate rate of 95%. Meanwhile, Shenzhen also pilots a real-time and data-backed smart parking management system, aiming to take 330,000 vehicles off the road each day for reducing traffic congestion (China Daily, 2019).

As the first Special Economic Zone (SPZ) established by China's Economic Reform, Shenzhen has a good foundation for the construction of SC. It is one of the most important cities of the national electronic information industry, with a series of high-tech electronic information and internet industry clusters led by Huawei, Tencent and other Fortune 500 companies (SHENZHEN CHINA, 2018). China High-Tech Fair (CHTF) held in Shenzhen every year is the largest and most influential science and technology exhibition in China (CHTF, 2019). Meanwhile, the Municipal Government of Shenzhen has attached great importance to the construction of the SC, to strengthen top-level design, introduce related policies and promote the implementation of new technologies and new models, which have already achieved remarkable results in many fields (SHENZHEN CHINA, 2018). All these can help Shenzhen to lay a solid foundation on fighting for its traffic jam and indirectly contribute to sustainable development of the city in the long run.

1.2 Problem Statement

Since the 1950s, the world has witnessed unprecedented urbanization. China is currently at the peak of urbanization. It is predicted that in the next 10 years, 870 million Chinese people will live in cities, accounting for about half of the total population (SOHU, 2010). Meanwhile, China is the largest car market in the world today. In large cities, there is an increasing trend of private car ownership and their usage which is especially rapid when comparing with smaller cities or rural areas, as the residents in metropolis usually experience faster economic growth and enjoy higher household disposable incomes (World Bank, 2018). However, the rapid expansion of urban population and surge of vehicle number will result in traffic supply/ demand problems, which will trigger severe traffic congestion in big cities.

Shenzhen as a flag of China's reform, through China's opening up and modernizing policy, it has developed from a small village into an international metropolis, with a population of 30,000 in 1978 to almost twenty million in 2018 (SHENZHEN CHINA, 2018). However, rapid development doesn't only bring Shenzhen with high speed development and wealth accumulation, but also bring China's youngest megalopolis with a series of social problems, especially severe traffic congestion (SZDRC, 2018). According to the statistics released by TomTom Traffic Index (2016), Shenzhen ranked as the 15th most congested city worldwide, under the same scale, while a city like Amsterdam ranks 129th. Such a situation has obvious negative impacts on the city's productivity and the socio-economic development, resulting in delays, fuel wastage and money loss at large (Agyapong and Ojo, 2018). In this project, the researcher focus on the inconvenience that traffic congestion brought to inhabitants' life.

1.3 Research Objective

The objective of this research was to analyze how a SC strategy can contribute to reduce traffic congestion and indirectly achieve sustainable development in Shenzhen. By assessing the activities of relevant stakeholders of the SC (e.g. government, enterprise and local citizen) from the perspective of policy, technology and public participation concerning the traffic jam issue,

practical implementation process and effectiveness of SC strategy were explored, in order to give recommendations to related stakeholders for effective construction of SC to mitigate traffic congestion in the future.

1.4 Research Outline

In this research, by analyzing existing literature (desk research) and interviewing with related stakeholders, the achievements of a SC strategy regarding traffic congestion reduction, as well as the problems of conducting such a process, were revealed. On the premise of that, key concepts of the research and analysis framework were presented. In the section of Conclusions (Chapter 5), the research questions were answered. Finally, the researcher gave suggestions and recommendations for handling existing problems during the implementation of a SC strategy to tackle the traffic congestion in Shenzhen in the future.

Chapter 2 : Literature Review

In this chapter, key concepts and theories related to the main topics of this research are presented: traffic congestion (Section 2.1.1) which introduces the general traffic jam situation concerning to the first sub-question (Section 3.2). Smart City (Section 2.1.2) presents evaluation systems and the aspects of the SC strategy, which are the key elements of the research framework. Section 2.2 mainly focuses on the theories that were used for designing the case study.

2.1 Key Concepts of the Research

2.1.1 Traffic Congestion in China

China, as the world's largest developing country has also suffered serious traffic congestions. According to China's Ministry of Public Security (MPS), as of 2018, the motor vehicle inventory in China has reached 325 million, with an increase of 15.56 million compared with the end of 2017. The number of motor vehicle drivers has reached 407 million, which has increased 22.36 million than last year. Meanwhile, the number of private cars also saw meteoric growth. The quantity of small and micro passenger vehicles registered in the name of individuals reached 187 million in total, and the private car ownership per 100 households exceeded 40 (MPS, 2018). In terms of cities, there have been 61 cities with > 1 million cars, 26 cities with > 2 million cars, and 8 cities with > 3 million cars (MPS, 2018).

For the past few years, China has committed to reduce traffic congestion with promoting Intelligent Transportation System (ITS) implements, facilitating public transportation, and furthering the infrastructure construction, measured by a "Congestion Delay Index" (i.e., "the ratio of urban residents' average actual travel time for one outgoing to their travel time under free flowing") (Amap, 2018). Although national GDP and the rate of car ownership in China are rising, its efforts appear to be working (MPS, 2018). According to the annual report released

by domestic navigation company Amap, who is working with the Scientific Research Institute of the Ministry of Transport and Alibaba Cloud, there are some improvements in China's traffic condition last year. Among the 100 major cities, 51 of them have experienced traffic congestion reduction, while 22 saw an increase. The rest of the 27 cites have not changed compared to the previous year. The report is based on a ratio of the time spent traveling during peak commute periods compared to free-flow hour, which means a higher number shows more severe congestion. In the 22 cities that have gone through a worsening of the traffic situation, the index shows that it took more than 1.8 times as long to travel during rush hours - from 7 to 9 am and 5 to 7 pm - as during off-peak hours. Compared with the year of 2016, the Congestion Delay Index was reduced by 2.45% in China's major cities, which is similar to the level of 2015 (Figure 1).
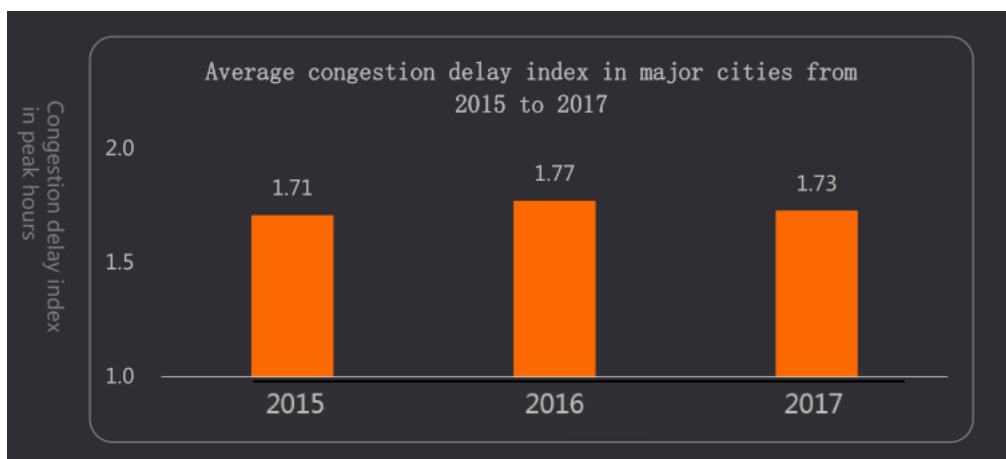
Figure 1. Average congestion delay index in major cities from 2015 to 2017 (Amap, 2018)

Shenzhen ranked the fifth place in the urban cities with congestion reduction, which was also the relatively lowest city in the mega-city level congestion list. According to the analysis in the report, apart from the advanced ICT, rotating bans on cars[2] based on the last digit of the plate number are probably other contributors to the improvement in some cities in China (Amap, 2018).

---

[2] Rotating bans on cars represents traffic restrictions based on even- and odd- numbered license plates

2.1.2 Smart City

Definition of Smart City

In recent years, the development of SCs is at the forefront of the urban discourse due to rapid urbanization rates and associated socioeconomic, environmental and governance challenges, along with the global innovation leadership challenge. Generally speaking, SC denotes a multi-dimensional strategy, involving multi-actor, multi-sector and multi-level stakeholders that are coordinated and integrated together with new technologies (ICT) to address social, economic and environmental problems in order to realize urban sustainable development (Ruhlandt, 2018). Figure 2 shows how smart technology applications can be used in SC for specific functions, such as traffic monitoring, video surveillance and energy management etc.

Figure 2. SC application (source http://www.iotphils.com/solutions/smart-cities/#prettyPhoto)

A SC strategy is a comprehensive system, which needs the support from multiple stakeholders. As a typical top-down management country, China has policy representing the willingness of the government, which is the precondition for promoting a SC strategy and ITS. The essences of a SC and ITS is to make work and life more convenient and efficient. There is no doubt, smartness and intelligence are both based on advanced technology, which are the soul of a

SC strategy. Citizens are the end-users of SC services and products. Furthermore, they are also the participants of the strategy. Their motivation and experiences have direct impact on the implementation of the strategy. In the following section, three aspects mentioned above are further explained.

Policy Aspect

The Chinese government views the construction of SCs as a matter of great importance. In order to lay a solid legal foundation of SC development, the central government has issued a dozen or so related policies at the national level over six years (2012-2017) (ISTIS, 2018). In general, four types of government policy documents are concluded on SC strategies: Firstly, specific plans or policies for smart cities, such as long-term government plans and construction schemes or guidelines. Secondly, overall government plans on national economy and social information development which included special sections for SC policy. Thirdly, policies on some other city brands, which carry some common characteristics or similar conceptualization with SC strategies, such as "intelligent city" and "digital city" (Yigitcanlar et al., 2018). Fourthly, some pilot projects funded by central government ministries focus on the development of SCs or related infrastructure (UNDP CHINA). In 2014, the State Council issued the National Plan for New Urbanization (2014-2020) which was an example of specific policy for SCs, which requires new industrialization, information technology development, urbanization and agriculture modernization, with a specific focus on improving urban governance ability to solve increasing seriously urban disease, so SCs become an important pillar in China's new urbanization plan (State Council, 2014).

Shenzhen, the reform pioneer of China, actively responds to the call of the state. The Municipality posed the Overall Scheme of New Smart City in 2017, which can be seen as a guiding document for constructing the SC of Shenzhen (SHENZHEN CHINA, 2018). In order to follow the strategies of cyber, digital and smart society development mentioned in China's 19th National Congress, Shenzhen has positioned itself as an international innovative modern city and regards peoples' livelihood and governance ability as a top priority, and insisted on a

strong promotion of the SC strategy to achieve six targets by 2020. The targets are related to the following aspects: (i) comprehensive perception with one picture[3]; (ii) one ID can solve all situations across Shenzhen[4]; (iii) one click can display the whole situation[5]; (iv) one integrated operation of the city[6]; (v) one step for business innovation[7] and; (vi) one screen for enjoying life[8]. Shenzhen's administrators want to build the city as a national benchmark city for other SCs and reach the world-class level (SHENZHEN CHINA, 2018).

Technology Aspect

Figure 3. Key technologies of SC (Quora, 2017)

---

[3] Shenzhen will build a comprehensive perception network system for urban security, traffic, environment and cyberspace, and use it for better perceiving the social operation of physical and virtual space.

[4] An electronic public service system will be established. Individuals can provide various public services through their id card number + biometrics, and enterprises with their social credit code + digital certificates.

[5] Build a decision support system based on big data, information sharing and artificial intelligence. All the required data from all departments and systems in the city and all kinds of customized decision support reports can be obtained by using the mouse.

[6] In all areas of public safety, urban operation and management, an integrated urban operation and management system will be established with rapid response, prediction and comprehensive coordination through information means, so as to realize the linkage among urban areas, departments and the military etc.

[7] Through data open platform and big data trading platform, release data dividends, build an innovation and entrepreneurship service platform based on open source data, and enhance the economic vitality of digital industry.

[8] It integrates various services related to citizens' life provided by the government, enterprises and social organizations, and builds an integrated civic service platform. Citizens can easily and quickly obtain high-quality life services through mobile phones and other mobile terminals.

Nobel economics award winner and former vice president and chief economist of the World Bank, J. E. Stiglitz, listed China's urbanization as one of the two key elements affecting the human development progress during the 21st Century beside high technology in US (Gu et al., 2012). In recent years, the new generation of ICT has not only changed the way of production and communication, but also changed the way of operating, managing and serving the city fundamentally, making urban life more intelligent and sustainable (SOHU, 2017). Thus, it gives birth to the modern concept of SC. It is well known that the construction of a SC is not a simple application of a single technology, but a synthesis composed of multiple applications, multiple industries and complex systems. SC is based on digital city, but more advanced. The advanced technology is mainly embodied in intelligence, highlighting several key applications of the new generation of ICT (Figure 3), typical examples are big data, IoT and artificial intelligence (AI) (NDRC, 2014). In the following paragraphs some of the most related SC technologies and terms are described, starting with "Big Data".

Big Data

Big data refers to large or complex data sets, and these huge amounts of data is the core of IoT services. For quite some time, huge volume, high velocity and a great diversity of data types are described as characteristics of big data, and have been created at ever-growing rates (Hashem et al., 2016). With its vital functionality, big data analytics becomes crucial for modern science and commercial organizations (Rathore et al., 2018). With the help of Big Data, large amounts of data can be gathered from IoT devices or other sources, which provides the potential for the city to gain valuable insights from huge amount of data. The functions of big data are reflected in four aspects of the SC: Firstly, scientific planning. Through the application of big data, all aspects of urban planning have a more reasonable basis. Secondly, real-time monitoring. The development of digitalization, networking and intellectualization can ensure the operation of the whole city is under control. Thirdly, accurate decision-making, including accurate information, intelligent decision-making plans, rapid action and performance assessment. Fourthly, efficient service, providing convenient, accurate and efficient services to the public (SOHO, 2017).

IoT

IoT, Internet of Things, is a foundation for connecting things, sensors, actuators, and other different kinds of smart technologies, thus enabling the communications of person-to-object and object-to-object (Liu, 2018). In other words, IoT is a kind of network of smart devices, from which data can be collected and exchanged. The number of connected devices will surge to 30.7 billion in 2020 and 75.4 billion in 2025 (Statista, 2016), which means trillions of data points will be generated every hour.

Cloud Computing

"Cloud computing is a template for providing suitable and on-demand network access to a shared pool of configurable computing resources, such as networks, servers, storage, applications and services, that can be rapidly provisioned and released with minimal management effort or service provider interaction"(Nowicka,2014), which can bring benefits to both individual and organizations, in terms of capital expenditure and savings in operational cost (Subramanian and Jeyaraj, 2018). In other words, cloud computing gives the centralized platform to access the data from anywhere in the world with the shared infrastructure at minimum cost.

AI (Artificial Intelligence)

AI, as a non-traditional advanced technique for discovering valuable information, is also playing a major role in Big Data Analytics. Comparing with other traditional method, such as regression-based models and other statistical models, the design of AI increases its accuracy and scalability (Wong et al., 2019).

Modern AI always contains self-learning systems which are trained by huge amounts of data, known as big data. It can also have interaction with intelligent agents, which can execute distributed reasoning and computation in an interoperable way. Specifically speaking, AI connects sensors with algorithms and human-computer interfaces, and extends itself into large networks of devices. For now, AI technology has been applied in many areas, such as industry, government and society, and is becoming one of the important driving forces for today's

economy (Amsterdam University). Specifically speaking, the primary advantage of AI in Big Data analysis is that it supports the heterogeneity and commonality principles that are part of the Big Data analysis. By going through the urban fabric, AI technology can capture the hidden structures of urban components. In this way, it can provide a deeper insight of common features. As the source of big data analysis, AI is introduced into SC for contributing to the area of urban design, planning process as well as governance.

The application of ICT in SC – Intelligent Transportation System (ITS)

Urban traffic congestion is one of the most severe problems of everyday life in Metropolitan areas. In order to cope with the increasing traffic issue, ITS technologies have been introduced in recent years (Stathopoulos and Karlaftis, 2003).

Figure 4. Urban ITS model (Hess et al., 2009)

ITS is a combination of advanced information and communication technologies applied to transportation and traffic management systems (Figure 4), which aims to improve the safety, efficiency, and sustainability of transportation networks. The effort will not only reduce traffic congestion, but also bring more convenience to daily trips for the residents. According to WSP, a globally recognized professional services firm, ITS mainly functions in several aspects: Firstly, automated activities replace the traditional human operation. Secondly, road network

performance is monitored and adjust in real-time. Thirdly, data is collected in a new and richer data base. Fourthly, analysis is undertaken by systems delivering intelligence through real-time data analytics. Fifthly, mobile devices/in-car systems act as new publication channels for road users to choose (WSP, 2017).

Community Aspect

China is now at a crucial stage of rapid urbanization and urban transformation. In the initial stage, many "SC"-strategies have been criticized for excessive dependence on the ICT and monitoring the end-users, who are working and living in the city (UNDP, 2015). In China, the central government has been promoting public participation as an innovative way to address China's emerging urbanization challenges. Public engagement was first stipulated in the Rural Planning Law of the People's Republic of China in 2008. Notably, the government also emphasizes that the SC concept should be human-centered, practical and demand-driven. In order to effectively promote public participation policy, the State Council has issued the New-type Urbanization Plan (2014-2020) in 2014, emphasized the importance of citizen involvement and positive interaction between citizens and the government for better SC construction (State Council, 2014). Apart from the above-mentioned micro policies, the central government also introduced many specific policy documents on how to promote citizen engagement. Such as "Opinions on Further Strengthening Government Information Disclosure Responding to Social Concerns in order to Raise Government Credibility" – which requested central and local government agencies to better take advantage of the online platform for disclosing information and responding to public concerns. The document also specifically emphasized the essential function to use new media and government hotlines to interact with the public, such as online surveys and interviews, the "leader's mailbox" for collecting public opinions and feedback on policies and governance (State Council, 2013). A SC shouldn't be made by people just receiving the inputs from the government, but by citizens adopting a leading role in the process of data collection and sharing (Sanseverino et al., 2018). China's central government noted the that connecting citizens is the timely   engine of urban change. They are trying to shift the management mode from the top-down to bottom-up. The

percentage of "Citizen Experience" increased to 40% in the new national SC evaluation system (2018) compare with 20% in 2016 can be seen as a signal of China's transition to human-centered government (mentioned in Section 2.1.3 Evaluation System).

Despite the top-level political support for bottom-up and human-centered ICT initiatives for SC development, challenges still exist. Mainly surrounding inadequate planning and coordination, a lack of human capacity and conflicting political incentives, which are barriers to maintaining or scaling-up ICT for public participation initiatives, according to the report from UNDP (2015).

2.1.3 Evaluation System of Smart City

Evaluation Standard from China

The new SC evaluation index (2016) (index 2016) is the first national evaluation standard for China's SC in strict sense issued in late 2016, covering new urbanization, high-end manufacturing, transportation management, industrial safety, agricultural services, cultural relic management and many other fields (SOHU, 2018). The system comprises 8 primary indicators and 21 secondary indicators that are further divided into 54 sub-indicators, with all indicators given different weights, and the secondary-level sub-indicators are used for specific data collection. The hundred-mark system is adopted, in which the total possible score is 100 points. The indicators, as shown in Table 1 are mainly based on objective and quantitative data, which are designed to avoid subjective scoring by experts. Transportation services are part of the public services and accounted for 3% of the total score. Meanwhile there are three sub-indicators behind it as well (Table 2), which are used for evaluating urban development of "internet + convenient transportation" and the services of providing public transportation information (NDRC, 2016).

Table 1. New smart city evaluation index in China (2016) (NDRC, 2016)

Primary indicators	Secondary indicators
Public services (37%)	Government affairs (8%), transportation services (3%), social security services (3%), medical services (3%), education services (3%), employment services (3%), urban services (7%), assistance services (5%), E-commerce services (2%)
Accuracy of administration (9%)	Urban management (4%), public security (5%)
Livability (8%)	Smart Environmental Protection (4%), Green Energy Saving (4%)
Smart facilities (7%)	Broadband network facilities (4%), spatiotemporal information platform (3%)
Information resources (7%)	Open sharing (4%), development and utilization (3%)
Network security (8%)	Network security management (4%), system and data security (4%)
Revolutionary innovation (4%)	Institutional mechanisms (4%)
Citizen experience (20%)	Citizen experience survey (20%)
Optional indicators (10%)	Determined by the respective provinces, maximum of 3 indicators

Table 2. The indicators of transportation services in the index 2016 (NDRC, 2016)

Second indicators	Sub-indicators
Transportation services (3%)	Traffic Performance Index release
	Real-time prediction rate of public transportation information (bus and tram)
	Usage rate of electronic payment for public transportation

In December 2018, the National Development and Reform Commission (NDRC) and the Central Cyberspace Affairs Commission (CCAC) jointly issued the new SC evaluation index (2018) (index 2018), in order to implement the evaluation work effectively and better promote the development of SC construction (Dalian Development and Reform Commission, 2019). Compared with index 2016, index 2018 still retains 8 primary indicators, but the number of secondary indicators and sub-indictors are adjusted to 24 and 52 (except citizen experience), respectively. The new version highlights the citizen experience and increases the weigh from 20% (index 2016) to 40% (index 2018), which is because of the low satisfactory rate of citizen in the process SC construction. The government hope that, by increasing the weigh, they can promote the healthy development of SC with people oriented mode. In addition, several new indicators are supplemented in combination with new national policies, new technologies and new needs. So three new secondary indicators are added, such as smart agriculture, smart

community and social credit. The indicators related to transportation remain the same, except the weigh decrease from 3% to 2%.

As the weight of citizen experience indicator has been doubled in the new evaluation index (2018), citizen is becoming another key aspects of the SC strategy and also the key stakeholder for solving the traffic congestion. So this project focused on the transportation services and citizen experience areas in the evaluation system .

2.2 Theoretical Basis of the Research Structure

The theoretical basis of the research is introduced in this section for better understanding the theoretical fundaments of the framework, interviews and research analysis, as well as the description of the reasons to choose those theories.

2.2.1 The Aspects of a Smart City

There is no concise definition for the concept of SC. However, it is widely accepted that ICT has played an important role driving the development of the strategy（Ismagilova et al., 2019）. During the transition to human centric governance, more and more academics and governments noted the importance to bring citizen (end user of SC service) into the construction process (Dall'O et al., 2017). However, these kinds of theory only focus on either one or two independent elements of what constitutes a SC. A report released by UNDP in 2015, called "Rethink Smart Cities- ICT for New-type Urbanization and Public Participation at the City and Community Level in China", indicted that the Chinese government should promote more public participation for the SC strategy with the help of advanced ICT, which proposed the integrated relationship among the key stakeholders. Similarly, Kunzmann (2014) also introduced the same aspects for SC development and put it in a more specific way. According to his theory, there are three existing aspects in the SC strategy: (a) Technology, which is the technical basis enable urban people live in an easier, more convenient and more secure way; (b) Community, who are the end users and beneficiaries of SC services, and their demands instruct which urban problems need to be tackled; (c) Policy, which enable SC initiatives and

it can minimize the negative impacts of SC disruption with legal measures. These aspects conform to the situation of SC strategy in China, which are suitably chosen as analysis perspectives for traffic congestion reduction in Shenzhen Municipality. A SC strategy is a comprehensive system with multi-levels and multi-actors. And each actor has an influential impact on the strategy. Therefore, CIT is introduced in the research to analyze the interaction among actors, in order to understand the development of the strategy better.

2.2.2 Contextual Interaction Theory (CIT)

According to Dall'O et al., (2017), the creation of a SC shouldn't be regarded as a goal, but as a process that enables coordination among all the relevant actors involved , and also must be analyzed as such. Similarly, the main reason for the researcher to choose CIT as the framework is that it can help the researcher to analyze the implementation process from the perspective of the different actors involved   and not just from the institutional view point. Since as multi-actor interaction process, it is ultimately driven by the actors involved.
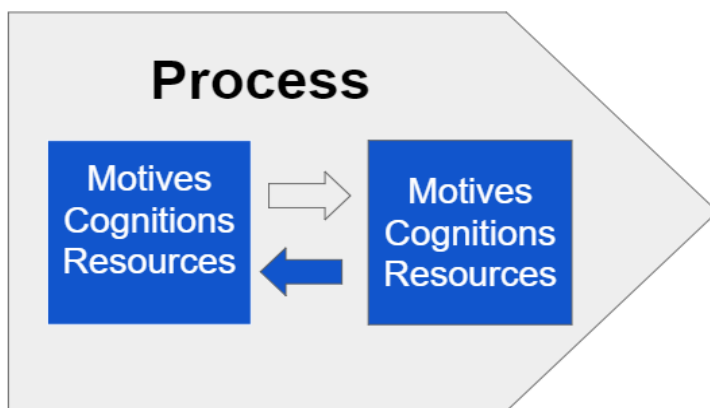
Figure 5. Process model with the actor characteristics used in Contextual Interaction Theory (Bressers, 2009)

From the previous literature review we can understand that ICT supports the development of SC strategy, which pushes China's government to work with those ICT firms and related research organizations for better implementing the policy. Also from the increase proportion of citizen experience in evaluation standard of SC which mentioned before, we can see the effort that the Chinese government has made towards the SC transition from the previous top-down approach to cooperation model, even though there's still a long way to go. In reality, no one can carve out the impact of a single factor from those of the others, and they must deal with specific cases/situations in which all factors are around simultaneously with combinations of all relevant factors (Bressers and O'Toole, 2005). Even in a simple case with only a few factors, exponential increase of different combinations of circumstances can be imagined, which is unworkable and over-done (Goggin, 1986). According to CIT (Figure 5), it is easier to explain

the course and effects of implementation with a set of three core factors per stakeholder (blue box in Figure 5). Three key factors are normally operated in this way: motivation will stimulate stakeholders into action, the stakeholders should have the correct cognitions, information, and they also should have enough resources which will provide them with the capacity to act individually and power in relation with actors. In order to enable the process to move smoothly, sufficiently strong combination of the factors (i.e. motivation, cognition and resource) are needed for each stakeholder involved (Bressers et al., 2016).

In this chapter, the researcher described the SC aspects (e.g. policy, technology, community) and the characteristics of CIT (e.g. motivation, cognition, resources), Both frames serve to analyze the opinions of representatives of each group of interest (e.g. government, ICT firms, citizens) respectively. In this way, the researcher could identify barriers in each of the sections and from them develop specific and workable proposals on the complex issues of traffic congestion in Shenzhen. The research framework and conceptual model are elaborated in Chapter 3.

Chapter 3 : Methodology

In this chapter, the research design and the research framework is presented based on the key concepts and theoretical basis of the research (Section 3.1). According to the literature review, policy, technology and community are regarded as the most important elements for a SC. Meanwhile, the current situation of traffic congestion and the evaluation system for smart cities, especially in the traffic filed, are also key components for analyzing the effectiveness of SC strategy to reduce the traffic congestion. The research questions, including main questions and sub-questions are presented in Section 3.2, followed by the research strategy (Section 3.3), which mainly covers research unit and its selection, research boundary and data collection methods. Three different kinds of methods are used for collecting data, such as desk research, literature review and in-depth interview with related stakeholders. Due to the interaction with people, an ethics statement is also included in this chapter. In the end, the method of data analysis and validation of data analysis are evaluated in the last section of this chapter.

3.1 Research Design and Framework

From the research design viewpoint, this case is considered as a single case, because the researcher only focused on the transportation service within the SC construction in Shenzhen. For this research, the key concepts to be included in the conceptual model were displayed in Figure 6, where SC and related aspects (policy, technology and community), traffic congestion, evaluation system conform the research framework that were derived from preliminary research, which enable the researcher to develop the conceptual model. As presented in Figure 7, the conceptual model is the framework for analyzing the traffic congestion in Shenzhen Municipality. This figure has an outer oval which corresponds to a symbolic geographical boundary of the research unit, i.e. Shenzhen Municipality in China. Inside the oval there are two boxes, the left one corresponds to the aspects of a SC: policy aspect, technology aspect and community aspect suggested by Kunzmann (2014) in his multilevel

model. The right box represents the effect of the SC strategy in terms of traffic congestion reduction. In other words, the researcher hypothesizes that traffic congestion reduction depends on the contextualized arrangements among the three aspects of SC construction.

With the purpose to further describe the model, the researcher enlisted some of the stakeholders (red color in the box of Figure 7) to be engaged for each of the SC strategy aspects through this research. Even further, the researcher indicated the type of method that was used for analyzing the related actors and its theoretical fundament (green color).
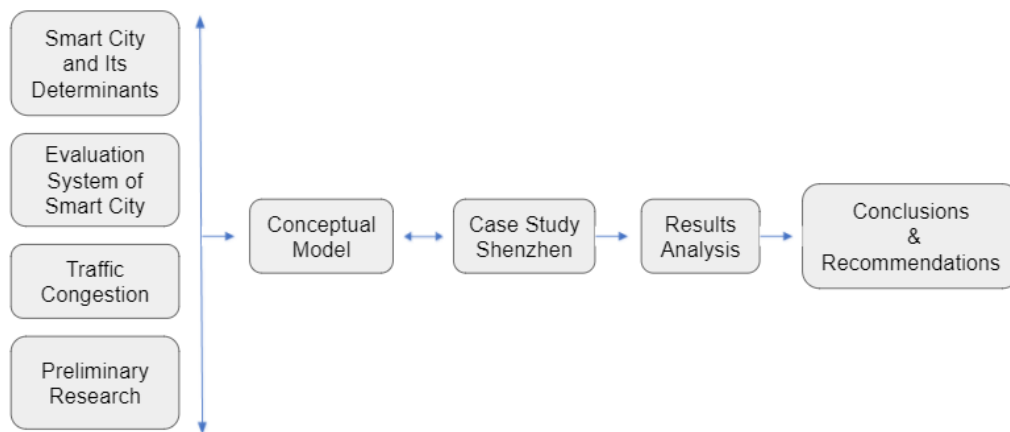
Figure 6. Research framework of reducing traffic congestion through smart city strategy
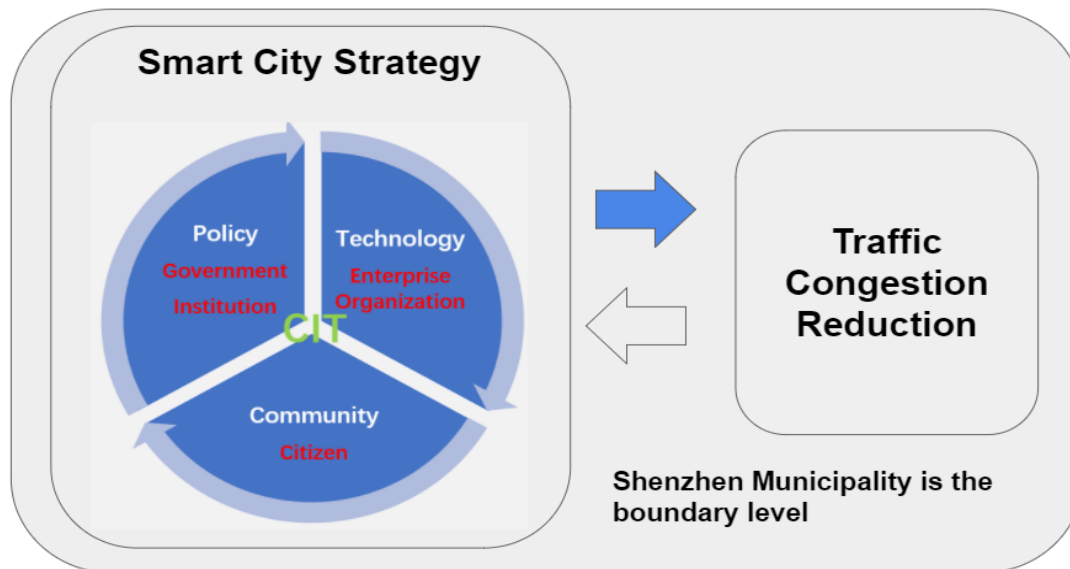
As displayed in Figure 7, for policy aspects, the main stakeholders are the governmental institutions, and for the technology aspect, ICT firms and research organizations are the target group, citizen are the major focus in the community aspect. It is well known from the previous literature review that, SCs cannot function only with any single aspect, but requires a synthesis that all stakeholders interact in an organized way, so based on Contextual Interaction Theory (CIT), the researcher analyzed the relationship among these actors from three characteristics: motivation, cognition and resource, which is introduced in Bressers et al., (2016). Hence, in this conceptual model, the researcher tries to identify the role and function of each key actors (i.e. government, enterprise and citizen) and how they cooperate with each other under the umbrella of SC strategy, in order to realize traffic congestion reduction. Due to the practical issues, in-depth interviews with related key stakeholders were the researcher's first option, in which the researcher received insights from different perspectives and obtained overall conclusions. Meanwhile, the indicators of transportation service of Index 2018 in China (Table 3&4) were also utilized as theoretical fundament for analyzing and adapting the research questionnaire with stakeholders.

3.2 Research Question

Main research question

How can the Smart City (SC) strategy contribute to reduce the traffic congestion in Shenzhen?

Sub-questions

1) What's the current situation of traffic congestion in Shenzhen?

2) Who are the actors (government, enterprise, citizen) involving the SC construction regarding the transportation service upgrading in Shenzhen?

3) What are the actors doing to enable Shenzhen successful transition to SC regarding solving the traffic congestion issues?

4) What are the challenges to solve the traffic congestion as part of the SC strategy in Shenzhen?

5) What are the prioritized challenges to be addressed in Shenzhen to solve the traffic congestion?

6) What are the strategies to accommodate the prioritized challenges to solve traffic congestion situation in Shenzhen?

7) What types of transportation service applications can be associate with solving the traffic congestion in Shenzhen?

3.3 Research Strategy

3.3.1 Research Unit

The effect of SC strategy regarding the traffic congestion reduction in Shenzhen Municipality was the research unit in this research. In particular, the activities of the key stakeholders (i.e. government, enterprise and citizen) in the major aspects of the SC strategy that have an

influence in the traffic congestion (i.e. policy, technology and community) were in the core of this thesis.

3.3.2 Selection of Research Unit

As described in preceding chapters, this case study was focused on identifying SC strategies that have the potential to mitigate the traffic congestion in Shenzhen. The municipality and research aspects were chosen for two reasons: First, Shenzhen Municipality is always acting as a leading role in SC construction in China. Its strong technological foundation enables Shenzhen to become the earliest batch of cities in China that can use SC technologies to solve the practical urban problems. Second, traffic congestion is becoming a severe urban problem, especially when Shenzhen is currently going through large scale of urbanization transition. On the one hand, the results of the research will be used as a good example to show the achievements Shenzhen has made for using SC strategy to solve the traffic issue. On the other hand, the analysis will help the related stakeholders in Shenzhen to identify their problems existing in the process of SC strategy regarding solving traffic congestion issue, in order to implement the strategy more effectively in the future.

3.3.3 Research Boundary

The geographical boundary of this research was the Shenzhen Municipality in China for practical reasons. Due to the complex factors that can influence traffic congestion reduction (e.g. infrastructure, population etc.), the researcher decided to limit this research to focus on the strategy of SC in order to specifically identify the relationship between traffic congestion mitigation and SC strategy. Consequently, the analyzed aspects and stakeholders in this research are all aspects for SC strategy, and for each aspect only the most representative stakeholders were chosen for analyzing. The scope of this research was to identify and analyze how the SC strategy can contribute to reduce traffic congestion with the improvement of transportation service in Shenzhen Municipality. Since government is the legal entity for issuing smart city policies, the technology and smart products for developing smart city are

based on the research of ICT firms and related research organizations, citizens are the end-users of smart city strategy. Stakeholders from related aspects were assessed: policy aspect (government), technology aspect (ICT firm/ research organization) and community aspect (citizen).

3.4 Research Materials and Data Collection Methods

Desk Research

Desk research (Literature review) is one of the most common research methods to identify relevant existing works on the specific field/topic of research. A systematic approach of reviewing the materials is also recommended for replicability purposes. Existing literature is regarded as secondary sources of information, such as journal articles, government reports, magazine, content of webpages etc., and these materials can be searched though the means of Scopus, Science Direct and some similar research networks with the searching key words, such as SC, ITS etc. Government annual report and government meeting minutes as well as the data released by the relevant department of the government were chosen and prioritized due to their high reliability. Additionally, other digital means like the digital library of the Twente University were used as credible sources during the desk research. More than 70 different kinds of literature were selected and used in this research.

In-depth Interview

This is a qualitative research method that consists of using a semi-structured questionnaire to interview respondents who can provide in depth information about the aspects associated to the research topic. The method can be applied to the interview with policy, technology and community-based actors. The Table 3-5 below explained the objective of each interview question from the perspective of government, ICT enterprise/ research organization and citizens. The questionnaires with different stakeholders can be found in Appendices 1~3.

Design of Questionnaire Content for Citizen		
Question Section	**Question**	**Objective**
Section 1-Introductory Question	Q1.1	Introductory question, for helping interviewees understand the topic clearly, in order to provide the effective information to the researcher
Section 2- Research Question	Q2.1	Concerning sub-question 1, it assesses the current situation of traffic congestion
	Q2.2	Concerning sub-question 7, it collects feedback for the current transportation service in order to improve the service for better solution of traffic jam reduction in the SC strategy
	Q2.3	Concerning sub-question 3, it assesses the activities of the citizens for reducing traffic jam in SC strategy
	Q2.4	Concerning sub-question 4-5, they assess the challenges and explore the most difficult part for citizens to participate the project of traffic jam reduction in SC strategy
	Q2.5	Concerning sub-question 6, it explores the strategies for dealing with the challenges mentioned before
	Q2.6	Concerning sub-question 7, it collects information for better implementation of the transportation service to reduce the traffic jam in SC strategy
	Q2.7	Open question for collecting additional information
Section 3- Contextual Interaction Theory	Q3.1	Assess the motivation, cognition and resource based on the CIT, in order to analyze the interactions among different actors
	Q3.2	
	Q3.3	

Table 4. Design of questionnaire content for ICT firm/ research organization

Design of Questionnaire Content for ICT Firm/ Research Organization		
Question Section	**Question**	**Objective**
Section 1-Introductory Question	Q1.1	Introductory question, for helping interviewees understand the topic clearly, in order to provide effective information to the researcher
Section 2- Research Question	Q2.1	Concerning sub-question 1, it assesses the current situation of traffic congestion
	Q2.2	Concerning sub-question 3, it assesses the activities of the ICT firms/research organization for reducing traffic jam in SC strategy
	Q2.3	Concerning sub-question 4-5, they assess the challenges and explore the most difficult part for ICT firms and research organization to contribute to the project of traffic jam reduction in SC strategy
	Q2.4	Concerning sub-question 6, it explores the strategies for dealing with the challenges mentioned before
	Q2.5	Concerning sub-question 7, it collects information for better implementation of the transportation service and innovative business model to reduce the traffic jam in SC strategy
	Q2.6	Open question for collecting additional information
Section 3- Contextual Interaction Theory	Q3.1	Assess the motivation, cognition and resource based on the CIT, in order to analyze the interactions among different actors
	Q3.2	
	Q3.3	

Table 5. Design of questionnaire content for government

Design of Questionnaire Content for Government		
Question Section	**Question**	**Objective**
Section 1-Introductory Question	Q1.1	Introductory question, for helping interviewees understand the topic clearly, in order to provide effective information to the researcher
Section 2- Research Question	Q2.1	Concerning sub-question 1, it assesses the current situation of traffic congestion
	Q2.2	Concerning sub-question 3, it assesses the activities of the government for reducing traffic jam in SC strategy
	Q2.3	Concerning sub-question 4-5, they assess the challenges and explore the most difficult part for government to contribute to the project of traffic jam reduction in SC strategy
	Q2.4	Concerning sub-question 6, it explores the strategies for dealing with the challenges mentioned before
	Q2.5	Concerning sub-question 7, it collects information for better implementation of the SC strategy and network model to reduce the traffic jam in Shenzhen
	Q2.6	Open question for collecting additional information
Section 3- Contextual Interaction Theory	Q3.1	Assess the motivation, cognition and resource based on the CIT, in order to analyze the interactions among different actors
	Q3.2	
	Q3.3	

Ethics Statement

The researcher fully understands that it is an important component of the ethical procedure at Twente University when people are involved in the research. The research project required approval from the ethics committee at BMS faculty, hence it was submitted online through the Ethics Assessment system before the execution of the research. The researcher also took great responsibility for explaining to the respondents on the topic of the case study, covering background, objective and the scope etcetera. All the interviewees signed up the "Consent form for interviews" (Appendix 6), which meant all the data and answers the researcher used from the interview for this research project had the approval of the interviewees. With the information and data received from the respondents, the researcher also has tried to minimize negative impact on the interviewees in the course of the case study.

3.5 Data Analysis

Through the process of data analysis, all the information and data from the research collecting methods (desk research and interview) were translated into answers to the sub-questions and the main question, which are presented in the Conclusions (Chapter 5).

3.5.1 Method of Data Analysis

In social science, two categories of methods are usually used for analyzing information and data of the research: qualitative and quantitative methods. In this case study, a qualitative method was chosen as the major analysis measure. The methodology for this research was summarized in Table 6, where each sub-question was linked to its required research methods, target group(s), and output to be produced after the qualitative analysis. Research methods include literature review (Chapter 2), in-depth interviews with semi-structured questionnaires (Section 3.2).

Table 6. Research methodology

Sub-Question	Research Method	Target Group	Analysis Method and Output
Q1	Literature review	Government ICT firm Research organization	Qualitative: The traffic congestion situation in Shenzhen with specific data
Q2	In-depth interviews Literature review	Government ICT firm Research organization Citizen	Qualitative: List of actors of the transportation aspects in SC strategy
Q3	In-depth interviews Literature review	Government ICT firm Research organization Citizen	Qualitative: Inventory of the initiatives oriented towards dealing with traffic congestion
Q4	In-depth interviews Literature review	Government ICT firm Research organization Citizen	Qualitative: Inventory of the challenges per actor to deal with traffic congestion
Q5	In-depth interviews Literature review	Government ICT firm Research organization Citizen	Qualitative: List of prioritized challenges per actor to deal with traffic congestion
Q6	In-depth interviews Literature review	Government ICT firm	Qualitative: Recommendations to deal with traffic congestion

		Research organization Citizen	according to the prioritized challenges.
Q7	In-depth interviews Literature review	Government ICT firm Research organization Citizen	Qualitative: Examples of transportation service model in SC strategy for reducing traffic congestion in Shenzhen

Answering the questions described in the Section 3.2 required the accumulation of data and information from several sources. In this section, the strategy of collecting and processing data to answer the sub-questions are briefly presented.

The first question dealt with quantitative data regarding the traffic congestion situation in Shenzhen. This information may be obtained through online searches, scientific studies, or consultation with relevant governmental entities, related ICT firms or research organizations.

The second question required the relevant actors to be identified. This information was obtained through literature review, consultation with previously conducted research, as well as through interviews with governmental entities, ICT firms, research organizations and citizens. The contents of the interviews were analyzed and provide answers regarding each type of actor.

The third question was a follow-up question of the previous one, so the answers should be obtained in the same manner. Most of the data and information were gathered from face-to-face depth interview with the key representative of each aspect based on the research questionnaire. Email was also taken as a means when the interviewees were not convenient to meet in person.

The fourth question dealt with challenges that how traffic congestion reduction could be implemented under the umbrella of the SC strategy. As the same with previous two questions (sub-question 2 & 3), these questions should be answered based on the data or information obtained from the interviews with relevant actors. In contrast to the previous two questions, this question required that the data or information provided through the interviews, compared with the previous desk research or even the comments from other actors in the interviews, to identify the similarities with the preliminary research and opinions from other stakeholders, in order to obtain the overall answers.

The fifth question was a follow-up of the previous question, and the challenges identified must be ranked according to their priority the actors involved in Shenzhen Municipality regarding the traffic congestion.

The sixth question required synthesis of strategies to accommodate the challenges that have been identified in the research. The strategies were generated from interviews with relevant actors, assessment and analysis with previous conducted research, followed by creative and independent thinking. In this way, efficient strategies could be developed to tackle the challenges.

The seventh question asked for the type of transportation service application that could be associated with traffic congestion reduction within SC strategy in Shenzhen, which could exist already or has a possibility to happen with good prospects. The answer to this question lies in previously conducted research and interviews with related actors, therefore it was necessary to conduct comprehensive desk research and in-depth interview to identify potential transportation service model for mitigating the traffic issue in Shenzhen.

It is expected that sufficient information or data will be collected to answer these seven sub-questions, which can provide a solid foundation for answering the main research question in this case study.

3.5.2 Validation of Data Analysis

Desk Research: The method was utilized as a starting point for the research. In order to ensure the reliability of the information, all the data and information for answering the research questions were collected from academic literature, official reports, website of the mainstream media and the government etc. Meanwhile the policies and legal framework involved in this research are the latest version to prevent outdated information.

In-depth interview: The validation of this method is based on the review from the respondents. After each interview, the researcher will send the transcript to the interviewees to make sure the information and data summarized by the researcher fully reflects the opinions provided by the respondents, in order to prevent misinterpretation and ensure the accuracy of the research.

More information for the data collection methods of the research was mentioned in Section 3.4. In order to solve urban development problems and achieve sustainable urban development, the construction of SC has become an irreversible historical trend of urban development in the world today (ARCHINA, 2018). Especially in the ITS fields, there is few research with a systematic analysis on the smart traffic. The original intention of this research was to analyze how SC strategy in Shenzhen can help to solve the traffic congestion and took Shenzhen as an example to spread the experiences to other regions. Bias and limitation exist. Firstly, due to the limited time, the researcher didn't analyze other cities as a comparison with Shenzhen. Secondly, different regions have their own social background, such as population, economy, technology and infrastructure etc., which limited the spread of the effectiveness of this research. However, the information and data of this research can be used as references to enlighten the solutions for solving the traffic congestion through the SC strategy in other cities.

Chapter 4 : Findings and Discussion

This chapter presents the findings and discussion derived from the research project, which is based on the qualitative interviews with relevant stakeholders, including government, ICT firms and citizens. A famous public transportation company was interviewed as another key stakeholder. All the transcripts of the interviews are presented in Appendix 5. In order to be more concise, the overlap content from different interviewees has been deleted, and the remaining transcripts cover all the opinion from the stakeholders.

A total of 30 potential subjects were contacted, from which 25 replied positively. Most of the interviews were conducted face to face, only in some cases when it was not convenient to communicate in person, interviewing through the cellphone or sending answers to the questionnaire by email were also possible. The success rate is 83.3%. The findings and discussion of the interviews are presented below based on three characteristics of Contextual Interaction Theory (CIT) of the identified main actors from government, companies (ICT firms), citizens and other stakeholders. Preliminary literature review is also key input in this chapter.

Among the respondents, the staff in Transportation Department in Shenzhen is regarded as the representative of the government. The staff and managers in Huawei, Pin An Technology as well as Tencent are the representatives of the ICT firms. In the aspect of community, two different kinds of citizens are selected: firstly, people who drive private cars much in their daily lives (Private vehicle driver). Secondly, people who usually take public transportation (Ordinary citizen). Staff and manager of the public transportation act as another stakeholders beside the key three aspects.

4.1 Government (Transportation Department in Shenzhen)

Motivation

The government has the strong motivation for promoting the SC strategy, both at the central level and local level (Shenzhen Municipality and its transportation department. According to the (ISTIS,2018), dozens of related policies are issued at the national level from 2012 to 2017. Meanwhile, many pilot projects on SC are funded by the central government for the development of SC and related infrastructure (UNDP CHINA). Shenzhen as the reform pioneer of China always responds to the appeal of the central government actively. Not only because of its strong financial and technical foundation, but also due to the needs of human life, especially for traffic congestion. Promoting the public transportation is regarded as the most effective way for dealing with the traffic congestion. Based on the interview with Shenzhen Transport and Communication Commission, the public transportation in Shenzhen is operated with high efficiency with the help of ITS. The public transportation in Shenzhen is accounted for 57.4% of the total volume which increased by 15.55% compared with that in 2016. According to the analysis report of transportation jointly released by Amap and China Planning Research Institute of Transportation, Shenzhen ranks 46 for traffic congestion, maintaining the trend of continuous decline.

Generally speaking, the local government in Shenzhen has enough resources in the key areas, such as finance, technology, legislation etc., and can get strong support from the central government to ensure the implementation of the SC strategy.

Cognition

The diffusion of the concept of SC or ITS within the governmental Chinese structure has been in place for a long period. The related staff to the SC strategy, such as the members of the policy research center are responsible for evaluating the SC related policy (China Daily, 2019). They will conduct a professional analysis to make sure the government fully understands the policy and implements it correctly. Pilot projects are usually tested in some typical regions before being expanded in large areas to minimize the risk.

Resources

Policy represents the wishes of the country. In China, a typical top-down management state (Fortune, 2019), most of the major policies are provided by the central government, which might present some drawbacks, but also bring strong executive power. As the first Special Economic Zone (SPZ) established by China's Economic Reform, Shenzhen has a good foundation for the construction of a "SC". It is one of the most important cities of the national electronic information industry, with a series of high-tech electronic information and internet industry clusters led by Huawei, Tencent and other Fortune 500 companies (SHENZHEN CHINA, 2018). The Municipal government of Shenzhen also has attached great importance to the construction of SC, especially in the traffic filed. They believe that smooth traffic is an important basis for developing into a more livable city. Thus, the local government strengthens top-level design, introduce reginal policies as well as set specified funding to promote the implementation of the new smart solutions of ITS, which has already achieved remarkable achievements in the traffic fields (SHENZHEN CHINA, 2018).

Discussion

The central government has a high motivation to promote the construction of SC strategies, and many positive policies related to SC and ITS have been released in several years. However, the promotion of these policies is far from enough. Although the Municipality of Shenzhen has sufficient financial resources and technical abilities, the construction of a SC also requires the cooperation of local citizens. Since the citizens are key components in the operation of the strategy, without their participation and feedback it will seriously slow down the strategy deployment. According to the respondent (Ordinary citizen 2, May 19, 2019), the most effective way to promote is to advertise SC strategies and ITS in public areas, such as metro stations, bus stops and shopping malls. Although many relevant information and data can be found in the government website, regular citizens might not be self-motivated to check such information. Insufficient incentives is another reason as this was mentioned by some of the interviewees (Private vehicle driver 3, June 3, 2019). Some respondents in the interview

indicated that less incentive is the reason that limit their participation (Private vehicle driver 2, May 11, 2019).

4.2 ICT firm

Motivation

The main purpose for the ICT firms is to generate profit. The concept of SC has opened new business opportunities for the ICT firms. For the construction of the smart traffic, most of the ICT firms are cooperating with the local government. Positive relationships with the local government will no doubt bring them more potential benefits as well as nurturing their green image in the citizens' eyes. Currently the citizens are becoming more critical for the products and services they are paying for (China Daily, 2019), if the ITS projects in collaboration with the government can help to increase the number of their potential customers, this would be a big economic success for those ICT firms. This can in fact explain why it is that those ICT firms are strongly competing to participate in the smart traffic strategy.

Cognition

The ICT firms understand the macro policy mainly from interpretation of the local government. Apart from that, marketing investigation, industry information collection and customer investigation are also key methods to translate the policy into the market demand. Combined with the orientation of the whole company as well as the direction of the development, the ICT firms can fully understand the policy (Manager of Eastern Bus company, June 13, 2019), such as SC strategy and ITS in the company level.

Resources

According to the interview, the respondents in the leading ICT firms indicated that there's no specific technology that reflects the SC or ITS principles. The new generation of those technologies is developed for universal functions, not just for solving traffic issues. The ICT firms have sufficient basic technology, financial support and public services, all they need to

do is to combine those technologies as smart solutions based on the demand from the market. And for the construction of ITS, many of the projects are done in cooperation with the government. In that way, they can get financial and political support. Their staff has expressed their concern in relation to carrying out fundamental research which is costly because the smart related products and services take a long time for being tested and optimized.

Discussion

According to the interviews, most of the ICT firms believe they have enough resources for developing smart traffic, including finance support, technology ability and social network. The bottleneck for them is the basic research period, as well as the testing and product/service optimization periods. Nowadays, more and more young students don't want to choose basic science as their major at universities. Mathematics, physics and chemistry etc. are regarded as unpopular majors in China，which are much less popular than economics. Since they believe any major in basic science cannot bring much profit for them. Specifically, it is basic science research that provides the input for SC solutions in relation to services and products (SOHU, 2017). The government and ICT firms should help the new generations to set up the right ideal and belief and pinpoint the importance of the basic science research which can inspire more people to participate the construction of the SC strategy (SOHU,2017).

According to the interviews, some respondents indicated that testing and optimizing for the ITS products and services take a long time during their life span (Manager of Ping An Technology, May 25, 2019). However, there were no interviewees who have ever participated in the improvement program of the ICT firms. Most of them even don't know how it can be carried out. Hence the ICT firms should think about how to enlarge the influence of their ITS products and inspire more citizens to provide comments and feedback in order to shorten the testing and optimizing period.

4.3 Citizen

Motivation

Most of the citizens who were interviewed for the purpose of this research said they would like to participate in the SC strategy in order to reduce the traffic congestion. Many of them are citizens born in Shenzhen or citizens that have been living in Shenzhen for a long time, they have a deep emotion for the city and they would like to assist with its continuous improvement (e.g. Private vehicle driver 1, May 22, 2019). Some of them indicated that smooth roads makes them feel happy (e.g. Ordinary citizen 1, May 14, 2019). Almost all the citizens would like to participate in the strategy based on their personal values, because they do not perceive the external pressure of the traffic congestion as the main motivation to push them to change. However, based on the interviews, there are still a small number of respondents who mentioned that they will only join the SC strategy if the traffic congestion had a strong impact on their daily life (e.g. Private vehicle driver 6, June 21, 2019).

Cognition

According to the interview, most of the citizens understand the SC policy and ITS from their own experiences of observation and the news released by the government (e.g. Private vehicle driver 6, June 21, 2019). Many of the respondents even haven't heard about these concepts, they complained that the publicity is not sufficient (e.g. Private vehicle driver 3, June 3, 2019). For example, electronic payment is used widely in Shenzhen. However, many of the users don't know if this constitutes a part of the SC strategy.

Resources

During the interviews, most of the citizens complained the limited resources they have to deploy the SC strategy (e.g. Ordinary citizen 1, May 14, 2019). Many of them haven't even heard about the concept of SC or ITS. For those motivated citizens who would like to participate in the strategy implementation, they were also not satisfied with the existing communication channels which are far from enough, especially for those official platforms with high influence (e.g. Private vehicle driver 2, May 11, 2019). Some respondents indicated that when they provide some comments through those "so-called" official accounts, they never received any reply from the government (e.g. Private vehicle driver 4, June 10, 2019). Most of the citizens believed their feedbacks were not seriously taken by the government, which can

also explain why most of the respondents do not want to participate in the construction of the SC or ITS (e.g. Ordinary citizen 2, May 19, 2019). Some respondents mentioned about the use of radio and TV programs as new potential channels to increase awareness and participation in the ITS (e.g. Private vehicle driver 6, June 21, 2019).

Discussion

Citizens have been playing an important role in the SC strategy and ITS, since they are the actual users of smart products and services. In the new SC evaluation index (2018), the government has doubled the weight of citizen experience from 20% to 40%, which highlighted the subjective feelings. In the interviews, some citizens mentioned the same problems. Firstly, moral quality for some citizens is needed for improving. Low personal quality has the negative effect on the promotion of ITS (e.g. Private vehicle driver 7, April 28, 2019). These citizens never follow the rules and reject to receive the new technology and ideas. Meanwhile, people with negative emotion on SC need instruction from the relevant channels/officers to help them understanding. Secondly, some respondents have participated actively to develop the strategy. However, they seldom got any replies from the government or ICT firms (e.g. Private vehicle driver, June 10, 2019). For example, many private car drivers mentioned during the interviews that the way to provide the information to the ITS platform is too strict for them to be able to participate. Even further, they also find the online interface not enough customer friendly to access the information and/or to provide their opinions (e.g. Private vehicle driver, May 11, 2019). If eventually they can send their feedbacks, they never obtain any replies from the ICT firms. Thirdly, some other citizens believe they don't have enough channels for participation. In the personal view from the researcher, maybe some of the citizens take this as an excuse for not participating. All in all, this also indicates that the promotion of SC strategy and ITS are not rooted into the local community.

4.4 Public Transportation Company

Motivation

Public transportation companies are regarded as key stakeholders for the ITS, since promoting the public transportation is an effective way to reduce the traffic congestion (e.g. Public transportation staff, May 15, 2019). In China, most of the public transportation companies are state-owned business, they are, therefore, active players for the SC strategy. Cooperating with the ICT firms might help to improve the management quality for the public transportation companies and consequently increase the service satisfactory rate for the passengers. For those private bus companies, fierce competition can push them to participate in the SC strategy and become more active trying to attract more customers (e.g. Manager of Eastern Bus Group, June 13, 2019).

Cognition

It can be said that public transportation companies have similar level of knowledge about the SC strategy than the ICT firms that were interviewed for this research. It can be, though, that for the state-owned enterprises, things are a little bit different. Since the orientation and function of such kind of firms are not just for making profit, but also for providing public services, which means they need to embed public policy into their operations (e.g. Manager of Eastern Bus Group, June 13, 2019). In other words, the state-owned enterprises can understand and implement the SC policies better, since they are also part of the government.

Resources

As the state-owned businesses, the public transportation companies can get support from the government in order to cooperate with ICT firms in connection to the smart traffic system. The local government instructs and supervises to make sure the company can benefit from ITS to improve its own management quality and provide better public services for the citizens. However, some respondents also mentioned that the traffic congestion cannot be solved only through the implementation of the SC strategy, some municipal works are not reasonable scheduled and construction are not implemented effectively. These later can be major reasons of traffic congestions in some areas in the city. Hence, departments responsible of those municipal works might need to cooperate together with the responsible people of the ITS (Public transportation staff, May 15, 2019).

Discussion

The public transportation companies also have cooperated with ICT firms, this was mentioned during interviews (e.g. Manager of Eastern Bus Group, June 13, 2019). A smart public transportation cloud platform system (Figure 8) has been developed, which has greatly improved the management quality of the companies whilst   it has been providing   convenient services for the citizens. Electronic payment is one of the biggest benefit of the ITS. All the respondents in the interview were satisfied with those payments, since they will not have money change problems or they do not have to make long lines to buy tickets (e.g. Private vehicle driver 4, June 10, 2019). However, many interviewees have mentioned the low accuracy rate of the prediction services given by APP. They complained that sometimes even the bus has already arrived, they still cannot find the information in the APP (e.g. Private vehicle driver 2, May 11, 2019). Some interviewees mentioned that if things continued in this way, more and more citizens will lose their patience and trust in their services. The ICT firms should check the performance of the GPS and other hardware in the buses regularly to make sure they can work and keep smoothly communicating with the ICT firms. In many cases, It is believed that the missing traffic information has something to do with the abnormal function of GPS installed in the bus.

Figure 8. The composition of smart public transportation cloud platform system (Source http://www.sohu.com/a/286985743_99949100)

Chapter 5: Conclusions

This chapter presents the conclusions that can be drawn from the information gathered during this research, the previous chapter of discussion, as well as related theories and information elaborated in the literature review, which is used to answer the sub-questions of this research. The sub-questions were used to structure the conclusions section with sub-header. In the end, the main question will also be responded.

5.1 Sub-question 1: What's the current situation of traffic congestion in Shenzhen?

Traffic congestion has been a serious problem in China in its fast transformation to urbanization. Shenzhen has implemented Chinese economic policy for more than 40 years, which has created a miracle, it is also inevitable to face some "urban diseases", such as traffic congestion, travel and parking problems. In the year 2018, the population of Shenzhen has reached 21 million, and the vehicle inventory has become more than 3.35 million. Because of the policy of banning motorcycles since 2016 for safety reasons, the number constitutes only cars. Furthermore, the vehicle density is up to 510 units per kilometer, which is not only ranking the first place in China, but also far exceed International Warning Line. While the number of traffic police in Shenzhen is only 1900, the contradiction of citizen, vehicle and road is becoming increasingly standout (ITS 114, 2018).

So for the past few years, China has committed to reduce the traffic congestion with promoting ITS implementation, facilitating public transportation, and furthering construction of infrastructure. According to the data released by the Shenzhen Transport and Communication Commission, In the year 2017, the total number of passengers of public transportation has reached 3744 million, including 1650 million from rail traffic, 1654 million from regular bus, the passengers volume from taxi is as high as 370 million, and the left 60 million is from other urban road passenger transports. The public transportation in Shenzhen is operated with high efficiency, which accounts for 57.4% of the total public transportation volume. According to the annual report released by Amap, the Congestion Delay Index was reduced by 2.45% in China's

major cities (Amap, 2018). Shenzhen, as the leading city with smart transportation technology, has experienced an improvement of traffic congestion reduction. And ranked 46 for traffic congestion, maintaining the trend of continuous decline.

As for the individual experience, subjective effects have a strong influence based on different interviewees. Most of the interviewees who participated in this research did not experience many changes for the traffic situation in Shenzhen as an effect of the SC strategy, since they still spend a lot of time travelling in peak hours. Even further, some users feel like the traffic congestion is getting worse. While others believe it is getting better. They also admitted that there are other external factors, e.g. the location of their works and homes, the transportation they choose, that should influence their perceptions. On the other hand, and according to the report released by Amap and transportation statistic from the government, the traffic situation in Shenzhen has improved as a whole. The public transportation is accounted for nearly 60% of the total transportation volume, which means more citizens would like to choose public transportation, especially metro. This increase might help to reduce the road traffic flow significantly and lead to reduce the traffic congestion effectively.

5.2 Sub-question 2: Who are the actors (government, enterprise, citizen) involved in the smart city construction regarding the transportation service upgrading in Shenzhen?

Based on the literature review and the interviews conducted during this research, it could be observed that many different kinds of entities are involved to contribute to the SC strategy that aims to deal with traffic congestions in Shenzhen. From the governmental authorities, the China's central government, Shenzhen Municipality, the transportation department were considered in this work because they are responsible for the policy elaboration and implementation and the provision of smart traffic systems. ICT companies and related research organizations were also included in this research because they are key players for advanced technology deployment which is a crucial component of the ITS. Shenzhen traffic police has

established 26 teams for innovation, and has set up joint labs in the field of AI and Biometric Identification Technology, such as traffic light control and video application, which gradually established a new management system with Shenzhen traffic police playing the leading role and other firms participating actively (ITS 114, 2018). Ping An Tech, Huawei, Amap as well as Tencent are key players in the smart traffic filed. Without a doubt, citizens play a very important role in the SC strategy deployment, since they are the ultimate beneficiaries; the goals of the strategy are formulated in terms of *convenience and efficiency* for the citizens that make the city more livable. Public transportation firms act as the other key stakeholder. For reducing the traffic congestion, it is important to promote better public transportation, which means public transportation company should become smarter in order to attract more citizens to take public transportation as their first travel mode. Perhaps other stakeholders, such as consultancies, NGOs etc. are also relevant. Since they are not regarded as the major stakeholders, so they were not discussed in this project.

5.3 Sub-question 3: What are the actors doing to enable Shenzhen successful transition to smart city regarding solving the traffic congestion issues?

The central government has issued several related policies of SC construction, such as specific plans, pilot projects etc. (ISTIS, 2018). In the transportation sector, the Ministry of Transportation has released the Smart Transportation Action Plan (2017-2020), which focuses on the integration of new generation of ICT and transportation service in order to reduce traffic congestion and improve transport efficiency. The Municipality of Shenzhen has responded to the call of central government, and has posed the Overall Scheme of New Smart City in 2017, which can be seen as a programmatic document guiding the construction of SC of Shenzhen. According to the interviews of the staff in Shenzhen Transport and Communication Commission, the government has been working on different initiatives to construct smart transportation structures in Shenzhen, some examples of those are: the information exchange platform; integrated monitor system; traffic operational command system; transportation management system; traffic overall regulatory system; traffic management and damage control system and; public travel information service, among others. Because ITS is the key element

for the smart transportation, then the government also has closely cooperated with the ICT firms, especially with those leading ICT firms in Shenzhen. Generally speaking, cooperation the government wants to increase the smart surveillance ability for the transportation industry, as well as to improve the quality of convenient service for the public. By optimizing the transportation resources and promoting public transportation to decrease the amount of vehicles on the roads, all that put together is expected to reduce the traffic congestion. Ping An Tech has cooperated with Shenzhen Transportation Commission and Public Security Bureau for the public transportation and traffic related pilot projects (Manager in Ping An Tech, May 25, 2019). Big data, block chain, IoT and AI technologies are regarded as the core technology for smart traffic solutions. With the support of AI, image identification can realize multi-scene monitor with high accuracy, which will push the drivers to better obey the traffic rules. Block chain technology can establish the electronic driver license which can record the driving data and information. Big data and cloud computing can deploy and analyze the resources, which will contribute to reduce the number of vehicles on the roads. Smart roadside parking system is a good pilot project in Shenzhen, with the combination of different technologies, such as RF (radio frequency technology), cellphone communication service and automatic monitoring technology for berth. This platform can provide real-time parking information to citizens and the upgraded electronic payment technology will deduct the parking fee automatically. The infrastructure of roads also contribute to the smart strategy. According to the interview, many newly built roads are constructed based on the vehicular network technology and applications. The most familiar traffic application developed by the ICT firms are Amap and Baidu map which can help the citizens plan the route   and forecast the time needed. There are also some other applications or platforms that the ICT companies worked upon, which have the indirect contribution to reduce the traffic congestions, such as the efficiency for dealing with the traffic accidents and the increasing hot line call completing rate. Some ICT firms also have worked with public transportation companies for promoting the public transportation among citizens, as well as, improving the management for the public transportation companies in Shenzhen.

Almost all the citizens are satisfied with electronic payment for transportation services. With the establishment of ITS, all citizens in the interview have felt the convenience for their daily life. Some citizens have tried to upload the traffic congestion situation by APP, which will help the government and the ICT companies to collect data(e.g. Private vehicle driver 2, May 11, 2019). Some citizens have tried to provide the traffic situation through Shenzhen Communication Radio, in order to share the traffic information with others. The radio platform is also a good channel for the transportation department to collect the traffic feedbacks and solve the traffic problems for the citizens (e.g. Private vehicle driver 6, June 21, 2019). Some citizens also have reported someone who violated traffic rules via the official account , such as illegal parking which will cause traffic congestion (e.g. Private vehicle driver 2, May 11, 2019). According to the interview, mangy of the respondents don't fully understand the meaning of SC strategy and ITS, even if they have already observed the advantage of smart traffic services (e.g. Ordinary citizen 2, May 19, 2019). They hold their opinions that obeying the traffic rules and choosing public transportation as much as possible are the best ways to reduce the traffic congestion. Some old citizen said they know nothing about advanced technology for SC strategy, what they can do is that they try not to go out in the peak time (e.g. Private vehicle driver 6, June 21, 2019) .

Other stakeholders, like the public transportation companies are also key players for the SC strategy to solve the traffic congestion. According to the staff of the transportation firms, they are working closely with the ICT firms. They have strong confidence of reducing the traffic congestion with the promotion of ITS. The companies are experiencing the transition from the traditional transport companies to smart transportation firm. And they have adopted many new ideas, such as smart public transportation cloud, inquiry and answer system for bus driver and so on, which will improve the management quality for the transportation company inside (Manager of Eastern Bus Group in Shenzhen, June 13, 2019). Shenzhen Eastern Bus Co., Ltd cooperates with the ICT firms to develop new services, including bus-hailing service, real-time information release, as well as electronic payment etcetera. With the technology of big data

and cloud computing, the company will increase the resource utilization. At the same time, it will provide better service for citizens to promote public transportation.

5.4 Sub-question 4: What are the challenges to solve the traffic congestion as part of the smart city strategy in Shenzhen?

The challenges for solving the traffic congestion problem with a SC strategy arose from statements during the interviews, which are also combined with literature review as well as the researcher's personal experiences. According to the interview with the citizens in Shenzhen, the insufficient promotion of a SC strategy is a big challenge for the participation of citizens. Since many of the interviewees haven't heard of the name of SC. Even for those have heard about the name of SC, most of them don't have a deep understanding of the meaning (e.g. Private vehicle driver 3, June 3, 2019). During the interview, some citizens also indicated insufficient incentives from the government and other organizations as other key barriers for their participation (e.g. Private vehicle driver 2, May 11, 2019). In their opinion, self-motivated behavior cannot last long without enough external drive. Moreover, many respondents complained because of insufficient platforms, especially official platforms for their participation. Even if citizens have provided the feedbacks on the traffic issues, they do not get a reply. And most of citizens believe there's not much influential effect for the other channels compared with the official channels. So they don't want to waste their time. In addition, for some platforms (e.g. APP), the rules are too strict for citizens to follow. Their applications are hard to be approved, such as sharing the traffic situation or providing the evidence of complaint by uploading through APP. Some citizens complained the rules are not reasonable, it would trigger safety problems if they truly follow the rules. Sometimes they have no choice but giving up, even if they want to participate in first place. Some citizens take the low moral quality of drivers and walkers (e.g. Ordinary citizen 1, May 14, 2019), who don't follow the traffic rules are also the challenges for other citizens to obey the rules of ITS. From the policy perspective, smart city strategy needs the support of the government. However, some municipal works regarding to the traffic congestion reduction in Shenzhen are not scheduled reasonable and some projects are not ongoing effectively. From the technology perspective, some functions

of ITS are not mature enough, such as car networking software, which is difficult to truly play a role in reducing the traffic congestion. According to the manager 2 from the ICT firm (May 25, 2019), the smart products and services need long time for testing and optimizing before put into use of ITS, which will decrease the efficiency for dealing with the traffic issues.

5.5 Sub-question 5: What are the prioritized challenges to be addressed in Shenzhen to solve the traffic congestion in smart city strategy?

According to the frequency of the mention from respondents, the impact on the process of SC strategy as well as the logical analysis of the researcher, there are two prioritized challenges for solving the traffic congestion in Shenzhen. Firstly, the insufficient promotion of the SC strategy in Shenzhen. Although many respondent in the interviews have mentioned the insufficient platforms for the SC strategy to reduce the traffic congestion (e.g. Private vehicle driver 4, June 10, 2019), but the source of the problem is most of citizens are not familiar with the related channels. Many of them even don't know the concept of SC. Consequently, they will not pay attention to the related platforms or take them as means for SC at all. The key problem is that the promotion of SC strategy is not enough in Shenzhen. Secondly, the rules set for participating the ITS by some APPs are not reasonable, and the citizens don't get enough respect from the authority, which seriously hindered the motivation of citizens for participating. The current major channels to provide feedbacks to government or ICT firms for citizens are through APP or online platforms. However, the rules for uploading files to related APP, such as Amap and Baidu Map, are not customer friendly at all. Many citizens will give up because of it (Private vehicle driver 2, May 11, 2019). Meanwhile, according to the interview none of the citizens that have ever provided complains or suggestions got any reply from it, which will strongly discourage citizens from participating in the SC strategy to solve the traffic congestion, since they thought they never got any attention at all.

5.6 Sub-question 6: What are the strategies to accommodate the prioritized challenges to solve traffic congestion situation in Shenzhen?

The government or related stakeholders should promote solution of traffic congestion through SC strategy among local community, especially by strengthening the concept of the SC strategy and make citizens understand the concept of it (Ordinary citizen 1, May 14, 2019). Carrying out promotional activities in grassroot communities and promote the use of ITS related applications, such as distributing brochures, organizing games to promote ITS etc. Establishing a specified department to collect the feedbacks from citizens, which is better to have offices in different community units (Private vehicle driver 4, June 10, 2019). Above all, the department or related subsidiary offices must be responsible for replying to all concerns raised by the citizens. For those valuable suggestions, the government should reward the individuals. In this way, more citizens might be motivated to participate in the SC strategy in Shenzhen and more valuable information can be absorbed by the government or other stakeholders for better optimizing the ITS and developing SC strategy (Private vehicle driver 2, May 11, 2019).

The ICT firms, especially those with major APPs for smart traffic also are suggested to work with the government and citizens closely. They might want to join the government projects for ITS and accept suggestions or complains from the citizens with an open mind. ICT firms are suggested to act as a bridge between the government and citizens. Understand the citizens' demand for traffic issues and the current problems for participating through the companies' application, update and upgrade their applications timely (Public transportation manager, May 25, 2019). Meanwhile, it is possible to combine the government requirements of ITS in SC strategy, advanced smart traffic technology and the need from citizens, in order to develop services or products that satisfy citizens which are in line with the SC development (Public transportation staff, 15 May, 2015).

5.7 Sub-question 7: What types of transportation service applications can be associate with solving the traffic congestion in Shenzhen?

Shenzhen Municipality has established ITS to reduce traffic congestion. GPS monitoring platform has been built for the public bus system, which is convenient for citizens to check the

location of the bus and save much time waiting for the bus, and it is also good for the management of the public transportation company.

The smart road projects in Shenzhen have combined intelligent signal control system and intelligent supervision system, which can realize traffic automatically control, increase the passing efficiency of the intersection and regulate the traffic order. Meanwhile, the smart street light will provide public free WIFI and dynamic traffic service information through electronic screen.
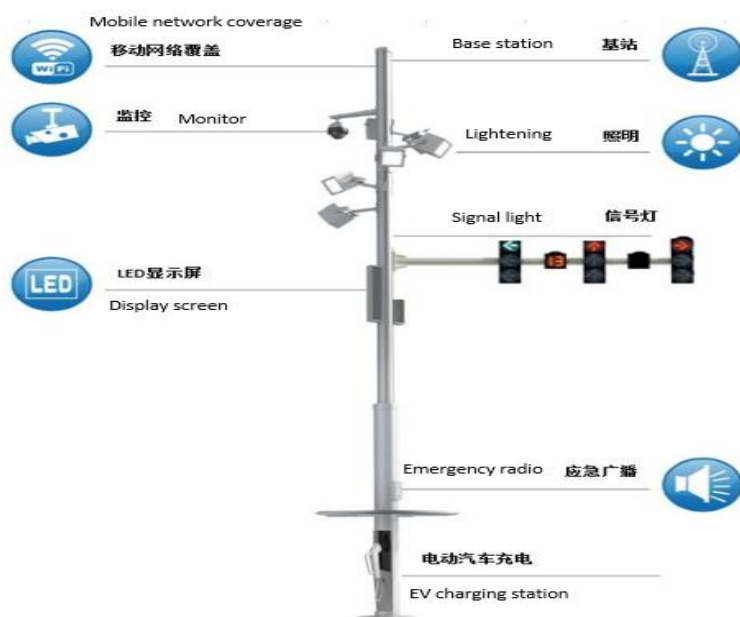
Figure 9. The function of smart street light (Source: https://www.qianzhan.com/analyst/detail/220/181107-9ea8fcca.html)

Almost all the public transportation in Shenzhen has upgraded electronic payment system, popular channels like Union Pay and WeChat can be used to pay the fee. Meanwhile, the government and the public transportation companies are working with ICT firms to develop APP for predicting bus waiting time. This initiative is set up to reduce the traditional waiting time and promote more citizens to choose public transportation. Some other APPs, such as Amap and Baidu Map can also provide the real-time traffic information and select the optimal route for customers.

The traffic reservation system has been put into use in Shenzhen since last year. Three vehicle reservation scenarios (i.e. large-scale event reservation, road capacity reservation and scenic spot entry reservation) can be realized with the help of big data and AI technology. The technology can recognize the registered vehicle plate number, which will largely reduce the traffic volume during the holiday period.

5.8 Main research question: How can the smart city strategy contribute to reduce the traffic congestion in Shenzhen?

SC strategy might require a multilevel and multi-actor synchronized effort and each actor might need to bring his/her own knowledge, expertise, resources to achieve a common goal. Smart traffic (ITS) is one of the important elements of the SC strategy in Shenzhen. In general, it can be said that ITS has taken the advantage of advanced technology, such as big data, AI, cloud computing, blockchain, IoT etcetera. Although there's no specified technology that is developed for SC strategies, the combination of these technologies can provide creative solutions to traffic congestions in Shenzhen. To deploy such strategies, different stakeholders are required to full fil different tasks for contributing to ITS. In particular, the government is responsible for issuing related policies and cooperate with ICT firms for constructing smart infrastructure in Shenzhen. The government should also promote the concept of SC strategy and ITS at the grassroots community level, encouraging and instructing citizens to follow the rules of ITS and actively participate in the strategy implementation. Different kinds of channels and specific offices are to also be established to collect and analyze feedbacks of citizens, valuable suggestions should be rewarded as well in order to give incentives to the participants. The ICT firms need to work closely with other stakeholders, understand the long-term plan of the government and the demand of their customers, keep optimizing their smart products and services and make them customer friendly, especially those applications that need the participation of the public. Even further, ICT firms are suggested to do more research and try to learn new ideas and technology from other countries which can be used into the smart projects in Shenzhen. As for the citizens, their own personal qualities are needed to be improved, such as obeying the traffic regulation, trying to use public transportation as much as

possible. SC strategy and ITS is not the task only to the government and ICT firms, regular citizens are also responsible for creating a healthy traffic situation for the whole city. They are suggested to accept the new ideas and new services, join the SC construction positively. Put forward their own suggestions on traffic congestion and work with the government and ICT firms through different channels.

Chapter 6. Recommendations for further research

During this research, a plethora of information was gathered and analyzed which was needed for addressing the research questions. Despite the researcher could overtake different issues while gathering the information, the author could identify several opportunities to either improve this work or go more in depth in its analysis and development. Hence, this chapter presents some recommendations for both, stakeholders who are involved in the SC strategy for traffic congestion reduction and for researchers who would like to continue carrying out research on this topic.

6.1 Recommendation to Practitioners

According to the interviews, many respondents (13/25) are not familiar with the concept of SC and ITS. This was observed in spite of them being young and being well-educated, which can easily explain the results that not many citizens join the smart traffic program actively in Shenzhen. Since the government policies are not fully transparent in China, Shenzhen Municipality is responsible to explain the key plan and intention of SC strategy to the local community. And promote the participation of citizens from the grassroot level, appreciate all the feedbacks from them and give them reply which will makes the participants feel they are being taken seriously.

It is better for the ICT firms to work closely with the government, citizens and related research organizations to develop more smart solutions to reduce traffic congestion. Many interviewees complained the results of traffic APP are not accurate and some functions are not customer friendly, which have the negative effects for the public to participate the ITS. Moreover, citizens are the end-users of the smart products and services, their user-experiences will be valuable for the ICT firms to reduce their testing and optimizing time. The feedbacks from the citizens should be valued by the ICT firms.

As for citizens, although many of them claim that they would like to join the SC strategy, the reasons that they haven't join is because they don't have enough resources, or the incentives are not strong enough. According to the interview, the respondents (Public transportation staff, May 15, 2019) mentioned the low moral quality of citizens hinders the spread of SC strategy, so the citizens should increase their personal moral quality, obey the basic traffic rules and ITS rules, take reducing the traffic congestion as one of their tasks as well (e.g. Private vehicle driver 7, April 28, 2019). In this way, they will have deep understanding of these smart related concepts better. Many respondents in the interview have expressed their great affection to Shenzhen (e.g. Private vehicle driver, May 22, 2019), since they are born or living here for long time. Actually, as a part of the city, everyone in Shenzhen is responsible for making the city better, not just the government or some ICT firms. In the public administration field, the conceptual research has been conducted which highlighted the value of citizen-centered analysis in smart cities (Ju et al., 2018). Citizens' opinions are valuable for the application of the ITS, as well as the whole SC strategy. Only people with smart behavior that can truly create SC (Public transportation staff, May 15, 2019).

6.2 Suggestions for Further Research Work

During the data collection, it was not possible to contact some of the key stakeholders, such as the staff from the research organization on the topic of SC and the government from provincial and central level. The research organization can provide systematic knowledge of SC and the practical implementation of the strategy in Shenzhen, especially in the traffic section, since they have been working on the topic for long time. Having the interview with the higher-level government could have helped the researcher to understand the policy and the new idea on SC deeply. Moreover, they could also provide the information and data from other cities, which could be used to compare with the situation in Shenzhen. For the future research, I suggest that the stakeholders should be contacted immediately. Given the actual conditions

in China, email contact should be abandoned, since email is not used widely in China. Indirect approach from the current participants to reach others is an effective measure, especially for the higher-level government.

For the content perspective of the research, given my limited time and resources, I cannot collect data and information from cities outside of Shenzhen. However, for further research, it is better to have some other case studies in different cities with the similar population and economy as Shenzhen, in order to compare the effectiveness of SC strategy on the traffic congestion and give effective suggestion for better implementation the strategy in China.

Since it is hard to conduct the poll or survey individually in China, it is better to cooperate with other organizations, if possible to get a large amount of data on the SC strategy and ITS on the traffic congestion. It was mentioned that the government and organizations are doing it, but it was not possible to contact them. Although deep conversations with many related key stakeholders were conducted, surveys applications to cover the citizens' opinions on this topic is highly recommended in future research. However, exploring the relationship between the SC strategy and reduction of traffic issues is one of the priorities in this research, so the respondents should fully understand these concepts in advance, in order to give more clear and effective feedbacks.

Acknowledgements

I would like to express my sincere thanks to my first supervisor Dr. Laura Franco, who provide feedback and guidelines during this research period. As a non-native English speaker, language was a challenge for my thesis. I was so touched that Laura is so patient and rigorous, apart from professional suggestions, she helped me to grammatically revise my thesis . Laura has motivated me to keep deadlines in order to finish my thesis as planned. I would also want to say thank you to my second supervisor Dr. Victoria Daskalova. She always pointed out the problems in my research sharply, her suggestions were very direct and instructive. Her clear ideas have brought me many new thoughts as well.

I really appreciate all the help from my friends, they provide me a lot of resources on my research and put me recommend me to communicate with some important stakeholders, such as the transportation department in Shenzhen, managers in ICT firms and public transportation company etc. Without their help, I would have not been able to collect enough information and data for my research. And for those interviewees, their information and opinions are really valuable for me to analyze their perceptions about the effectiveness of SC strategy and effects on traffic congestions. Their suggestions turned to be very creative for solving the traffic issues in the future.

I would also want to say thank you to my parents. During my time in Twente University, they give me a lot of support, both spiritual and material. It is them that teach me how to be tough and brave. It is them that makes me not feel lonely in a foreign country. I love them so much. They are very special for me and I am and will be always very proud of them.

References

Abaker, I., Hashem, T., Chang, V., Badrul, N., Adewole, K., Yaqoob, I., … Chiroma, H. (2016). International Journal of Information Management The role of big data in smart city. International Journal of Information Management, 36(5), 748–758. https://doi.org/10.1016/j.ijinfomgt.2016.05.002

Agyapong, F., & Ojo, T. K. (2018). Managing traffic congestion in the Accra Central Market , Ghana. Journal of Urban Management, 7(2), 85–96. https://doi.org/10.1016/j.jum.2018.04.002

Ahvenniemi, H., Huovila, A., Pinto-Seppä, I., & Airaksinen, M. (2017). What are the differences between sustainable and smart cities? Cities, 60, 234–245. https://doi.org/10.1016/j.cities.2016.09.009

Allam, Z., & Dhunny, Z. A. (2019). On big data , artificial intelligence and smart cities, 89(January), 80–91. https://doi.org/10.1016/j.cities.2019.01.032

Amap. (2018). Traffic Analysis Report of Major Cities in China. Retrieved from http://cn-hangzhou.oss-pub.aliyun-inc.com/download-report/download/quarterly_report/18Q1/Traffic Analysis Report 2018Q1.pdf

Amsterdam University. (n.d.). Artificial Intelligence. Retrieved from http://www.uva.nl/shared-content/programmas/en/masters/artificial-intelligence/artificial-intelligence.html?1552572041608

Atta, A., Abbas, S., Khan, M. A., Ahmed, G., & Farooq, U. (2018). An adaptive approach : Smart traffic congestion control system. Journal of King Saud University - Computer and Information Sciences. https://doi.org/10.1016/j.jksuci.2018.10.011

Borsekova, K., Koróny, S., Vaňová, A., & Vitálišová, K. (2018). Functionality between the size and indicators of smart cities: A research challenge with policy implications. Cities, 78(June 2017), 17–26. https://doi.org/10.1016/j.cities.2018.03.010

Bowerman, B., Braverman, J., Taylor, J., Todosow, H., & Wimmersperg, U. (2000). The vision of a smart city. 2nd International Life Extension Technology Workshop (Paris).

Bressers H, O'Toole LJ Jr (2005) Instrument selection and implementation in a networked context. In: Elidas P, Hill MM, Howlett M (eds) Designing governmen t. From instruments to governance. McGill-Queen's University, Montreal, pp 132–153

Bressers, H., Bressers, N., Kuks, S., & Larrue, C. (2016). The Governance Assessment Tool and Its Use. https://doi.org/10.1007/978-3-319-29671-5

Bressers, J. T. A. (2004). Implementing sustainable development: how to know what works, where, when and how. In Governance for Sustainable Development: The challenge of adapting form of function (pp. 284-318). Cheltenham: Edward Elgar.

China Daily. (2019). China Driving Smart Traffic Development. Retrieved from http://global.chinadaily.com.cn/a/201806/13/WS5b207426a31001b825720389.html

CHINACITY. (2010). Traffic Congestion. Retrieved from http://www.chinacity.org.cn/csfz/cshj/62056.html

CHTF. (2019). The Introduction of CHTF. Retrieved from http://www.chtf.com/liaojiegaojiaohui/zynr/gaikuang/

Dalian Development and Reform Commission. (2019). City Evaluation Index（2018）. Retrieved from http://www.pc.dl.gov.cn/html/WenHaoTongZhiTongGao/df1bb86833794c40899e4f72e0c48175.html

Dall'O, G., Bruni, E., Panza, A., Sarto, L., & Khayatian, F. (2017). Evaluation of cities' smartness by means of indicators for small and medium cities and communities: A methodology for Northern Italy. Sustainable Cities and Society, 34(July), 193–202. https://doi.org/10.1016/j.scs.2017.06.021

Dameri, R. P., Benevolo, C., Veglianti, E., & Li, Y. (2018). Understanding smart cities as a glocal strategy: A comparison between Italy and China. Technological Forecasting and Social Change, (July), 1–16. https://doi.org/10.1016/j.techfore.2018.07.025

Fortune. (2019). How China's top-down political system holds it back. Retrieved from https://fortune.com/2019/05/18/how-chinas-top-down-political-system-holds-it-back/

Gladys Frame, Arturo Ardila-Gomez, and Yang Chen (2017). The kingdom of the bicycle : what Wuhan can learn from The kingdom of the bicycle : what Wuhan can learn from Amsterdam. Transportation Research Procedia, 25, 5040–5058. https://doi.org/10.1016/j.trpro.2017.05.203

Goggin ML (1986) The 'too few cases/too many variables' problem in implementation research. Polit Res Q 39(2):328–347

Gu, C., Wu, L., & Cook, I. (2012). Progress in research on Chinese urbanization. Frontiers of Architectural Research, 1(2), 101–149. https://doi.org/10.1016/j.foar.2012.02.013

INRIX. (2018). Interactive Ranking & City Dashboards. Retrieved from http://inrix.com/scorecard/

INRIX. (2019). Global Traffic Scorecard.

Ismagilova, E., Hughes, L., Dwivedi, Y. K., & Raman, K. R. (2019). Smart cities: Advances in research—An information systems perspective. International Journal of Information Management, 47(December 2018), 88–100. https://doi.org/10.1016/j.ijinfomgt.2019.01.004

ISO 37120:2018 (en). (2018). Retrieved from https://www.iso.org/obp/ui/#iso:std:iso:37120:ed-2:v1:en

ISTIS. (2018). Promotion Policies of Smart City in China. Retrieved from http://www.istis.sh.cn/list/list.aspx?id=11315

ITS 114. (2018). Innovative Practice of ITS in Shenzhen. Retrieved from https://www.sohu.com/a/272246175_649849

Ju, J., Liu, L., & Feng, Y. (2018). Citizen-centered big data analysis-driven governance intelligence framework for smart cities. Telecommunications Policy, 42(10), 881–896. https://doi.org/10.1016/j.telpol.2018.01.003

Kostakis, V., Bauwens, M., & Niaros, V. (2009). The Emergence of Peer-to-Peer Infrastructure : Four Future Scenarios with an Impact on Smart Cities, 116–124.

Kunzmann, K. R. (2014). Smart Cities : a New Paradigm of Urban Development. CRIOS Critiwues, 7, 9–19.

Liu, L. (2018). ScienceDirect Science Direct IoT and A Sustainable City feasibility of using the heat demand-outdoor temperature function for a long-term district heat demand forecast. Energy Procedia, 153, 342–346. https://doi.org/10.1016/j.egypro.2018.10.080

MIIT. (2016). IoT Development Plan (2016-2020). Retrieved from
http://www.shxca.gov.cn/n596033/n596103/n604015/n623995/c656968/part/656970.pdf

MIIT. (2017). Three-Year Action Plan for Cloud Computing Development (2017-2019). Retrieved from
http://dqs.ndrc.gov.cn/dlkjxx/201707/t20170731_856764.html

MIIT. (2017). Tree-Year Action Plan for Promoting AI Industry Development (2018-2020). Retrieved from
http://www.miit.gov.cn/newweb/n1146290/n4388791/c5960863/content.html

Ministry of Transportation (2017). Better Trip with Smart Transportation Action Plan. Retrieved from
http://zizhan.mot.gov.cn/zfxxgk/bnssj/kjs/201709/t20170926_2919414.html

Ministry of Transportation (2017). Smart Transportation Action Plan. Retrieved from
http://zizhan.mot.gov.cn/zfxxgk/bnssj/zhghs/201702/t20170213_2163996.html

MNR. (2019). Technical Program of Spatiotemporal Big Data Platform Construction in Smart Cities (2019).
Retrieved from http://gi.mnr.gov.cn/201902/t20190218_2395831.html

MPS. (2018). The Motor Vehicle Population Has Reached 325 Million in China. Retrieved from
http://www.mps.gov.cn/n2255079/n2256030/n2256031/c6314462/content.html

National Development and Reform Commission, (2016). City Evaluation Index (2016). Retrieved from
http://www.ndrc.gov.cn/zcfb/zcfbtz/201611/W020161128608245432911.pdf

National People's Congress. (2007). Urban and Rural Planning Law of the People's Republic of China. Retrieved
from http://www.npc.gov.cn/englishnpc/Law/2009-02/20/content_1471595.htm

NDRC. (2014). Guidance for Promoting Healthy Development of Smart Cities. Retrieved from
http://www.ndrc.gov.cn/gzdt/201408/t20140829_624003.html

NDRC. (2014). The Guidance on Promoting Healthy Smart City Development (p.1). Retrieved from
http://www.sdpc.gov.cn/gzdt/201408/W020140829409970397055.pdf

Newman, K. (2019). Cities With the World's Worst Traffic Congestion. Retrieved from
https://www.usnews.com/news/cities/articles/2019-02-12/these-cities-have-the-worlds-worst-traffic-congestion

Nowicka, K. (2014). Smart City logistics on cloud computing model. Procedia - Social and Behavioral Sciences,
151, 266–281. https://doi.org/10.1016/j.sbspro.2014.10.025

Odendaal, N. (2003). Information and communication technology and local governance: Understanding the
difference between cities in developed and emerging economies. Computers, Environment and Urban Systems,
27(6), 585–607.

People.cn. (2018). Traffic First Promote the Construction of Smart City. Retrieved from
http://leaders.people.com.cn/n1/2018/1206/c128280-30447416.html

Quora. (2017). What is the relationship between big data, IoT, and cloud computing? Retrieved from
https://www.quora.com/What-is-the-relationship-between-big-data-IoT-and-cloud-computing

Rathore, M. M., Paul, A., Hong, W., Seo, H., & Awan, I. (2018). Exploiting IoT and big data analytics : Defining Smart Digital City using real- time urban data. Sustainable Cities and Society, 40(November 2017), 600–610. https://doi.org/10.1016/j.scs.2017.12.022

Riva Sanseverino, E., Riva Sanseverino, R., & Anello, E. (2018). A Cross-Reading Approach to Smart City: A European Perspective of Chinese Smart Cities. Smart Cities, 1(1), 26–52. https://doi.org/10.3390/smartcities1010003

Ruhlandt, R. W. S. (2018). The governance of smart cities: A systematic literature review. Cities, 81(October 2017), 1–23. https://doi.org/10.1016/j.cities.2018.02.014

S. Hess, G. S., Evensen, K., Festag, A., Weber, T., Cadzow, S., & M. Arndt, A. W. (2009). Towards Standards, 2009(November), 1–8.

Sansaverino, E. R., Sansaverino, R. R., Vaccaro, V., & Zizzo, G. (2014). Smart rules for smart cities: Managing efficient cities in euro-Mediterranean countries. Springer International Publishing Switzerland.

Shen, L., Huang, Z., Wong, S. W., Liao, S., & Lou, Y. (2018). A holistic evaluation of smart city performance in the context of China. Journal of Cleaner Production, 200, 667–679. https://doi.org/10.1016/j.jclepro.2018.07.281

SHENZHEN CHINA. (2018). Overall Scheme of New Smart City. Retrieved from http://www.shenzhen.gov.cn/zfgb/2018/gb1062/201807/t20180730_13798766.htm

Smart City Expo World Congress. (2018). Smart City Expo World Congress will focus on citizen empowerment on its biggest edition. Retrieved from http://www.smartcityexpo.com/en/home#

SOHU. (2010). Serious Urban Disease in China. Retrieved from http://news.sohu.com/20100405/n271331523.shtml

SOHU. (2017). Basic Science Research. Retrieved from http://www.sohu.com/a/125670954_610722

SOHU. (2017). Supporting Technologies of Smart City. Retrieved from http://www.sohu.com/a/202847936_100018121

SOHU. (2018). China's overall smart city evaluation index system will be preliminarily established in 2018. Retrieved from https://www.sohu.com/a/224323811_240918

State Council of the People's Republic of China (2013). Opinions on Further Strengthening Government Information Disclosure that Responding to Social Concerns in order to Raise Government Credibility. Retrieved from http://www.gov.cn/zwgk/2013-10/15/content_2506664.htm

State Council of the People's Republic of China (2014). National New-type Urbanization Plan (2014-2020). Retrieved from http://www.51baogao.cn/uploads/xinxingchengzhenhua(2014-2020).pdf

State Council. (2014). National Plan for New Urbanization. Retrieved from http://www.gov.cn/zhengce/2014-03/16/content_2640075.htm

State Council. (2015). Opinion on Promoting the Innovative Development of Cloud Computing. Retrieved from http://www.gov.cn/zhengce/content/2015-01/30/content_9440.htm

Stathopoulos, A., & Karlaftis, M. G. (2003). A multivariate state space approach for urban traffic flow modeling and prediction, 11, 121–135. https://doi.org/10.1016/S0968-090X(03)00004-4

Statista. (2016). Internet of Things - number of connected devices worldwide 2015-2025. Retrieved from https://www.statista.com/statistics/471264/iot-number-of-connected-devices-worldwide/

Subramanian, N., & Jeyaraj, A. (2018). Recent security challenges in cloud computing. Computers and Electrical Engineering, 71(July 2017), 28–42. https://doi.org/10.1016/j.compeleceng.2018.06.006

TOMTOM. (2016). Traffic Index in Shenzhen. Retrieved from https://www.tomtom.com/en_gb/trafficindex/city/shenzhen

UN. (2018). SDG11. Retrieved from https://www.un.org/sustainabledevelopment/cities/

UNDP CHINA. (n.d.). Smart Cities and Social Governance. Retrieved from http://www.cn.undp.org/content/dam/china/docs/Publications/Smart Cities and Social Governance-EN.pdf

UNDP. (2015). RETHINKING SMART CITIES. Retrieved from https://www.researchgate.net/publication/298647532_Rethinking_Smart_Cities_ICT_for_New-type_Urbanization_and_Public_Participation_at_the_City_and_Community_Level_in_China

WCCD. (2018). ISO 37120. Retrieved from http://open.dataforcities.org/

Wong, Z. S. Y., Zhou, J., & Zhang, Q. (2019). Artificial Intelligence for infectious disease Big Data Analytics. Infection, Disease & Health, 24(1), 44–48. https://doi.org/10.1016/j.idh.2018.10.002

World Bank. (2018). Reducing Traffic Congestion and Emission in Chinese Cities. Retrieved from https://www.worldbank.org/en/news/feature/2018/11/16/reducing-traffic-congestion-and-emission-in-chinese-cities

WSP. (n.d.). ITS. Retrieved from https://www.wsp.com/en-RO/services/intelligent-transportation-systems-its

Wu, Y., Shen, J., Zhang, W., Peng, Y., & Mo, Z. (2017). Smart city with Chinese characteristics against the background of big data: Idea, action and risk. Journal of Cleaner Production, 173, 60–66. https://doi.org/10.1016/j.jclepro.2017.01.047

Xinhua. (2016). The National 13th Five-Year Plan. Retrieved from http://www.xinhuanet.com//politics/2016lh/2016-03/17/c_1118366322.htm

Yao, Y., Hong, Y., Wu, D., Zhang, Y., & Guan, Q. (2018). Estimating the effects of "community opening" policy on alleviating traffic congestion in large Chinese cities by integrating ant colony optimization and complex network analyses. Computers, Environment and Urban Systems, 70(August 2017), 163–174. https://doi.org/10.1016/j.compenvurbsys.2018.03.005

Yigitcanlar, T., Lee, S.H., (2014). Korean ubiquitous-eco-city: a smart-sustainable urban form or a branding hoax? Technol. Forecast. Soc. Chang. 89, 100–114.Yigitcanlar, T., Yun, J. J., Kamruzzaman, M., Buys, L., da Costa, E. M., Ioppolo, G., & Sabatini-Marques, J. (2018). Understanding 'smart cities': Intertwining development drivers with desired outcomes in a multidimensional framework. Cities, 81(November 2017), 145–160. https://doi.org/10.1016/j.cities.2018.04.003

Appendices

Appendix 1. Questionnaire for Citizen

Interview Statement

Dear respondent,

I am a student from University of Twente and I am conducting this survey for collecting data and information for my master thesis in Environmental and Energy Management.

My thesis aims to analyze how the SC strategy could contribute to relieve the traffic congestion in Shenzhen. Thus the concepts of SC strategy, ITS have the direct connection with the traffic congestion. For analyzing the topic from different aspects, three types of key stakeholders will be interviewed for collecting data and information, such as government (transportation department), ICT firms (provide technology for SC strategy), citizens (private vehicle driver, public transportation driver, people who usually take public transportation).

Each interview will take about half an hour, you can participate anonymously. Your answers will be used for this research only. Ethical consent form is carried out to protect the right of participants.

Thank you for your contribution to this research.

Sincerely,

Linlin Zhang

The Master of Environmental and Energy Management from Twente University

Email: l.zhang-10@student.utwente.nl

Citizen Questionnaire Description

This citizen questionnaire is consisted of three sections. In introductory section, key concepts of the research are asked or explained. In the research section, all the questions have direct connection with the sub-questions in this research. The indicators of transportation service are also considered in designing the questions for evaluating the effect of SC strategy regarding dealing with the traffic congestion. The last section focus on Contextual Interaction Theory (CIT), which is used for analyzing the relationship among the stakeholders in this research.

1. Introductory Question

1.1 Have you heard of the concept of Smart City (SC) and Intelligent Transportation System (ITS)?

- **If yes:** Do you think they will contribute to the reduction of traffic congestion? Why?
- **If no:** Explain the concept to the respondents

2. Research Question

2.1 Transportation Service

   a. Which type of transport you usually take?

   b. Are you satisfied with current transportation service in Shenzhen? (e.g. traffic performance index release, electronic payment and real-time prediction rate of public transportation…)

   - **If yes:** Why?
   - **If no:** Why not?

   c. Do you think these service can help to reduce the traffic congestion?

   - **If yes:** How? (e.g. change the travel mode…)
   - **If no:** What's the limitation?

2.2 What are you doing to enable Shenzhen successful transition to SC regarding solving the traffic congestion issues?

   a. Have you ever tried to cooperate with government or ICT firms/research organization

for better implementing ICT to solve the traffic congestion?

- **If yes:** How? (e.g. provide feedbacks / suggestions…)

- **If no:** Why not?

b. Is there any other way for you to contribute to SC strategy concerning reduction of traffic jam in Shenzhen?

2.3 What are the challenges to participate activities of SC for tackling the traffic congestion in Shenzhen? Which do you think is the biggest challenges? (e.g. citizen perspective…)

2.4 Do you have any suggestions to accommodate the prioritized challenges mentioned before?

2.5 What types of transportation service (ITS) models of SC can be associate with solving the traffic congestion in Shenzhen?

2.6 What are additional comments on the SC strategy regarding traffic congestion reduction in Shenzhen?

3. Theory Question (CIT)

3.1 Why do you want to participate in SC construction activities for reducing the traffic congestion in Shenzhen? (e.g. internal goals &values, external pressure…)

3.2 How to ensure you understand the reality of SC and transportation service (ITS) correctly? (e.g. observation, comparison, interpretation)

3.3 Do you have enough resources or channels to support participating the activities of SC regarding reducing traffic congestion in Shenzhen? Which kind of resources or channels are available and accessible now? which are not ready yet? (e.g. need support by others…)

3.4 Do you think there are other relevant stakeholders involved in the SC strategy to reduce the traffic congestion in Shenzhen?

- **If yes:** How can they engaged and by whom?

Appendix 2. Questionnaire for Government

Interview Statement

Dear respondent,

I am a student from University of Twente and I am conducting this survey for collecting data and information for my master thesis in Environmental and Energy Management.

My thesis aims to analyze how the SC strategy could contribute to relieve the traffic congestion in Shenzhen. Thus the concepts of SC strategy, ITS have the direct connection with the traffic congestion. For analyzing the topic from different aspects, three types of key stakeholders will be interviewed for collecting data and information, such as government (transportation department), ICT firms (provide technology for SC strategy), citizens (private vehicle driver, public transportation driver, people who usually take public transportation).

Each interview will take about half an hour, you can participate anonymously. Your answers will be used for this research only. Ethical consent form is carried out to protect the right of participants.

Thank you for your contribution to this research.

Sincerely,

Linlin Zhang

The Master of Environmental and Energy Management from Twente University

Email: l.zhang-10@student.utwente.nl

Government Questionnaire Description

This government questionnaire is consisted of three sections. **In introductory section**, key concepts of the research are asked or explained. **In the research section**, all the questions have direct connection with the sub-questions in this research. The indicators of transportation service are also considered in designing the questions for evaluating the effect of SC strategy regarding dealing with the traffic congestion. **The last section** focus on Contextual Interaction Theory (CIT), which is used for analyzing the relationship among the stakeholders in this research.

1. Introductory Question

1.1 Have you heard of the concept of Smart City (SC) and Intelligent Transportation System (ITS)?

- **If yes:** Do you think they will contribute to the reduction of traffic congestion? Why?
- **If no:** Explain the concept to the respondents

2. Research Question

2.1 What do you think about the current situation of traffic congestion in Shenzhen compared with previous time (e.g. without ITS)? What causes these changes?

2.2 What is the government doing to enable Shenzhen successful transition to SC regarding solving the traffic congestion issues?

   a. What kind of policy (e.g. SC construction policy, ICT promotion policy…) has been issued for SC strategy regarding traffic jam reduction? Is that working?

   b. Has the government ever tried to cooperate with ICT firms/ research organizations or local citizen for better implementing SC strategy to solve the traffic congestion?

   - **If yes:** How? (e.g. technology from the ICT firms/ research organization, collect feedback from citizen)
   - **If no:** Why not?

2.3 What are the challenges for the government to implement SC strategy regarding tackling the traffic congestion in Shenzhen? (e.g. develop related policies and network with other

stakeholders) What are the prioritized challenges need to be addressed first?

2.4 What are the strategies to accommodate the prioritized challenges mentioned before?

2.5 What types of SC models (e.g. ITS) or cooperation network model can be associate with solving the traffic congestion in Shenzhen?

2.6 What are additional comments on the SC strategy regarding traffic congestion reduction in Shenzhen?

3. Theory Question (CIT)

3.1 Why does the government want to implement the SC strategy regarding reduce the traffic congestion in Shenzhen? (e.g. internal goals & values, external pressure, self-effectiveness assessment)

3.2 How to ensure the government understand the reality of SC and transportation service (ITS) correctly? (e.g. observation, frame reference, interpretation)

3.3 Does the government has enough resources for supporting its strategy of reducing the traffic congestion? Which kind of resources are available and accessible now, which are not ready yet? (e.g. need attribution of power by others…)

Appendix 3. Questionnaire for Enterprise

Interview Statement

Dear respondent,

I am a student from University of Twente and I am conducting this survey for collecting data and information for my master thesis in Environmental and Energy Management.

My thesis aims to analyze how the SC strategy could contribute to relieve the traffic congestion in Shenzhen. Thus the concepts of SC strategy, ITS have the direct connection with the traffic congestion. For analyzing the topic from different aspects, three types of key stakeholders will be interviewed for collecting data and information, such as government (transportation department), ICT firms (provide technology for SC strategy), citizens (private vehicle driver, public transportation driver, people who usually take public transportation).

Each interview will take about half an hour, you can participate anonymously. Your answers will be used for this research only. Ethical consent form is carried out to protect the right of participants.

Thank you for your contribution to this research.

Sincerely,

Linlin Zhang

The Master of Environmental and Energy Management from Twente University

Email: l.zhang-10@student.utwente.nl

Enterprise Questionnaire Description

This enterprise questionnaire is consisted of three sections. **In introductory section**, key concepts of the research are asked or explained. **In the research section**, all the questions have direct connection with the sub-questions in this research. The indicators of transportation service are also considered in designing the questions for evaluating the effect of SC strategy regarding dealing with the traffic congestion. **The last section** focus on Contextual Interaction Theory (CIT), which is used for analyzing the relationship among the stakeholders in this research.

1. Introductory Question

1.1 Have you heard of the concept of Smart City (SC) and Intelligent Transportation System (ITS)?

- **If yes:** Do you think they will contribute to the reduction of traffic congestion? Why?
- **If no:** Explain the concept to the respondents

2. Research Question

2.1 What do you think about the current situation of traffic congestion in Shenzhen compared with previous time (e.g. without ITS)? What causes these changes?

2.2 What is your company doing to enable Shenzhen successful transition to SC regarding solving the traffic congestion issues?

a. Which kind of specific technology (e.g. big data, IoT, cloud computing and AI…) used for dealing with the traffic congestion challenges in Shenzhen? And how? Explain some practical ICT solutions for traffic problem. (e.g. traffic performance index release, electronic payment and real-time prediction rate of public transportation…)

b. Has your company ever tried to cooperate with government or local citizen for better implementing ICT to solve the traffic congestion?

- **If yes:** How? (e.g. ITS for government, collect feedback from citizen)
- **If no:** Why not?

2.3 What are the challenges of your company to develop solutions or products for SC strategy regarding tackling the traffic congestion in Shenzhen? What are the prioritized challenges

need to be addressed first?

2.4 What are the strategies to accommodate the prioritized challenges mentioned before?

2.5 What types of transportation service (ITS) models or business model can be associate with solving the traffic congestion in Shenzhen?

2.6 What are additional comments on the SC strategy regarding traffic congestion reduction in Shenzhen?

3. Theory Question (CIT)

3.1 Why does your company want to invest on new generation of information communication technology for traffic congestion? (e.g. internal goals & values, external pressure, self-effectiveness assessment)

3.2 How to ensure your company understand the reality of SC and transportation service (ITS) correctly? (e.g. observation, comparison, interpretation)

3.3 Does your company has enough resources for supporting its strategy of reducing the traffic congestion? Which kind of resources are available and accessible now, which are not ready yet? (e.g. need support by others…)

Appendix 4. Consent Form for Interview

Traffic Congestion Reduction and Smart City Strategy

A Case Study in Shenzhen, China

Consent to take part in research study interview

(Source from https://alessiogemma.weebly.com/consent-form.html)

- "I, ………………………………… , voluntarily agree to participate in this research study interview.

- I understand that even if I agree to participate now, I can withdraw at any time or refuse to answer any question without any consequences of any kind.

- I understand that I can withdraw permission to use data from my interview after it, in which case the material will be deleted.

- I have had the purpose and nature of the study explained to me and I have had the opportunity to ask questions about the study.

- I agree to my interview being audio-recorded.

- I understand that all information I provide for this study will be treated confidentially.

- I understand that in any report on the results of this research my identity will remain anonymous if preferred to be so. This will be done by not explicitly mentioning my name and disguising any details of my interview which may reveal my identity or the identity of people I speak about.

- I understand that I am entitled to access the information I have provided after the interview.

- I understand that I am free to contact any of the people involved in the research to seek further clarification and information."

Here as follow the names of the people involved in this case study, who can ensure the agreed use of the consent form and the information collected from the interview.

Researcher: Linlin Zhang

Project Supervisor: Dr. Laura Franco-Garcia, Dr. Victoria Daskalova

Signature of participant:

Date

Appendix 5 Transcript of the interviews

Government

Shenzhen Transport and Communication Commission (June 10, 2019)

In the year of 2017, the total amount of passengers of public transportation has reached 3744 million, including 1650 million from rail traffic, 1654 million from regular bus, the passengers volume from taxi is as high as 370 million, and the left 60 million is from other urban road passenger transports. The public transportation in Shenzhen is operated with high-efficiency. The public transportation in Shenzhen is accounted for 57.4% of the total volume. According to the analysis report of transportation jointly released by Amap and China Planning Research Institute of Transportation, Shenzhen ranks 46 for traffic congestion, maintaining the trend of continuous decline.

The government has been working on the overall plan for the smart transportation in Shenzhen. Setting up the overall framework of ITS according to the need of different period. Meanwhile the government is implementing the special plan and key item construction, which strongly instructing the development of ITS in Shenzhen and help Shenzhen to lay a solid foundation to be the leader of smart transportation in China. Under the framework of SC strategy, Shenzhen take city governing service as the core and actively promote the development of ITS in the new era. Since 2016, Shenzhen Municipality came up with the idea of constructing SC, and establishing the specialized leading organization to lead the overall construction work of SC and ITS in Shenzhen. Until now, according to the need of smart transportation, Shenzhen has confirmed information exchange platform and integrated monitor system, traffic operational command system, transportation management system, traffic overall regulatory system, traffic management and emergency simulation decision support system and public travel information service, which comprises the overall framework of ITS. In recent years, Shenzhen has established more than 30 kinds of application system, covering smart bus, smart facility, smart logistics and smart government services and ITS has gained huge achievements. The construction of ITS in Shenzhen is presented as follows:

1. **Increase the smart surveillance ability for the transportation industry**

   a. Promoting the construction of GPS monitoring platform for public transportation, and establishing the ITS for vehicle monitoring and management.

   b. Installing the video equipment for monitoring the traffic passenger flow, which can increase the statistical accuracy of passenger volume and provide the data support for the industry.

   c. The government is working on connecting the operational data of online bus-hailing service, in order to realize the digital surveillance and analysis of the online bus.

   d. The government has established electrical certificate management system, with IC card covering the information of enterprise and vehicle. As well as matching with RFID technology for all the bus stops in Shenzhen, the move will improve the surveillance management, such as daily public transportation and entering and leaving station management.

   e. The government is now promoting the connection of the car surveillance video to the government surveillance platform, taking the advantage of the technology of face recognition, behavior recognition to increase smart inspection intensity. Through the "sky eye", the government can realize the visualization, distant and high efficiency for vehicle surveillance.

2. **Increase the handy service for the public**

   a. The government has implemented the pilot construction of the electrical sign for public transportation.

   b. The government has tried to optimize the function of public transportation APP in Shenzhen. Widening the contents of released information in order to improve the information service ability.

   c. The government has also upgraded POS in the public transportation, promoting electrical payment, such as Unionpay and Wechat.

   d. Implemented the service comment function for passengers with the smart terminal, in order to improve the riding experiences for customers and service quality for the driver.

ICT Company

Manager of the leading ICT company 1 (Tencent) in Shenzhen (May 8, 2019)

The traffic situation in Shenzhen is getting better. Apart from government policy and related hardware conditions, such as widening the road, developing rail transportation and promoting green travel. ITS has played an important role for dealing with the traffic congestion. since last year, his company has cooperated with Shenzhen Transportation Commission and Shenzhen Public Security Bureau for public bus as pilot projects. Through the online interaction between vehicle to vehicle and vehicle to signal light, the traffic will become better. Meanwhile, by road detection, pavement detection and inducting the speed of bus, it can connect the information of public bus and signal light which will increase the passing speed of bus.

The respondent indicated that many newly built roads construction are based on the vehicular networking technology and applications. For example, ITS can be installed in the intersection which can realize initiative public bus signal priority and the instruction of the driving speed. Meanwhile, his company is also working on the electronic bus-board which can release the dynamic public transportation information. He also mentioned the smart parking system which is very important to reduce the traffic congestion since illegally parked cars are one of the key issue causing the traffic congestion in Shenzhen. Since 2015, his company has participated the project of smart roadside parking management system, which is a good example to implement the traffic policy and SC strategy in Shenzhen. His ICT company is in charge of providing hardware equipment of front end berth, communication network, computer room equipment and software platform etc. Shenzhen Transportation Management Commission has constructed the big data platform to analyze the traffic flow information based on the parking data to provide real-time parking data information and "tide parking information" (park in the evening and leave in the morning). The government want to construct a accurate and convenient sideroad parking system through the technology of radio frequency technology (RF), cellphone communication service and automatic monitoring technology for berth, in order to help the citizens finding the parking space easily and reduce the traffic congestion.

As a member of the smart transportation team in ICT firm, she believed her company has combined traffic management and transportation to establish an integrated platform which can contribute to solve the traffic congestion in Shenzhen. For example, her team is now building the platform for monitoring the smart transportation operation and supporting the decision-making. Specifically speaking, five intelligent applications have been established, including congestion management, safety management, command and scheduling, traveling service and comprehensive management. The technology of AI and big data have been used for developing the platform of smart traffic cloud which has been already put into operation in Shenzhen. These application can realize the accurate intelligent control, develop three vehicle reservation scenario, such as large-scale event reservation, road capacity reservation and scenic spot entry reservation, which can help to solve the traffic congestion caused by lacking of traffic resources.

In her opinion, the traffic congestion situation in Shenzhen has been improve a lot since the implementation of ITS. Firstly, the congestion time has been shortened especially in the worst hotspots, average driving speed has been increased and waiting time in intersection has been decreased as well. Secondly, the efficiency of dealing with traffic accidents by the traffic police has been increased, the traffic accident rate has been decreased. Thirdly, traffic violation rate has decreased, created civilized traffic. Fourthly, the satisfactory rate for traffic service, especially the service for citizens. With the ITS, the hot line call completing rate has been increased as well as the automatically answering rate. Many advanced technology have been used in SC strategy for reducing the traffic congestion in Shenzhen, such as AI, big data, blockchain and smart electronic payment. Her company has been working closely with Shenzhen government and related department for dealing with the traffic issue. Taking the advantage of AI technology for checking and supervision. With the image identification, AI can realize multi-scene monitor with high accuracy which can be used for vehicle peccancy surveillance. Block chain technology can establish the electronic driver license and vehicle passport which can accomplish information exchange. The big data technology can deploy the

resources and the deep analysis can increase the ability of dealing with the congestion condition, such as the forecasting for high way congestion, smart traffic dispersion, vehicle restrictions for unusual weather and emergency processing of traffic accidents. Accurate image recognition technology and smart payment technology can make highway and parkin lot payment more convenient. Her company has been working with Shenzhen government for ITS. And the company has enough technology, finance and the public resources. However, the smart products and services need practical testing for optimizing which takes long time for developing.

Staff of the leading ICT company 3 (Huawei) in Shenzhen (May 6, 2019)

The specific respondent didn't much changes of the traffic congestion, maybe he lived near the company. Even he went somewhere further, he usually took the metro, so he hasn't felt much changes. And in his opinion, ITS would not have much contribution to reduce the traffic congestion, unless the high degree intelligence for the vehicles has become the key point in the process of communication and decision-making. Otherwise, with the large amount of the vehicles and widely varying abilities of the drivers, the congestion situation would still continue. As a staff in the ICT firm, his company has joined the communication and control section for intelligent vehicle. In his opinion, IoT and AI are major technology for automatic auto, which were the key element for ITS and has direct connection in the traffic decision-making process. The new generation of the technology was for universal function, not just for solving the traffic issue. There is no special technology developing for reducing traffic congestion. SC is a new market, the company wants to join it and make money. Because they have all the technology, all they need to do is to combine them as a solution. Although he was not in the department which has direct connection with the smart transportation. However, he got rich knowledge of smart technology from market investigation, industry information collection and customer investigation. And he was confident to believe that his company has large amount of resources and ability. However, AI related research is not enough and the communication research is very important. If only for the current solution, the company have all the resources, covering from the software to the hardware.

Citizen

Private vehicle driver 1 (May 22, 2019)

This private car driver didn't feel like there is much differences on traffic congestion compared with previous time. Because it still took him much time for driving in the peak hour. He thought it was because it cannot contain more vehicles on road. As the technology frontier in China, traffic congestion reduction is always a tough problems in Shenzhen. However, technology only an auxiliary tool, people who use the tool are the most important part.

Private car is his first option when going out for convenient reason, apart from private car, metro is his second option for avoiding the congestion. He is basically satisfied with current transportation service in Shenzhen. Firstly, he always use navigation APP to check the congestion situation when planning to go out and it worked quite well. Secondly, electronic payment currently almost covered all the public transportation, so he can go everywhere with only cellphone. Thirdly, he heard about real-time prediction services for the public transportation, but he seldom takes bus, he usually call DiDi Taxi (on-line reservation taxi).

He thought these traffic service can help Shenzhen to reduce the traffic congestion, because if the citizens knew the traffic situation in advance, they can choose other routes or other time for going out. The private car driver has tried to upload the traffic congestion situation by APP to help the ICT company collecting traffic data. Other than this, he believed the best he can do was trying to choose public transportation or off-peak time to go out in order to contribute to reduce the traffic congestion.

He thought the biggest challenge for the citizens to participate the SC activities was the convenient degree. For example, when you were driving with navigation APP, it was not convenient to upload the congestion situation through it. So he hoped the ICT firm should improve the operation method of APP, in order to promote the participation of citizens, such as voice action. In his opinion, many congestion were actually caused by people, didn't know the way, overtaking, rear-end accidents, fatigue driving and maintenance of roads all can lead to traffic congestion. From this perspective, he thought government need to improve the road

markings, promoting the use of navigation software, meanwhile the government also needed to promote the traffic safety and strengthening supervision. As for ITS models, he thought there two requirements were needed. Firstly, the ITS models can promote the awareness of people to reduce the traffic congestion. Secondly, the model should be easy to operate and customer friendly. He believed the lack of unified rules for going out was a very serious problem. It was critical to set a unified rule to let every component, such as vehicle, bicycle, passerby and even bind people can clearly understand how to choose the way for going out. Punishment was only a tool, cannot solve the problem from the source.

As a person born in Shenzhen, he had the deep emotion for it and hope it can develop better and he also believed that regulated his own behavior and tried to not make the city more congestion is the best participation. He understands the concepts of SC and ITS based on the information released by the authorized organization, objective information and his own experiences. Meanwhile, he believed technology tool can help the city becomes better. However, the channels for him to participate was not enough.

Private vehicle driver 2 (May 11, 2019)

The driver indicated that the traffic congestion was getting worse, it took him more time now compared with previous time. Because with the increase of citizen's income, there were more vehicles on road now. He was not sure the ITS can deal with all the additional cars in Shenzhen or maybe the ITS is not widely used.

Private car was his first option when going out. As for transportation service in Shenzhen, he expressed that he was not familiar with the traffic performance index released by the government, he usually used the APPs or listening to the traffic radio to know the situation of different roads. Meanwhile he emphasized that he was very satisfied with the electronic payment. It brought him convenience, since he didn't need to take purse any more, the electronic payment covered all. However, he complained the prediction services for public transportation. Because there was no screen in the bus station for showing the information of the bus, meanwhile the APP for prediction time was not accurate. And even they have the

screen in the metro station, they only show the time left for the next metro, not the accurate time for each metro. He believes these services cannot solve all the congestion problems, since the major problems rely on people, so people need to have the awareness of the traffic issue and increase comprehensive quality.

He has tried to provide the complaint through the official account for illegal parking in front of the primary school to reduce the traffic congestion. And if possible he always chooses Alibaba APP to pay when he needs to park his car, since the new method connect the car license number and the bank account, so it will deduct the parking fee automatically which is convenient and efficient. To some degree, it will increase the passing time, reduce the waiting time for other cars on roads and contribute to traffic congestion reduction.

He also mentioned the same complaint as the private vehicle 1 that the requirements for providing information is very strict, which is a bottle neck for promoting citizens to participate, meanwhile he also emphasized that limited channels and no incentive to promote are also challenges as well.

He found many new cars have been equipped with the software of car networking to record many key data and share the traffic information. But because the old cars don't have them, so currently the data of car networking cannot cover all. But he believe it will become a good trend, and the situation of traffic congestion will be solved then if each car can be connected with each other.

He wanted to participate the SC strategy from his internal values, because the external traffic actually is not that bad to give others much pressure. He understands the concepts from observation by himself, comparison with other cities and interpretation from other channels. He expressed that now the channels and resources are not enough and some infrastructure like networking are not fully connected, which are the barriers for participating the activities.

Private vehicle driver 3 (June 3, 2019)

The driver didn't feel there's much differences, the traffic flow is still very large and the traffic congestion still happens in peak time. She chose private cars because of convenience. She is

basically satisfied with the current transportation service and he believes these services will contribute to reduce the traffic congestion since it will help citizens to choose a better travel mode based on the prediction from the APP. She hasn't tried to cooperate with the government or the ICT firms to provide suggestions or feedback, because those people are more professional than her and she didn't know the channels for her to do that. In her opinions, the key point is to promote the smart transportation from different channels to make citizen understand. She recommends AI technology, and believed that we should take the advantage of AI to direct the traffic in peak time to reduce the traffic jam. she would like to have the channel she wanted to participate since she wanted our living environment is getting better and can create a better environment for the next generation. However, for now she was not familiar with the concept of SC and ITS, she only can get a little bit information from the internet which is not enough.

Private vehicle driver 4 (June 10, 2019)

The driver didn't feel there's much differences compared with previous time. Because it took almost the same time to the same places. Private car was her first option, although the condition of public transportation has improved a lot, they were still too crowded. She was not familiar with the traffic performance index, but satisfied with the electronic payment. She was not satisfied with the prediction services, because it's not that accurate for prediction. She complained that sometimes even the bus has arrived she still cannot find the information from the APP. She believed that smart transportation services can help to reduce the congestion. And she mentioned the same advanced payment system for parking as private driver 2. She also indicated that the new payment system has been used in high way as well. She didn't know the traffic performance index. And the bottleneck for the public to participate lies in the promotion is not enough. She thought if the transportation department really want to spread the information, they need to try to do some advertisements in the station or some public areas to let people know.

She also hasn't cooperated with the ICT firms or government. The channels for doing that are not that many. And she doubted that even she left a message in the platform, the government

or ICT firms will look through it or not, because her husband ever tried to leave some suggestions there, but never got any reply yet. Meanwhile, she also mentioned the channels for participating is not enough, as well the strict requirements to join. As for smart transportation service, she had her own idea which was the electronic driving license. She explained that when people drive the car, the electronic driving license will record everything during the driving, including the illegal behavior during the driving. Because in her opinion, driving against the traffic regulation was a key issue for traffic congestion.

She wanted to participate from her internal values, and she understood the concepts basically by observation and interpretation. She believed resources and channels are not enough. Even for the existing platform, she was not sure they had enough staff to collect and analyze the feed- backs from the citizens.

Private vehicle driver 5 (June 15, 2019)

The driver felt it was getting better than before. Because the amount of vehicles is getting more and more, but the traffic situation is not getting much worse. Due to the need of work and life, he would choose private car. He was basically satisfied with the current transportation service, but he didn't give specifically reasons for each services. He indicated that compared with other cities, Shenzhen is better. He took positive attitude to the smart transportation services for relieving traffic congestion, since it would reduce time cost and reduce the space per person trip on road. As a lawyer, he ever has proposed to the Chinese People's Political Consultative Conference (CPPCC) on the traffic issue. Since he didn't know many different channels for participating the SC activities, he thought that try to use big data collection APPs is a good way to contribute. He also appealed to increase the channels for participating smart transportation services, because he thought a good ITS models should be services that people can understand and participate. However, the problem now is that there's not many promotion for the strategy, many people even don't heard about that. As a person in Shenzhen he wanted to participate and government need to provide more data that can be checked by the citizens. For now he usually looks into the data in the official website, but the data is very limited.

Private vehicle driver 6 (June 21, 2019)

The driver understood SC strategy well and believed it would help citizens to know the traffic situation in advance in order to avoid the congestion. ITS will take the advantage of the remote control, such as big data comparison of car plate number can control the number of citizens to go to hot area in holidays by reservation in advance. So she felt it's getting better than before. Besides SC strategy, other methods, such as reversible lanes[9], traffic restriction (e.g. plates are not from Shenzhen, reservation for travelling in holidays). Private car is her first choice, the second option is metro. Because private car is easy for controlling time, while metro is convenient and green travel. She is satisfied with the current transportation service in Shenzhen. The examples are that there are screens in the high way to show he traffic situation ahead. And also the electronic payment in the high way has saved the time for passing the toll station. As for the APPs, it can help to do the real-time prediction, which can change the mode of travelling. She hasn't cooperated with government or ICT firms. Because there is not many negative effects in her daily life from the traffic congestion. During the interview, she also mentioned a radio platform to provide the feedback, in which the staff can contact Shenzhen transportation department online immediately and they will answer these questions or help to solve the problems. For herself, she will try to take the public transportation as much as possible or try not to go out in the peak time. From her perspective, the biggest challenge is there is not many official channels for promoting the participation and some platforms lack the influential for noticing by the government. The respondent indicated that the objective of ITS should reduce the amount of vehicles going out in the same time and increase the driving speed. Reservation system should be used in hot areas and limited parking areas. Meanwhile the system should provide the congestion information which will help the drivers to avoid the congestion and choose other ways, as well as real-time information of the parking lot, in order to reduce the amount of vehicles waiting on road. Honestly speaking, the respondent believed she was not a noble person. If she wanted to participate maybe she just wanted to solve the

---

[9] Reversible lanes refers to the change of driving direction of a certain lane in different periods of time according to different morning and evening traffic flow.

personal need first. And she understood the concepts based on her own experiences. As for the existing resources she thought for now it is almost enough. From the TV platform (e.g. First Scene program), radio platform and official account in Wechat, citizens can participate in the activities if they want.

Private vehicle driver 7 (April 28, 2019)

The driver cannot feel there is much improvement, because there is still serious traffic congestion in peak time. The most changes compared with the previous time are 1. The traffic police can deal with the traffic management faster than before. 2. The drivers can choose other ways based on the prediction in the APP. Private car and metro are his favorite. He is basically satisfied with the public transportation service, especially monitoring the real-time congestion situation can help citizens to choose different kinds of transportation mode. However, he is not pretty sure whether these services can reduce the traffic congestion effectively. He has ever provided the feedbacks to the government through the official website before, but never got reply. In his mind, personal quality is the biggest bottleneck, because he always can find pedestrians and people riding electrical motor do not obey the traffic rules, which is not only negative to the traffic congestion, but also very dangerous. So he thought strengthening the punishment for people do not obey the traffic rules should be put in the list, especially those with electrical motors and pedestrians. They do not have plates, so the smart camera in the ITS cannot find and record them. He wants to participate because of internal goals and values. As the amount of traffic flow is increasing, he hopes ITS can help to relieve the congestion situation.

Ordinary citizen 1 (May 14, 2019)

The citizen thought it's getting better. The major reasons for the traffic congestion are traffic accidents, large amount of traffic flow, traffic light and slow speed of driving. These are all getting improved. He usually chooses metro to go out, since it will help to avoid traffic congestion and can control the travel time. He was satisfied with the public transportation services. He believed citizens can understand the general traffic situation in advance and

reduce the blindness of the travel. He hasn't tried to cooperate with government or ICT firms. And he indicated the biggest challenges are low moral quality of the citizens, especially jumping a queue. Against the large amount of vehicles on road, he suggested that the government need to increase the driving cost for citizens and punish the queue jumpers in order to maintain the traffic in order. As for ITS, he believed a good system should be easy to understand, norm driving behavior, meanwhile dealing with the traffic accidents must be put into the key list as well. He believed the smoother road can makes everyone happy, that's why he is willing to participate. However, he didn't have enough resources to participate. And he thought the transportation department should collect the opinions from the citizens, not just check the big data. After all, it is people who are on the road.

Ordinary citizen 2 (May 19, 2019)

The citizen believed It's getting worse, it took her more time now. But maybe because when she was in College, she usually went out not in the peak time. Now she needed to go to work in peak time, so she felt it was getting worse. Metro is her first option when going out. However, she is not satisfied with traffic performance information since they are not often released in time. Such as breaking down and delay, she complained that she usually got these kind of information long time after the trouble already happened. She suggested that they should be released in time, so people can choose other travel options. She is really satisfied with electronic payment. Nowadays almost every public transportation can be paid with public transportation card, and many metro stations and buses are installed a special equipment that they can be paid by Wechat, which is a popular APP in China. She used some APPs, such as "Bus Coming" and "Amap" to get the public transportation information (e.g. the location of the bus, when the next bus will come to a specified station), as well as the best route and predicted time to the destination. But she also complained that the accuracy of the information needed to be improved. The predicted time is usually longer than the actual time required. and the "best route" sometimes is not perfect due to the outdated data, so the data needs to update in time. Even though the services are not perfect, she still thought these services can contribute to reduce the traffic congestion. With the electronic payments, people don't need to wait in line

to buy the ticket in the box office, especially in the metro station. So more people would like to choose metro as their first option. She hasn't cooperated with government or ICT firms for some reasons. Firstly, effective channels are limited. Secondly, she thought her feedbacks will be ignored, since the traffic congestion is always be complained by many people, but the situation is not getting better, she just doesn't want to waste her time. So she suggested that the government should provide more official channels for promoting public to participate the activities. Meanwhile, these channels should be wide spread to let public well known. For example, they should be presented in the public areas, such as bus or metro station. Besides the smart transportation strategy, she thought the government should promote the use of bicycles or walking to reduce the traffic congestion and develop green city. The problem now is that there is no independent path for bike in Shenzhen. If they have, she will prefer to go somewhere not far away by bike to reduce the traffic jam.

As for ITS, she indicated that maybe ICT firms can cooperate with companies to develop shuttle bus for their employees. Because for now only some limited big companies can provide their employees with such service. For small companies, employees need to go to work on their own, which is negative to traffic situation in peak time. Meanwhile, the government also needs to provide the subsidy for these kind of ITS.

She enjoys participating the SC activities due to her internal values. Because many people waste their time waiting on road every day, or people squeeze in the bus or metro. Some of them are pregnant women, old people and children. But they don't have better options. So she wants to contribute to improve such situation if she can help.

Other 10 ordinary citizens (May, 2019)

For other 10 ordinary citizens who took metro or walk to the working places every day, since their opinions are similar with each other, their ideas are summarized in this section. All of them didn't feel much changes from the ITS, since there is still serious traffic jam in the peak time or on holidays. Some of them have heard about SC or smart transportation. However, they didn't think there's much connection with their daily lives. All of them haven't cooperated

with the government or the ICT firms since they don't know the channels for doing that. Meanwhile, there's also no personal need for them to do that. All of them are satisfied with the electronic payments and the Amap which can provide the information of the best routes for them. They haven't heard about the traffic performance index. They believe that the best way to contribute to reduce the traffic congestion is that they can do what they should do to obey the traffic regulation, and choose public transportation as much as possible. They thought the main problems for participating is that the government promotion is not enough, many people even don't know these concepts, not to mention participation.

Other Stakeholders

Public transportation staff (May 15, 2019)

The respondent in the metro station indicated that he understood the concept of SC and ITS and he thought they will help to contribute the reduction of traffic congestion in a long run through the big data and improving the passing efficiency. Specifically speaking, smart transportation has taken full advantage of the unoccupied road in the peak time, increase the driving areas, eventually increase the driving speed and reduce the traffic congestion. however, he also believed the current traffic situation hasn't significantly improved yet. Only some chronic congestion sections are slightly getting better compared with previous time. But there is too large amount of vehicles in Shenzhen, reducing thousands of vehicles for each crossing in peak time actually cannot change anything. He usually takes metro because of punctual and high efficiency. He is satisfied with the public transportation service, and he indicated that compared with other cities, the services in Shenzhen is the best. As a staff in metro station, he is positive to believe that increase the metro lines can relieve the traffic pressure effectively, especially the government should develop the line to connect the suburb and city center, as well as lines connect external cities and Shenzhen. He hasn't cooperated with government or ICT firms before. Because in his mind individual citizen is too weak to give suggestions. It is more practical for government officials and transportation department leaders to give suggestions. He also believed that making people "smart " is the first step to contribute

the SC strategy, which means that increase the personal quality for drivers and pedestrians, forming good habits for going out, strengthening the control for the public transportation lane in peak time to promote the bus trip. Speeding up the development for metro lines, optimizing the routes, the priority should be introduced to the dense population areas. The biggest challenge for now is lacking the promotion and lacking the drivers for participating. So he suggested that the government need to increase the citizen right to be informed, increasing the promotion and truly let citizens can join the activities. He thought a good ITS model for citizens should monitor the traffic situation in different time frame and roads based on the big data to adjust optimal routes. Meanwhile, it is also necessary to implement hard punishment for traffic violation, including pedestrians violation, strengthening the traffic quality education and developing smart transportation with more resources. He wanted to participate in the SC strategy, since he is also living in Shenzhen, solving the traffic congestion is a good thing for him and for all others. As one staff in the public transportation services, he knew many related information earlier than others, that's why he can understand these concepts. The problems now is there's not many resources for him to participate. And the traffic congestion cannot be solved only with SC strategy, some municipal works are not scheduled reasonable and construction are not implemented effectively are also major reasons, which need all departments in the government cooperate together, not buck-passing.

Manager of a leading public transportation Group (Shenzhen Eastern Bus) (June 13, 2019)

The manager believed the traffic congestion will get better in Shenzhen, but it will take some time to digest additional vehicle on road. Since the company has adopted many new ideas to transit to smart bus company, such as smart public transportation cloud, inquiry and answer system for bus drivers and so on. All of these methods will help the company to improve the management quality and satisfactory for the customers. Meanwhile, the government has also divided the bus lane in the rush hour (i.e. 7.30-9.30 am and 17.30-19.30 pm), which means other vehicles cannot drive in the bus lane. In this way, actually people who take bus will be faster to arrive the destination than the private car. Her company is also the biggest online-bus

hailing service platform in China. With APP for reservation, customers can get punctual and convenient services. Meanwhile, the client-side of e-bus APP has updated more than 100 times, which includes the function of bus information and message. And the management-side of the APP also upgraded many times, for now they have the modules of demand management, product planning and management, scheduling and extra bus, after-sales services, supervisory statistics, back-end data and so one, which will improve the management efficiency of the company. The company is now in the transition to the smart public transportation. Firstly, real-time surveillance. The company can locate every bus accurately to know the situation of buses in operation as well as the drivers' state. Secondly, scientific operation. According to the collection of information of intelligent measures, the company can deeply analyze the routes, develop reform, plan the operation routes scientifically, distribute the amount of bus, increase/decrease the amount of station and optimal scheduling. Thirdly, improve the customer services. Customers can have the real-time information of the arriving time of the bus, the options information for transferring, the comparison information of travel time and ticket price, which can reduce the waiting time, reduce the traffic congestion, optimize the travelling experiences and promote more citizens to take the public transportation. Last but not the least, improving the electronic payment and keeping the connection with the scenes of life. From the technology perspective, the company has promoted smart operation mode, with the help of big data and cloud computing technology, the operational data can be deeply analyzed to change single bus load, in order to establish a highly effective scheme for single time and departure interval.