

# The Effects of Smart-city Related Public-Private Partnership Contracts on Innovation and the Performance of Smart Cities in China

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## Abstract

Currently smart cities theories do not have much linkages with more established schools of thoughts, this has limited the scope of theoretical exploration. This is because smart city has just got increasing attention after 2013 in China and there exists a paucity of literature illustrating its theory. The way smart cities got planned and executed, could be connected with the public-private partnership (PPP), because city building which often requires a long time and the cooperation between the public and private sectors have matched the features of PPP. Thus, the PPP conceptual framework can provide useful and valuable lessons on how to build the conceptual framework for smart-city related theories. Moreover, in the process of practice, smart city development also encounter a series of challenges. This article proposes to exam the current development of smart city in China from the theoretical and practical perspectives.

**Key words:** PPP, China, Smart city, digitalization

## 1 Introduction

### 1.1 Background

Looking back to history, the public-private partnership (PPP) mode was first formally proposed in the United Kingdom (UK) in 1982 (Zhang et al., 2019). Back in the 18th century in Britain, the government has outsourced some cleaning jobs to the private sectors for some street lamps (Hodge and Greve, 2007). It was not until 1992 that the concept of PPP was put into practice in Britain in the form of the Private Finance Initiative (PFI) by allowing the private sectors to

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invest in public projects (Rodney and Gallimore, 2002; Tieman, 2003). The British conservative government developed the PFI to enable the private firms to design, refurbish, as well as to invest in and operate the public building at that time (Hampton et al., 2012). The initial rationale behind this is that the government planned to limit the risk and the public spending by sharing the risk with the private sectors and from the perspective of the private firms, this is a new type of investment opportunity backed by the government (Hodge et al., 2018). The assumption and motivation for the government to adopt such an innovative method are that PPP mode can improve the efficiency and quality of the projects while the risk transfer and allocation is acceptable and beneficial for both parties (public and private) (Ismail, 2011). Up to now, PFI is one of the most popular types of PPP in Britain and over the globe (Hodge and Greve, 2007; Liu et al., 2015). In 2012, PFI still accounts for 10 to 14% of the public investment in providing public services (Cheung et al., 2012). The PFI is characteristic of two key features, which are government involvement and risk-sharing (Liu et al., 2015). After introducing such a model in the UK, other types and industries of PPP have been extended. For example, the scope of PPP has been extended from the traditional infrastructure projects include "arrangements for financing, building, and operating hard infrastructures such as transportation, electricity, telecommunication, and water facilities" to soft infrastructure such as the cultural industry, education, healthcare and so on (Bertelli et al., 2020; Yang et al., 2013, 478). The following years have witnessed a rise in the global PPP projects with a total nominal value of 775.1 billion dollars from 1985 to 2011 just for the infrastructure projects (Fu, 2018). Moreover, the PPP especially those in the infrastructure industry continues to grow over the past decades (Tariq and Zhang, 2020). According to the world bank, more than 134 countries used the PPP method, and infrastructure investment has occupied 15-20% of the overall PPP investments (Bertelli et al., 2020).

Although PPP has become a widely adopted model, it has often been criticized by coming with a complicated structure, huge risks, and public service ethos that may be undermined (Liu et al., 2015; Wang et al., 2017). On the one hand, the failure rate or instability rate in the public-private alliance can reach 30% to 50%, or even 70% sometimes (Garg and Garg, 2017). On the other hand, the advantages of PPP mainly lie in the risk-sharing, when the private partners and the government cooperate with each other, the risks, benefits and costs can be shared among these two actors (Alford and O'flynn, 2012; Hodge and Greve, 2007, 91). In the example of privately-

funded public projects, the PPP can bring about mutual benefits for both parties (public and private sectors). On the one hand, the government may find it difficult to finance the public infrastructure alone; on the other hand, the private sectors want to improve the cost-effectiveness in the public projects they invest in by engaging more in the whole process of PPP projects (Garg and Garg, 2017).

Despite that, there is also some kind of government cooperation between the government and private sectors, the advent of PPP has marked a new and innovative type of model compared to traditional procurement (Hodge and Greve, 2007; ?). Compared to the traditional contracts, private sectors in PPP contracts has a greater level of involvement in delivering the public goods because they will not only be responsible for providing services or goods for each separate step but also may need to carry out the whole project from design to operation (Hoppe et al., 2013; Raisbeck et al., 2010). It is also noteworthy that instead of requiring less government participation, PPP actually needs more skilled and demanding government involvement in carrying out the projects (Yang et al., 2013). The key difference is the operation because private companies will be responsible for this as well in PPP contracts, which is supposedly the responsibility of the government in the traditional procurement. In this way, the increase of private involvement in public good delivery has not only delegated more responsibilities but also gave them more bargaining power. For instance, it is often the case that the relationship in the PPP model is a bilateral monopoly one because the private company can be a monopoly in the market (Button and Daito, 2014). For example, in Hangzhou's smart city projects, the Hangzhou city government cooperated with Alibaba to carry out the city brain project. To require the company to deliver the project from design to operation means that the company may need to have a high level of capacity, which is often the monopoly in the market.

However, sometimes a strong position from the company side will give them more bargaining and lobbying power, which will give rise to the concerns of undermining the public goods (Tamayo et al., 2014). Specifically, the corruption and collusion between the government and private sectors may let the consumers bear the consequences by suffering the lower quality of public services provided (Chan et al., 2015). A more academic and general term to describe the unclear boundaries between the public and private sectors' interests is hybridity (Rainey and Chun, 2005). The hybridity can be divided into two kinds: governance hybridity (cross-sectional collaboration) and

logical hybridity (PPP projects combine different logics embedded in the different organizations involved) (Quélin et al., 2017). Another important feature of PPP is the risk-sharing and responsibility sharing in the PPP projects, however, through the special purpose vehicle (SPV) where the sponsoring firms raised funds to the public projects, the non-resource principle and incompleteness of debt contracts may often lead to the moral hazard problem that undermines the PPP project application (Shi et al., 2018; Amadi et al., 2018). Thus, there are also some strong calls on the government or even independent human agents to adopt stricter monitoring on the PPP projects for the benefit of the public (Agyenim-Boateng et al., 2017). Some people even pushed further to argue that PPP has represented a new type of government (Osborne, 2000). However, PPP is widely believed to provide the public good in an effective and efficient way, which is why it enjoys high popularity in the past decades (Pu et al., 2019). Also, some scholars argue that the main motivation behind the rise of PPP is the In general, the similarities and differences of PPP procurement and traditional procurement are summarized in Table 1.

	Traditional procurement	PPP procurement
History	3,000 BC.	Since 1992
Advantages	design certainty, manageable/fair allocation of risk, transparency and simplicity	cost effectiveness
Disadvantages	lack of speed, separation of design from production, high cost	principle-agent problem, collusion
Examples in a infrastructure building contract	The tasks of construction and operation will be delegated to one contractor	The tasks of construction and operation will be delegated to two contractors

Table 1: Comparison between the traditional procurement and PPP procurement

## 1.2 PPP in China

In the case of China, the PPP model has a shorter history but still shows an upward trend throughout these years. The main reasons of adopting PPP are often related to fiscal pressure, efficiency, and political environment ( political reform), which describes the case in China well (Wang et al., 2017). Starting from the 1980s, China implemented the reform and opening policy, but the whole nation is lack of funding and resources to develop. China is facing fiscal pressure

(lack of funding) and a favorable political environment (the permission for private sectors and the market in China) at that time. The market development was implicitly and formally granted by the government, which means the private sector started to be allowed in China since the end of the 1970s. This has laid the foundations for the development of PPP. In 1984, Shenzhen city initiated the PPP projects with a Hong Kong-based company in a power plant project, which can be considered as the first PPP project in China in the form of the Build– Operate–Transfer (BOT) model (Zhang et al., 2015). As the private sectors were a lack in money and experience at that time, the government had to take the initiative and concentrate the resources so that the development of the economy can be pushed forward (Liu et al., 2015). In recent years, the Chinese government has been active in promoting the PPP in China by publishing several official documents to encourage and regulate the PPP applications especially after 2014 (Pu et al., 2019; Wang et al., 2017). In 2016, the amount of PPP projects in China has reached more than 10471 and the total investment amount is 12.46 trillion Yuan (Wang et al., 2017). In recent years, the types of PPP have become more diverse as well in addition to the infrastructure PPP, water PPP projects, some cultural PPP seems to rise (Tariq and Zhang, 2020).

It is noteworthy that in China, PPP refers to the partnership between the public sectors and private sectors including state-owned enterprises (SOE) and private firms (Zhang et al., 2015). The growth in the number of PPP projects is partly because the government and the SOEs actively engaged in the PPP projects. Among the private sectors participating in the PPP projects, 80% of them are SOEs (Chen et al., 2017). This is because inherently SOE has a close relationship with the Chinese government and the state often holds the largest share in its stock (Hu, 2000). Currently, the relationship between the government and the private enterprises has a relatively weak control force even though the government still has a stronger position and competitive advantage (Chen et al., 2017). It is thus easier for the government and the SOEs to cooperate with each other to provide public services and goods. If the companies do not belong to the government, there will be a series of administrative and legal issues to pay attention to and this is still the case today, which explains why SOEs have occupied a large share in the PPP projects in China. On the other hand, the overwhelming account of SOEs also comes with the problems of low efficiency and waste of resources (Chen et al., 2017). However, in the case of smart city, there has been more private firms in this area because the operation skills and technical skills needed in the process are often

possessed by the private firms.

As for the purposes of the PPP, they are mainly used to finance infrastructure projects, urban renewals, and providing professional services such as education and healthcare, especially in developing countries (Kang et al., 2019). To increase the quality of the projects and lower the cost, the government adopt PPP mode so that it can bring about market competitiveness to the public area when providing a public good (Kang et al., 2019). The market approach is often considered as having high-efficiency level in the use of capital and resources, which is one of the most important reasons why the government tends to incorporate the private sectors in the public projects from the first place (Hodge et al., 2018).

## **2 Literature Review**

### **2.1 The Concept of PPP**

Admittedly, the concept of PPP can be vague and ambiguous in spite of the abundant existing literature trying to make a definition (Garg and Garg, 2017). Due to its complexity, some literature even refers to the term PPP as the language game to convey a warm message to the private parties by naming the relationship as the "partnership" (Hodge and Greve, 2010). Each different form of public management may require a different mindset and skills and in a broader structure, the forms of public management can have three forms: contracting out (which is the traditional form), PPP, and multi-sectional collaboration (Dickinson, 2018). Generally speaking, PPP mainly has two distinctive features: the interactions between the public and private sectors and the long-term cooperation. On the one hand, PPP is described as a "procurement method between the public and private sectors to produce an asset or deliver a service" (Tang et al., 2013; Rainey and Chun, 2005, p. 163). From the perspective of the government, PPP contains a series of policy approaches (Rivera, 1996). A large amount of literature emphasizes the interactions and cooperation between the government and private enterprises in producing public serves in the form of procurement. In addition to this, some scholars extended the idea of private sectors to the private firms, consortiums, or special purpose vehicles (SPV) (Amadi et al., 2018). Under the structure of procurement, public and private sectors share the interests and risks seeking to pursue benefits and provide a public good (Zhang et al., 2019). In this way, smart city projects

can be considered as PPP projects because it is often in the form of government procurement and then the public and private sectors are working together to carry out the projects. The aim of this study is to first analyze the factors analyzed in the previous literature regarding the PPP projects in China, and then identify the key factors associated with the smart city projects.

Another key feature of the PPP projects is the long-term contractual agreement (Liu et al., 2015; FHWA, 2004). The time length of some PPP projects can be up to 25 to 30 years sometimes (Hodge and Greve, 2007; Zhang et al., 2020). Technically speaking, the process of PPP has three stages including development, realization and operation (Zhang et al., 2015). In more details, the stages can be further divided into five: "(1) feasibility, (2) procurement, (3) construction, (4) operation, and (5) transfer" (Shrestha et al., 2017, 1). The typical process of the PPP projects have been drafted in the Figure 1.

It is said that the long-term contracts work especially effectively in the infrastructure and housing area in the PPP projects (Alford and O'flynn, 2012). This is because such projects inherently are in need of long-term operation and accountability. The involvement of the private sectors, in the long run, has clarified the accountability and brought about stability to the project operation. However, as for the wicked problems such as climate change and terrorism, traditional partnerships may be better than PPP in tackling these issues, as strong mutual trust and belief are needed (Dickinson, 2018). This is not to say that the trust in PPP is not important. On the contrary, a mutual trust relationship is critical in the success of PPP projects as part of the managerial strategies (Bertelli et al., 2020). However, due to the attributes of the private sectors and profit priority of private firms, cooperation may be more appropriate in the industries that put profit and efficiency as the top priority.

## **2.2 Different Types of PPP**

The categories of PPP can be different when adopting different criteria. For instance, there are different types of PPP based on how they manage and operate: BOO model, rebuild–operate–transfer (ROT), transfer–operate–transfer (TOT), transfer–operate–transfer (TOT), build–operate–transfer (BOT), as well as other models, open tendering (OT), invited tendering (IT), competitive negotiation (CN), competitive dialogue (CD) and single-source procurement (SSP) (Pu et al., 2019). Based on the regions, there may exist different types of PPP practices as well. For example, the

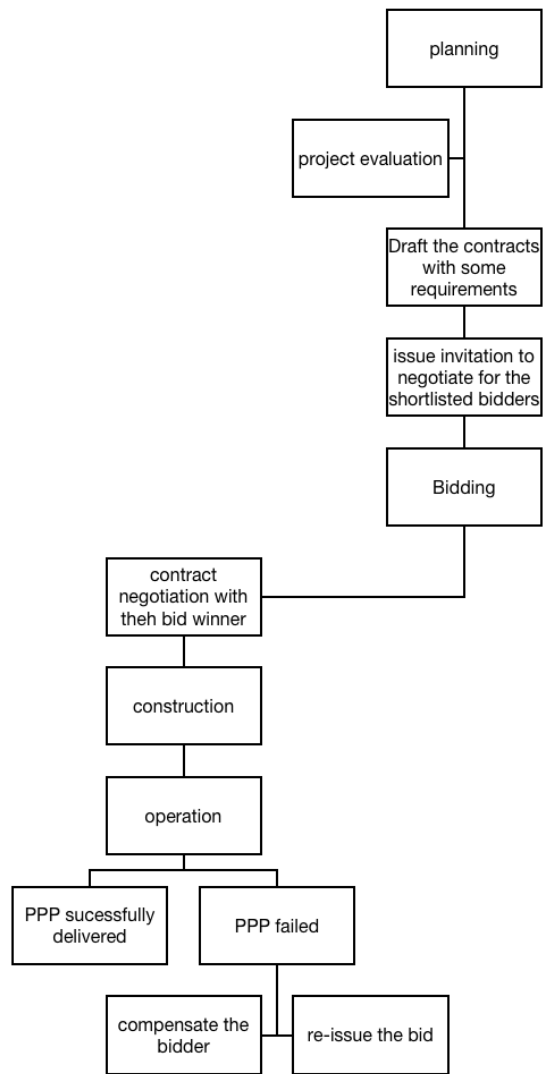


Figure 1: The typical stages of PPP projects



World Bank has the private participation in infrastructure (PPI) model; the UK developed the PFI mode for the first time in history; In Asia Pacific area the BOT is a common type of PPP (Zhang et al., 2015). Moreover, although the PFI in UK has been paid substantial attention to in the literature, in the early 2000s, the Public-Private Joint Venture Partnerships introduced in the UK has represented another type of PPP that is also frequently used worldwide nowadays (Agyenim-Boateng et al., 2017). More importantly, it is noteworthy the meaning of PPP may differ in different countries as well (Rainey and Chun, 2005). For example, in the US the term may have a broader meaning by including the activities that the government cooperated with the non-for-profit organizations and private sectors to achieve public policy goals, while western Europe mainly focuses on risk-sharing, financing, improving efficiency and quality of the PPP projects (Rainey and Chun, 2005). Depending on the purposes of the projects, the infrastructure PPP can be further divided into smaller categories including water projects, high-way projects, energy projects and so on (Jiang et al., 2019).

The research report from the U.S.-China Economic and Security Commission review (2020) stated that "the development of Chinese smart cities technology is primarily top-down, driven by government investment." For example, in the case of Hangzhou city brain (a pilot smart city program), it was the Hangzhou government that initiated the "city brain" projects by inviting over 13 companies including Alibaba Cloud to collaborate on this project in October 2016. This means that from the first place, such projects have been supported by the government, and building up smart cities requires cooperation between the public and private sectors ranging from infrastructure building, operations, providing services and so on. In Hangzhou's city brain project, Alibaba Cloud is responsible for building up and operating the online digital platform for the government to store, process, and analyze the data. These features of smart-city projects mean that they are subject to the category of PPP.

### **2.3 Stakeholders Analysis**

To have an overall picture of the PPP projects, the stakeholders involved in these programs are worth paying attention to. In addition to the key internal actors including the public and private sectors in the PPP projects, the external actors such as "local communities, trade unions, and end-users" are often overlooked (Amadi et al., 2018, 2). Specifically, the external actors may

engage in the PPP projects through the following five ways: "project location; transparency of internal stakeholders; timing of stakeholder engagement; knowledge of PPP; and relationship with internal stakeholders" (Amadi et al., 2018, 6). This has also been noticed by other scholars by including "technical and financial advisers, funders and investors, government departments and users of public assets and services" by stating the importance of network relationship of the above actors in the PPP projects (Roehrich et al., 2014). However, in reality, citizen participation, especially in developing countries occurred only after the implementation of the PPP projects (Xu et al., 2015). This undoubtedly has been a dangerous sign for the future development of certain PPP projects because the citizens are the users. If their opinions are not consulted or taken into consideration in the process of decision-making, it is hard to say that this project is satisfying and meet the goal.

## **2.4 The CSF and CRF of PPP**

In order to evaluate the performance of PPP projects, it is important to identify the initial goals and the results. There are often two factors that should be taken into account: critical success factors (CSFs) and critical risk factors (CRFs). CSF refers to those that tend to have a positive influence on increasing the possibility of success in the PPP projects, while CRF may lead to early termination of those projects. Sometimes the projects may achieve the goal of delivering the time before the deadline and within the budget constrain, however, the result does not necessarily be cost-effective and efficient (Hodge et al., 2018). The ultimate evaluation can be difficult because as mentioned earlier, PPP can be a long-term project. Another reason is that the goals may not be clear enough for the government and the enterprises from the beginning. In a broader sense, the performance of PPP projects should consider the content and scope (Wang et al., 2017). "operating environment, partnership structure, and nature of the activities" are recognized as the important elements in PPP projects (Bazzoli et al., 1997). Ideally speaking, the favorable environment includes low production costs, a favorable policy environment, and fewer public constraints (Yang et al., 2013). Moreover, the collaboration between the government and the private sectors is expected to produce more benefits than going alone, which makes PPP meaningful (Huxham and Vangen, 2000). The actual benefits that the projects brought to the people and how this is done may be hard to assess.

One concept to capture the "cost savings" due to the collaboration of PPP is value for money (VFM) (Opara, 2018). Statistically speaking, the National Audit Office reported at least 10% VFM in the major PPP projects and the range is mainly from 10 to 30% (O'Flynn and Wanna, 2008). For example, in the infrastructure PPP projects, those projects that are believed to produce higher economic value and to facilitate the progress of the PPP projects can be considered as having VFM by having cost savings compared to the traditional infrastructure contracts (Cui et al., 2018). However, the concept of VFM can be vague and difficult to measure in reality sometimes. It is said that the costs can be sometimes underestimated in these projects and the calculation of VFM may be misleading (Leigland, 2018). To set up a more clear standard, it is argued that two elements should be addressed: the technique issues and the government elements (Wang et al., 2017, 16). The technical issues and the procedures to carry about the projects may be easier to tackle such as "cost, efficiency, equity, quality, and satisfaction" (Wang et al., 2017, 16). In addition to the technique issues such as the cost and efficiency, the performance of PPP can be seen as a "network performance" that incorporates the governance elements including accountability and governance (Wang et al., 2017, 16). If the PPP is perceived as the network project, then the network management is needed including activating resources, adjusting network arrangements and guiding interactions (Warsen et al., 2018). However, the function and initiative of the enterprises have been largely overlooked by some literature. One important reason behind the failure of the PPP projects is that the profit-oriented enterprises tend to focus on minimizing the cost instead of improving the services, which undermines the initial goal of the PPP projects: the VFM (Grout, 1997). The Figure 2 below illustrate the meaning of VFM.

Despite that the goals are unclear and the evaluation may be difficult, it is possible to distinguish the critical success factor (CSF) and critical risk factor (CRF) in the PPP programs. Still, there is a lack of a universal standard and index to evaluate the performance of PPP (Song et al., 2018). In the process of seeking the possible risk factors that may lead to failure, sometimes the failure cases may be relatively easier to identify because they are canceled or postponed indefinitely. There are executive delays and non-executive delays (Kraiem and Diekmann, 1987). The reasons behind these delays can be diverse, such as the communication among the government sectors are problematic or some objective obstacles prevent the final delivery of the projects. In addition to the project delay, a worse scenario may be the termination of PPP projects. After the

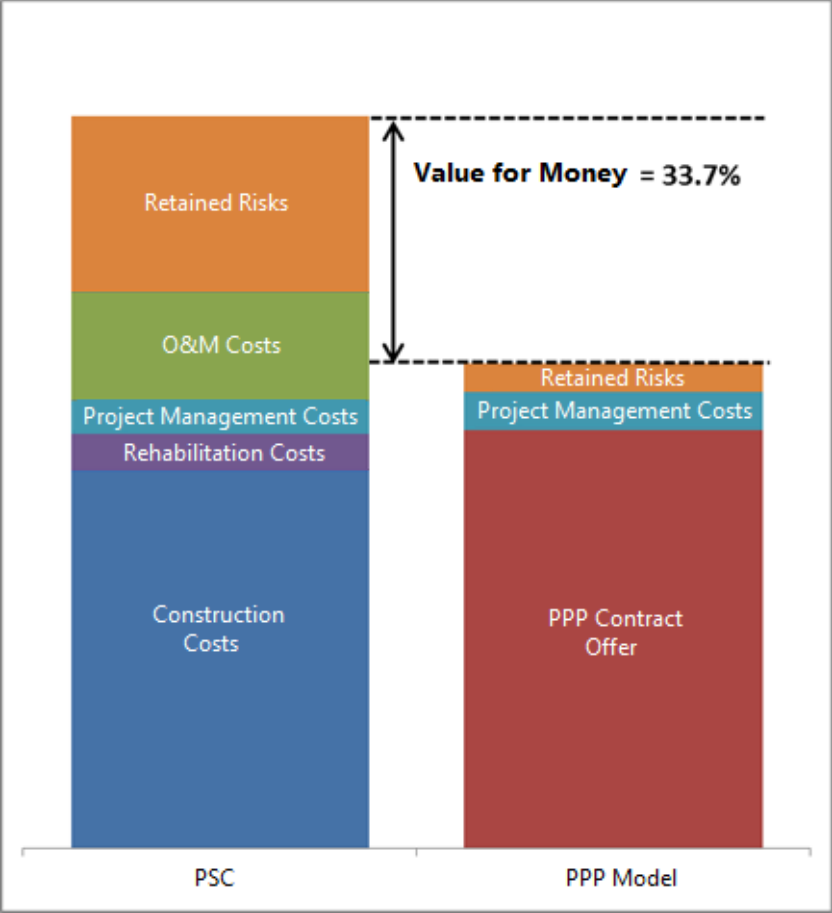


Figure 2: The Components of the Public Sector Comparator (PSC) and P3 project

termination of the procurement, sometimes rebidding or compensation for the private sectors is needed, which means that both sectors have to bear the significant loss from it (Song et al., 2018). In other words, the project can fail due to the innate attributes of PPP projects or the problematic operation process (Bertelli et al., 2020). In other cases, the PPP projects may be considered as fail because of the mismatch between the expectations and actual results. For example, due to the lack of experience, the government may promise a high return rate that cannot be achieved based on the current capacity by directly communicating with the private sectors without consulting the related experts (Tariq and Zhang, 2020). According to the world bank, between 1980 to 2016, 314 of 8,722 projects were terminated and one-sixth of them are located in China, which may be due to lack of experience for both public and private sectors in China (Song et al., 2018).

Risk sharing and allocation are important for the PPP projects and the deepened relationship between the public and private sectors distinguishes PPP procurement from the traditional procurement in the past (Wang et al., 2017). Risk transfer is perceived to be critical in realizing VFM in PPP projects (Bing et al., 2005). Although the risk factors may diverse be based on different criteria, for simplicity, this study will analyze risk factors from the perspectives of different stakeholders including the public sectors, private sectors, and other external stakeholders that do not belong to the above two categories. One way to achieve the share of risks, benefits, and costs among the stakeholders excluding the end-users is the equity share. In recent years, some calls are made to argue that the government should be the shareholder of the PPP projects and this will be beneficial for improving the performance of PPP projects (Hu et al., 2020). The risks can be generally divided into several types: government-related, law-related, procurement-related. Specifically, the government-led PPP risks can include "legal and regulatory provisions, policy framework, public sector capacity, project preparation and planning, project procurement, and contractual arrangement" (Wibowo and Alfen, 2015, 122).

In the analysis of the financing model of China's PPP in port, the financing risks can come from policy, exchange rate, financing, and operation (Liu et al., 2015). In the PPP projects there may exist three stages: "planning, procurement, and contract management" (Bing et al., 2005, 26). Then in the process of procurement, typically two stages are identified: bidding and contracting (Pu et al., 2019). Based on the procurement structure of the PPP projects, it is important from the beginning as the selection of the best bidder matters in the PPP projects in China (Raisbeck

et al., 2010). A reliable partner from the private sector can be vital in the final success of the PPP projects. The reliability can be judged by the government from past experience, the capability of the private sector, and the financial balance sheet of the companies (Xiong et al., 2019). The next step is to the contracting stage after winning the bid. Transparency throughout the processes can be important in the success of the final PPP projects. It means that the government and the bidders should negotiate and decide on the details and requirements that will be included in the contracts. However, sometimes the prolonged and lengthy negotiation to determine the risk allocation and operation details can be costly and have a low efficiency, which is a waste of public resources as well (Dixon et al., 2005).

Good governance has been perceived as a critical factor in determining the success of PPP projects (Zhang et al., 2015; Xu et al., 2015; Spraul and Thaler, 2019). In the contracting process, managerial strategies and operation skills are essential to the success of PPP projects. The managerial strategies include building trust through proper communication and relation approach, contract management, as well as the establishment of third-party agencies to monitor and supervise the PPP application (Rivera, 1996; Agyenim-Boateng et al., 2017). This is because, without the proper guidance and governance from the public sector side, the profit-pursuing nature of the private firms will even lead to lower quality of the final public services and good (Roehrich et al., 2014). However, in terms of relation approach, it may have the tendency towards corruption especially in the context of Chinese society that value interpersonal relation, which may become one of the risks (Chan et al., 2015). Moreover, considering the possible staff shift from both sides of the cooperation, the establishment of the information management system is more important in learning the lessons and experience from certain projects (Schofield, 2004). The knowledge gap that prevailed in the PPP projects not only refers to the skills needed in the risk allocation and the whole project assignment, but also the information asymmetry between the public and private sectors, which indicates that interpersonal communication is greatly needed (Boyer, 2016). Based on the unique features and application of different PPP projects, it is dubious whether certain experience such as the skill sets needed in one type of projects can be directly transferred to other PPP projects even in the same country, but it can be important to transfer the knowledge and experience at least within the same PPP project so that it will not be greatly influenced by the staff turnover. In the context of China, the specialized national agency to provide guidance and

monitoring for the PPP projects was not established until 2014 when the Ministry of Finance officially transferred the PPP working group to a PPP center (Cheng et al., 2016). After all, to achieve the goal of public good and VFM, the delivery of PPP projects requires endeavors from different stakeholders.

## **2.5 CSF and CRF in Chinese Smart City**

In China, economic development also brings about rapid urbanization and technological advances. The smart city concept has become popular these years with the promotion of the governments and the participation by the Chinese technology giants. In 2019, the global urbanization rate has reached 55% and the statistics in China is 60%, which is already higher than the global average level according to the world bank (World Bank, 2019). These days, the smart city is increasingly perceived as the solution for the various issues and problems occurred in urban development (Allam and Newman, 2018). Similar to the PPP concept, the smart city concept is vague and unclear as well. Although it has been often portrayed as the ultimate goal of the PPP projects, the scope of the smart city can be extended to a pretty large scale ranging from the transportation card system to traffic light smart control. Specifically, the types of smart city services can be divided into the following parts: economy, mobility, environment, people, living, and governance (Achmad et al., 2018). In terms of industries, the smart city concept has been prevalent in China as well with the advent of smart environment, smart traveling industry, smart governance, smart transportation, smart healthcare and a series of other applications. Compared to the other PPP projects, smart city has some key features. However, due to the ambiguity and ambitious goals of smart city projects and lack of relevant experience in achieving these goals, about 40% of smart city projects are suspended in China in 2018 according to the Ministry of Finance (Yang and You, 2019). This means that Chinese smart city projects are problematic and they are operated without clear guidance. The concept of a smart city is still novel around the world and a series of attempts are under further examination, and China is constantly making its efforts to grasp the opportunity to explore the new area. However, sometimes these so-called "smart city projects" turn out to be a waste of social resources and tax money when some opportunists made use of the title of the smart city so that they can obtain the funds and investment more easily without actually figuring out how to carry it out.

To pinpoint the major factors involved in smart city development, it is important to clarify the conceptual framework from the beginning. When it comes to the definition of smart city projects, it may be difficult to define them in a different context. On the one hand, some smart city projects are part of the PPP projects, which gives them some innate attributes of the PPP initially. On the other hand, the concept of the smart city is so broad that the boundaries between smart city devices and traditional digital devices are a blur. However, due to the comprehensive coverage of the smart city concept, sometimes even improving the internet online system or buying some smart-city related equipment such as the smart guidance machine can be considered as part of smart city projects as well. In a broader sense, it is true that smart city is built based on the minor improvements of some digital devices, the updates of the online platforms, and even the expansion of the use of smart applications on people's cell phone. However, for the clarification of discussion, in this study, only the smart city-related PPP projects will be discussed. The smart city PPP projects refer to those contracts attached with the name "smart city" clearly and it is a long-term project to achieve the final goal of a smart city in certain cities. The deal is often made between the city government and certain technology companies. For example, the Hangzhou government has initiated the city brain project cooperating with the Alibaba Cloud, which is a tech giant in China.

As for the smart city-related elements, there is some literature as well. It is argued that the important factors in smart city development can be measured by the internal factors (Citizen participation, leadership, and infrastructure) and the external factors (fourth industrial revolution, political will and stakeholders) (Myeong et al., 2018, 6). However, when measuring the external and internal factors, the concept can still be vague and unclear. More importantly, the elements associated with the smart city projects are a plethora. It seems to be clearer to categorize the determinant factors in smart city development based on three major actors involved in the smart city project: public sector, private sector, and the end-users. This is the main logic in including the factors relating to the smart city project development according to the 14 literature selected.

Compared to the other PPP projects, smart city PPP projects have their own characteristics. There are mainly two distinctive features are a high requirement and high level of interactions with the end-users. As for the former point, the smart city is newly developed in China, which means that both the public sectors and the private sectors are lacking relevant experience in



managing such projects, which requires a high level of managerial and communication skills to achieve cross-sectional cooperation. Even within the public sectors, in order to obtain the support and data sources from the different departments, a collaboration between the big data bureau and different government departments is necessary. From the perspective of the private firms, sometimes the technology requirements to carry out the projects are high as well depending on the specific project requirement. For example, in the case of the city brain, facial recognition technology, cloud computing, and other related techniques are developed for the overall smart city application. However, this does not necessarily be the case when the technology required is just to build a mobile phone application in the Wuxi city situation. However, it is fair to say that the overall requirements on managerial skills and technical skills are relatively higher than the traditional PPP projects in the past.

Another crucial feature of the smart city is the high level of interaction with the users. At the initial stage of the smart city, the skeptical views on personal privacy issue have prevented some projects from operating (Rebentisch et al., 2020). This reflects that the citizens have to at least implicitly agree with the data share, which is the premise of smart city development. Data is the core factor in the building of the smart city (Fu, 2018). Without permission to use the data, the construction will not be started. After the construction of certain smart cities has been completed, citizens again need to get adapted to the new changes and even learn new things so that they can use the new technology to actually facilitate their life. For instance, when the "smile to pay" function and the Quick Response code were adopted in China, people have to get used to them and learn how to use them on the cellphone. Although the transaction cost is little for the majority of citizens in China, sometimes the senior citizens have difficulty playing around the new things because many elderly people are even not familiar with the use of mobile phones.

Based on the characteristic of the smart city projects and the literature examining the determinant factors in PPP projects, this study has listed the following CSFs and CRFs that are considered to be critical in the smart city development in China. The Figure 3 below shows that the determinant factors in smart city PPP project development.

As for the CRFs in smart city PPP projects, one of the major problems is the laws and regulations are not well-established, which has been frequently pointed out by numerous literature (Yang and Xu, 2018). This has led to a series of other problems including the unclear monitoring

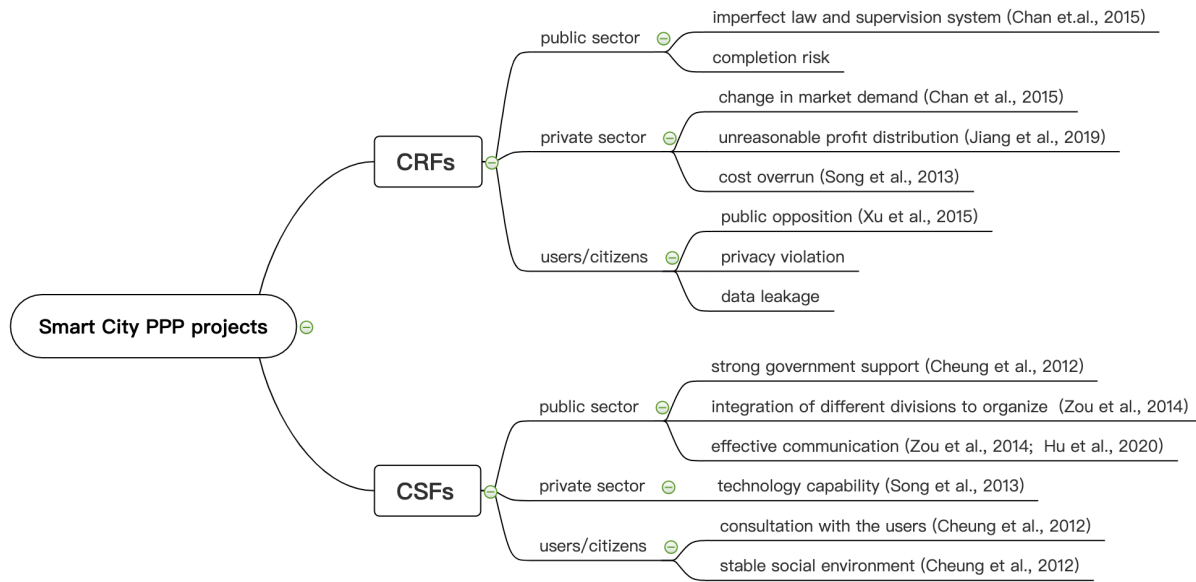


Figure 3: The CRFs and CSFs in smart city PPP projects in China

responsibility, the ownership and the use of personal data, and so on. Moreover, based on the high termination rate of smart city-related projects, the completion of such projects is problematic as well, which means that the social resources may be wasted in the process. From the side of private firms, they also suffer from the major risk of profits. They may get unfair benefit distribution when negotiating with the government. The cost may overrun compared to their expectations and the compensation from the government may not be guaranteed. Moreover, as part of the profit may come from the operation, if there is a change in the market demand, the enterprises will suffer from the loss when the profits cannot meet the expectations. For citizens, they may not be willing to give their personal data due to the cybersecurity concerns where people may misuse their personal information. Sometimes public opposition may call an end to smart city projects.

When discussing CSFs, the supportive government is undoubtedly essential in carrying out the projects. The supportiveness can be shown in the high level of managerial skills by incorporating the related government departments in the communication process. As for the private sectors, their own technical ability and experience in developing related smart city products and services are important, which will increase the possibility of success. In terms of the citizens, if their

opinions can be included in the decision-making process, the product design and service delivery may tend to be more popular among the users. As in the case of a survey regarding the smart city application used in Guangzhou city, which is a high-income city in China, the residents show a low level of satisfaction with concerns relating to "responsiveness, information accuracy, system reliability, perceived cost, and perceived risk" (Lin et al., 2020). As for the overall social atmosphere, if the cultural and social environment in certain places focus less on privacy issues and people hold an open attitude towards new technology and changes, the smart city projects are more likely to go smoothly afterward.

### 3 Data

In terms of measuring the research method used in the PPP performance-related elements, literature survey, interview method and case study are the most commonly adopted research methodologies (Jiang et al., 2019). However, in this article, we intend to explore more on the existing published documents and open data to run some analysis on the development of smart city. So far, we have collected three sets of database extracted from the website: the Chinese government contract website<sup>1</sup>, Bailu thinktank website<sup>2</sup>, and the open data platforms at different cities in China<sup>3</sup>. Overall, these three databases have illustrated the progress of open data in China and how smart city developments are pushed forward by the Chinese government.

The first one, the government contract database have included the bidding information about the smart city-related projects. However, it is noteworthy that the contracts can be ranging from updating the internet system to building up an online platform for the government departments. Essentially, this is due to the vague nature of the concept of smart city. When identifying whether this project is related to smart city or not, the criteria may be difficult from the first place. However, to make a more precise judgement to select the contracts that meet the requirements of the purpose of our study: smart-city related. We later have turned to the text analysis method based on the Bailu thinktank database to identify the smart-city related contracts. Bailu thinktank website, though it is a commercial website, has generated the policy documents from all levels

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<sup>1</sup><http://www.ccg.gov.cn/>

<sup>2</sup><http://www.bailuzhiku.com/>

<sup>3</sup><https://data.beijing.gov.cn/>, for example

of the government. This is valuable and convenient because normally the government documents are dispersed at different websites. As this Bailu website has collected all the policy documents in one website, we can obtain a relatively comprehensive policy documents relating to smart city by extracting information from this website. Firstly, we searched the key word "smart city", then if the title contains this key word, we will extract the following information from this piece of policy documents: title, context, government department, release time. Second, after 8625 policy documents were collected, we run a text analysis on the context of the documents and then summarized the word frequency that appeared in all the document context. Based on these words that are frequently shown in the smart-city related policy documents, we will use these words to identify the smart-city related contract in the first database. Specifically, if the contract title contains the key word, we will regard this as the smart-city related contracts.

The last database is about the open data platforms, it has been developed by some different cities especially after the year 2016. The open data platforms is established by the government and its goal is to release some datasets held by different government departments and let the individuals, enterprises and social organizations have chances to get access to the data and fully utilize them by making mobile phone apps or other ways. From the open data platforms, we extracted the following information: total number of the datasets, total number of the visits, total number of downloads, total number of API use, title of individual dataset, the publish time of the dataset, the update time of the dataset, the government department published this dataset, the downloads of the datasets, the API use times of the datasets, the APP made based on the datasets released. However, through collecting the datasets, a large number of missing values exist especially in terms of API use. Moreover, as different government website in each different may have a different formats, sometimes the missing values are due to the different designs of the website and certain cities do not release the categories that are available on others. This database is mainly used for measuring the application levels and the data release in each city. At this point, we have collected the information from 11 cities including Beijing, Fuzhou, Jiaxing, Lishui, Ningbo, Quzhou, Shaoxing, Shenzhen, Taizhou, Wenzhou, and Zhuhai.

### 3.1 The Government Contract Database

To identify the smart-city related research articles, this study adopted the key-word identification method. Firstly, we identified the smart city-related and technology-related key words as much as possible: IoT, Blockchain, Big data, Data analysis, AI, Smart city, Tianwang, PPP, Digital Government, Xueliang, Safe city, Intelligence. Specifically, if the contracts' context contain these key words, they will be included in the database.

Furthermore, we also tried to extract other data and information from the website including Date, Bid winner, The address of supplier, The context, The amount of money, Purchasing agent/Procurer, The address of procurer, The list of evaluation experts and Title. Secondly, I calculated the number of bids in provincial-level as the proxy for the government spending on smart city. However, the eventual research scope will be at the city level. The city level is more reasonable because the regional disparities in smart-city development among different cities can be large. Thus, it will be more appropriate to adopt the city-level data. The Table below lists the number of bids in each province from 2016 to 2019.

As shown in the Table 2, Beijing, Henan, Fujian, Guangdong and Gansu tend to have more smart-city contracts overall speaking. In terms of time scope, the year 2018 witnessed a relatively large number of contracts happening compared to 2017 and 2019. Generally speaking, the places have a relatively low economic level will not have a lot of smart-city related contracts such as Xinjiang and Xizang. However, places like Hunan and Tianjin also have fewer smart-city contracts compared to other provinces with similar economic development levels.

	2017	2018	2019	Overall (2013-2020)
Beijing	3180	4967	3906	24604
Tianjin	104	139	279	850
Hebei	1284	1732	1912	11316
Shanxi	138	460	366	2063
Neimongal	316	124	300	3664
Liaonin	649	988	699	4269
Jilin	827	1028	738	5060
Heilongjiang	1098	1318	1050	6557
Shanghai	838	572	459	5680
Jiangsu	561	827	965	5958
Zhejiang	708	499	81	6116
Anhui	7584	4185	1923	19450
Fujian	2205	3279	2547	27706
Jiangxi	1795	288	186	5181
Shandong	5248	7891	5570	35583
Henan	27900	39203	20273	130874
Hubei	532	530	532	2994
Hunan	134	121	103	860
Guangdong	5520	5422	4362	40345
Guangxi	2054	2694	1799	13294
Hainan	349	398	276	2062
Chongqing	309	481	614	3796
Sichuan	138	229	258	1304
Guizhou	634	1037	751	4844
Yunnan	1369	1823	1110	9707
Xizang	42	64	146	603
Shan'xi	1053	800	91	3516
Gansu	3002	4170	2747	17319
Qinghai	276	515	19	1118
Ningxia	717	1234	1246	6266
Xinjiang	44	75	160	608

Table 2: The number of bids at the provincial level

### 3.2 Bailu Thinktank Policy Documents

After collecting the 8625 smart-city related policy documents, we run an analysis on the context of the data and calculated the word frequency appeared in the policy documents. Figure 4 shows 20 policy-context words with highest frequency. Although in the table and the word cloud only the first 20 ones are shown, we have calculated the word frequency of 1000 words in total. Due to the limit of the space, we will only show the first 20 ones here.

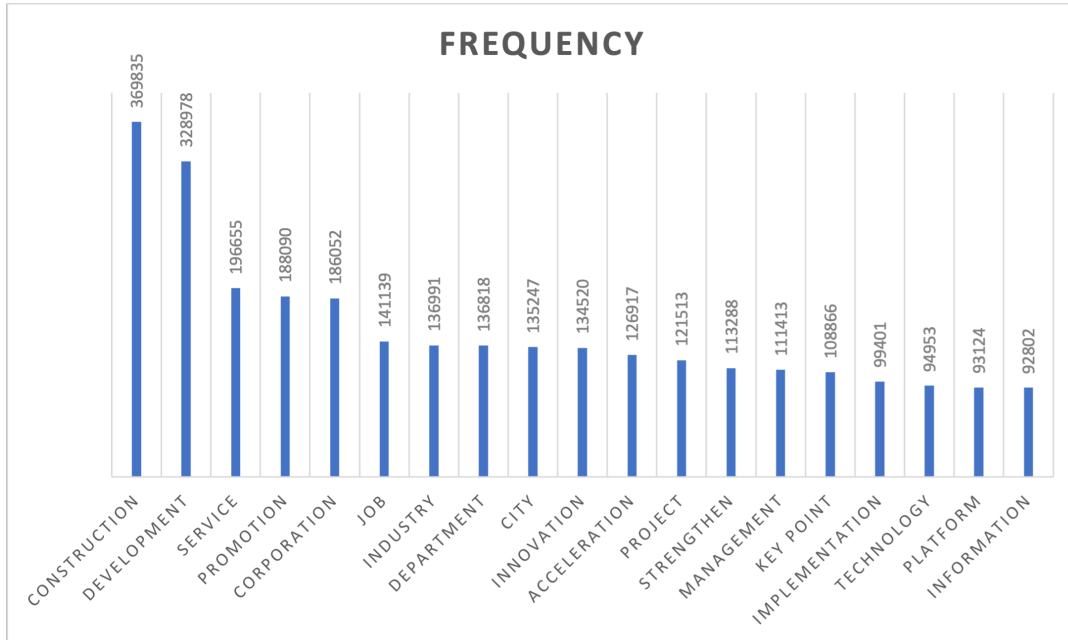


Figure 4: Frequency of Policy-Context Words

As shown in the Figure 5 below, some words are so general that it is hard to link them with the smart-city directly. The word "Build", "development of" and "advancement" have a relatively higher frequency among all the key words, however, this is mainly because the documents frequently talk about the building up the smart cities in their cities. It is also noteworthy that the word "enterprise" also shows up frequently, which means that the public and private sectors are working closely to carry out the smart-city projects in China. Based on this, we will select the key words based on the relevance of the smart-city instead of the ranking of the key words. After selecting the key words, we will use these key words to match the smart-city related contracts in the government contract database.



Figure 5: Word cloud

### 3.3 The City Government Open Data Platforms

The open data platforms are newly developed by the government in recent years. Most of the cities have built such a platform, however, only a few of them have released the API that can directly be used by the APP developers. This is a very important variable because if they have the API, which can significantly facilitate the process of developing APPs and the developers can directly use some of the computer functions embedded in the datasets from the first place. The API is often comes with the datasets, and the datasets with the function of API can be made into APPs more easily. In most of the cases, the API and datasets share the same names, but sometimes the datasets are released without the API attachments.



As shown in the Figure 6, Beijing and Shenzhen departments have performed well in providing the datasets attached with the API. Moreover, the bureau of statistics tend to the department that publish large flows of datasets. In the wenzhou, the big data development authority publish the most API. This is understandable because the responsibility of these data organizations is to collect the data from the local area. If they are willing to release more data on the open data website, the amount of data and API released will be large.

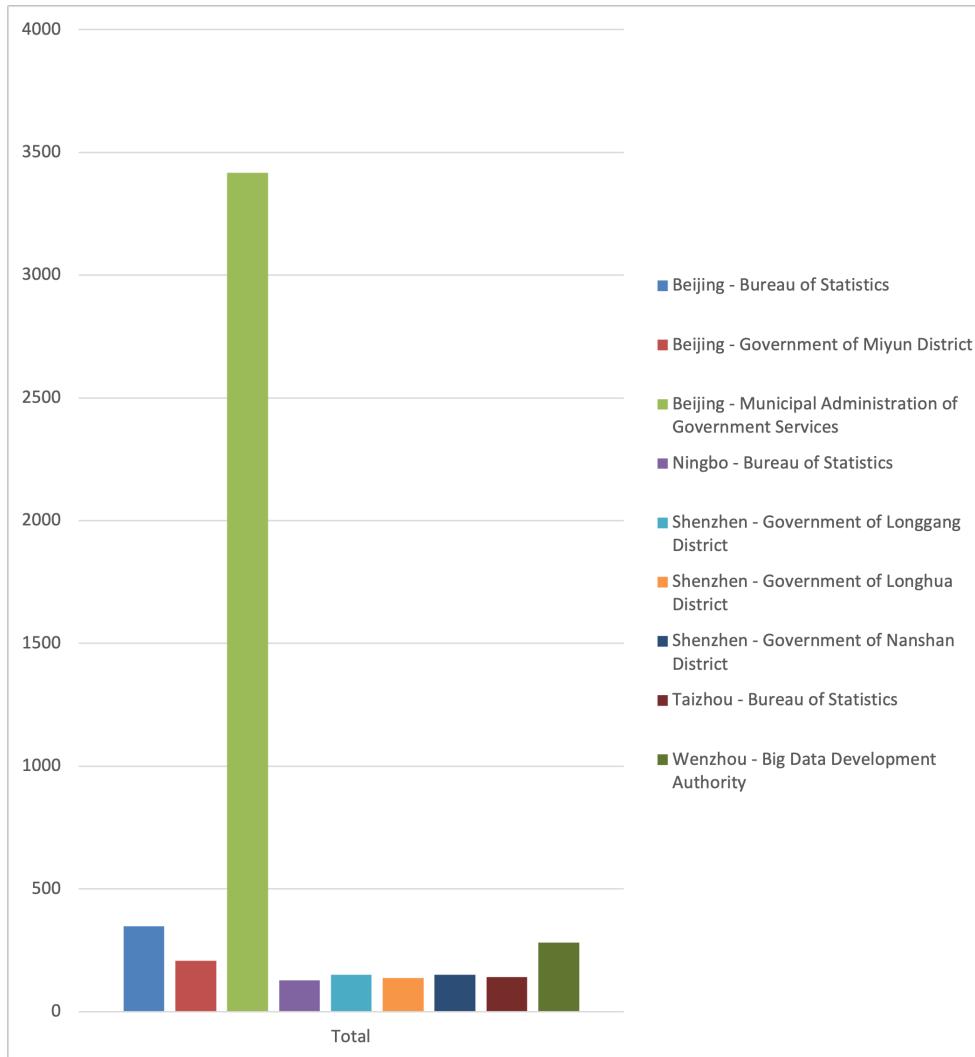


Figure 6: Ten departments with most API Released

In the Figure 7, many cities only have recordings about the publish time within these two years. However, due to a large amount of missing values, it is hard to make a judgement about the situation before the year 2020. This is also because the website is newly established for most of

the cities in China. Moreover, due to the lack of universal formats in the websites, sometimes they do not have the publish time for some datasets. The data also indicates that Shenzhen perform well in terms of the completeness of the categories released, as it has the publish time for the datasets even back to the year 2016. It has started paying more attention to the data release, website building and the comprehensiveness of the data from a early time.

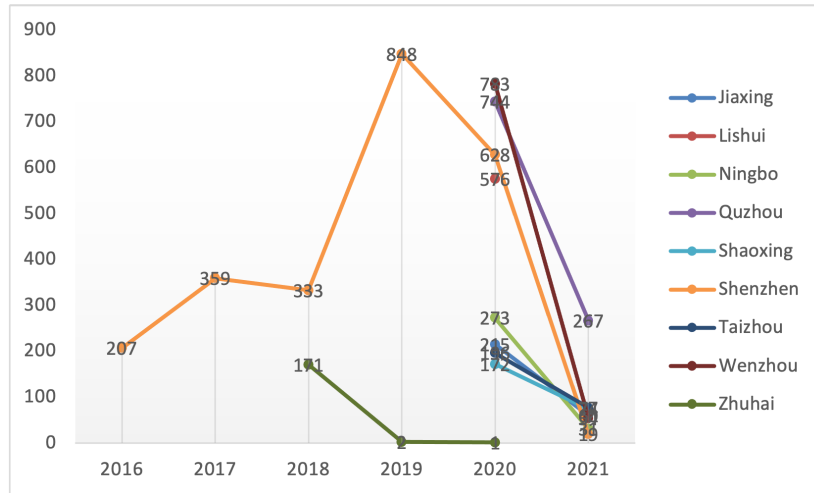


Figure 7: The Amount of Datasets Released from 2016 to 2021 in 11 Cities

As for the industry categories in Figure 8, it is not surprising to see that the government sector has released the most datasets compared to other ones. However, as this classification is directly extracted from the website, we have founded that sometimes the datasets in other industries are also categorized as the government. Even the classification in the same city is not consistent because sometimes two similar contracts are categorized as two different industries. We will further categorize the industry by ourselves. Apart from the government sector, education, life service and environment have published the most datasets overall speaking. This is a good sign as these three categories are closely related to people’s daily life. As the website is mainly built to open to the public, the datasets that are more related to the people’s life should be publish more to some extent.

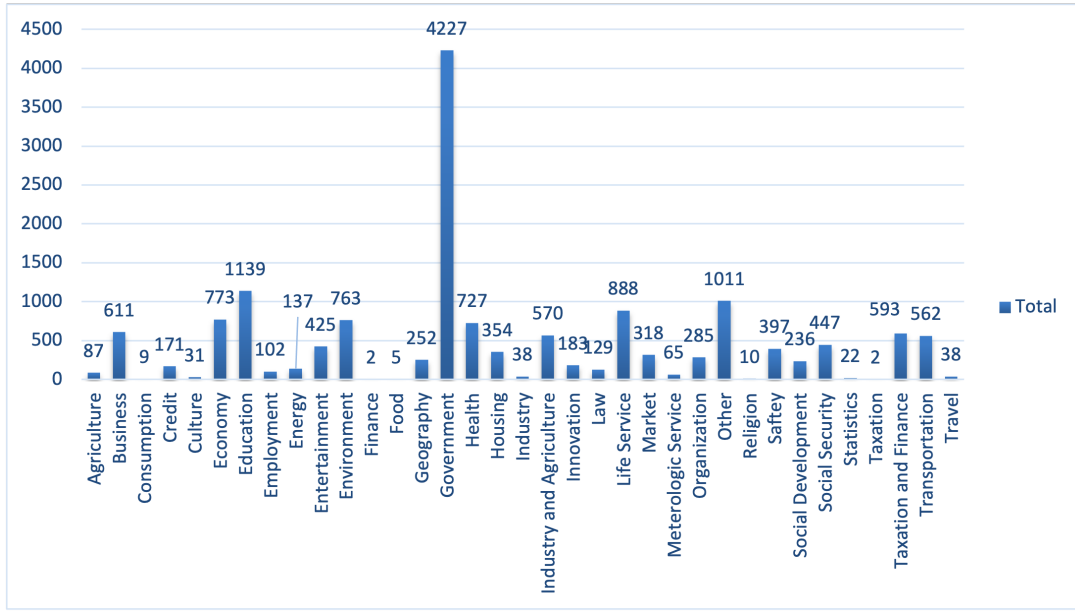


Figure 8: Frequency of each industry

Table 3 reports key internet user’s information by sectors, including the sum of viewer, the sum of download, the sum of data, and the sum of API use. The distribution of each sum is not even and it cluster in some sectors, implicating that internet users’ primary concerns are economy, entertainment, social development and agriculture. Surprisingly, finance and taxation, which are regarded as the field mostly driven by big data by normal people, draw less attention than what we expected. On the contrary, the data from the agriculture has received more attention than other ones. This is maybe due to the weather data. Although weather is actually seen as an index that are concerned with individual’s daily life, it has been put in the category of agriculture. Moreover, since weather data is not sensitive and has already been available on multiple platforms, the government is also willing to release such data.

Sector	Sum of download	Sum of Viewer	Sum of Data	Sum of API use
Agriculture	115063	16939	3930793	174709
Consumption	4876	516	6436	10
Culture	27573	6980	3674	3498
Economy	1907266	73808	18378594	
Entertainment	925466	37275	245249	
Finance	2218	539	288	207
Food	2339	382	98	22
Industry	39282	9652	4367	4272
Religion	23969	587	1018	57
Social Development	943562	52223	7856205	
Statistics	9357	2218	87967	1052
Taxation	2135	536	3054	227
Travel	14628	1679	1345759	38

Table 3: Internet’s Information by sectors

## 4 Conclusion and Policy Implication

In conclusion, from the perspective of theory building and actual construction, smart city development in China still has a long way to go. Based on the literature analysis, in the future, it is important to further improve the legal and regulation regarding the data use and monitoring in the smart city projects in China. Moreover, rather than the quantities of smart city projects, the quality of them should be focused on as well. Not only the communication between the public and private sectors should be effective, but also the involvement of the citizens is important as well, which has been largely overlooked all the time in China and other places as well. Without the proper participation of the citizens, the final product and services may not have a high level of satisfaction among the end-users.

Based on the situation of the current open data platforms, a large amount of datasets do not get enough attention from the public with 0 download. On the one hand, the website may not be widely known among the citizens when they want to find the related data. On the other hand,

the supply of the datasets sometimes do not meet the expectations and needs of the people. This is because due to the security concerns, the government may not release the important datasets and the ones released are not very relevant to people's daily life. To pursue the larger number of datasets released to make the statistics look good, they may try to release a large number of datasets that people do not care about. This is the major problems occurred in the establishment of the data platforms. However, we also need to admit the efforts put into building up the websites and many cities have been holding competitions to encourage citizens utilize the data to develop APPs these days. we believe the trend of data release and data use among people will keep evolving in the future.

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