

PUBLIC-PRIVATE PARTNERSHIPS FOR IMPLEMENTING
SPONGE CITY DEVELOPMENT: A CASE STUDY OF
XIAMEN CITY, CHINA



A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Science in Urban Strategies

Department of Urban and Regional Planning

FACULTY OF ARCHITECTURE

Chulalongkorn University

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การร่วมทุนระหว่างรัฐและเอกชนในการดำเนินโครงการพัฒนาตามแนวคิดเมืองฟองน้ำ:

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ติง ชู : การร่วมทุนระหว่างรัฐและเอกชนในการดำเนินโครงการพัฒนาตามแนวคิดเมืองฟองน้ำ: กรณีศึกษาเมืองเซี่ยเหมิน ประเทศจีน. (PUBLIC-PRIVATE PARTNERSHIPS FOR IMPLEMENTING SPONGE CITY DEVELOPMENT: A CASE STUDY OF XIAMEN CITY, CHINA) อ.ที่ปรึกษาหลัก : อภิวัฒน์ รัตนวราหะ

ใน การ ล ด กั ย พื ธิ บั ติ จ า ก ส ท า พ อ า ก า ศ ที่ รุ ้น แ ร ง ซึ่ง มี ส า เ ห ตุ มา จ า ก วิกฤตการณ์เปลี่ยนแปลงสภาพภูมิอากาศในเมือง รัฐบาลจีนได้เสนอแนวคิดการสร้างเมืองฟองน้ำขึ้นในช่วงไม่กี่ปีที่ผ่านมา อย่างไรก็ตาม การก่อสร้างเมืองฟองน้ำมีลักษณะเฉพาะที่สำคัญ ได้แก่ การลงทุนมหาศาล มีระบบหมุนเวียนที่ขึ้นขา และมีความเสี่ยงมากมาย จึงเห็นได้ชัดว่า เป็นการยากที่จะดำเนินโครงการเหล่านี้โดยอาศัยและพึ่งพาการลงทุนจากเพียงภาครัฐเป็นหลัก ดังนั้น จึงได้เกิดโครงการความร่วมมือภาครัฐและภาคเอกชน (Public-private Partnership) ทำให้เกิดโครงการที่ภาคเอกชนได้เข้ามามีส่วนร่วมกับภาครัฐในการจัดสร้างแบบจำลองเมืองฟองน้ำ

การ ดำ เนิน การ โ คร ง ส รั ้าง พื ฐ าน ข อ ง เมื อ ง โ คร ง การ PPP สามารถช่วยลดความเสี่ยงอย่างมากในหลายด้านให้แก่ผู้มีส่วนเกี่ยวข้องกับการจัดสร้างเมืองฟองน้ำในหลายแง่มุม รวมถึงการเร่งรัดการก่อสร้างโครงสร้างพื้นฐานของเมืองฟองน้ำหลายแห่ง อย่างไรก็ตาม รูปแบบ PPP อาจยังมีข้อบกพร่องอยู่บ้าง งานวิจัยฉบับนี้จะอธิบายความหมายพื้นฐานของฟองน้ำเมือง และความสำคัญของการใช้แบบจำลอง PPP ในการก่อสร้างของเมืองฟองน้ำ เมื่อ พื จาร ณา จ า ก คุ ณ ลั ก ษ ณะ ความ ตี อ ง การ และ การ วิ เ ล ร าะ ห์ เมื อ ง ฟ อ ง น้ า รวม กับ ลักษณะ และ กลไก การ ดำ เนิน งาน ของ แบบ จ ำ ล อ ง เมื อ ง ฟ อ ง น้ า โดย แนว ท าง PPP ผ่านกรณีศึกษาของการก่อสร้างแบบจำลองเมืองฟองน้ำด้วยวิธีการ PPP ที่เซี่ยเหมินในประเทศจีน ได้มีการเพิ่มปัจจัยความสำเร็จในการสร้างเมืองฟองน้ำ PPP เพื่อปรับปรุงรูปแบบการดำเนินงานทั่วไปของแบบจำลองเมืองฟองน้ำ PPP ได้แก่ การระดมทุนจากแหล่งต่าง ๆ การประเมินความคุ้มค่าทางการเงิน การกระจายความเสี่ยงทางการเงิน รูปแบบการดำเนินงาน การกระจายความเสี่ยง และ กลไก การ ท ด แ ท น การประเมินและกลไกการกำกับดูแลบทบาทที่สำคัญอย่างยิ่งต่อการส่งเสริมและผลักดันแบบจำลอง เมืองฟองน้ำ PPP ให้พัฒนาต่อไปในอนาคต

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To mitigate the disasters caused by extreme weather induced by climate change in cities, the Chinese government has proposed the implementation of sponge cities in recent years. However, the construction of sponge cities is characterized by significant investments, long project cycles, and many risks. It is difficult to implement the project only by relying on government investment. Therefore, Public-private Partnership (PPP) model is gradually applied to sponge cities' implementation. As a model of urban infrastructure implementation, PPP can significantly reduce stakeholders' risks in some respects and accelerate infrastructure implementation in sponge cities. However, the PPP model has some disadvantages.

Therefore, the research purpose of this thesis is how to improve the sustainable development of Sponge City PPP projects by avoiding the defects of the PPP model as much as possible. This thesis mainly analyses the critical success factors in the case of Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP Project to discuss this problem. However, before that, the basic concepts and contents of Sponge City, PPP model and critical success factors of Sponge City PPP projects will first be introduced as the basis for discussion. The critical success factors that this thesis will discuss include value for money evaluation, financial affordability demonstration, operation mode, risk allocation, contract system, project transaction structure and return mechanism, procurement method, performance appraisal, and supervision system.

Field of Study: Urban Strategies

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To be or not to be is a matter of thought. The rustling wind does not take away the sadness, nor does it bring joy, since later, there is no reason to be sad and happy. Everything is just life. But there are still some people and experiences to be thankful for.

Firstly, it is much appreciated for the time of this period. It perhaps is the most memorable time in my long 20-odd years. The feeling is as if a swimmer who has been drifting on the sea for a long time sees an island in different weather. Sometimes it's there, and sometimes it's gone without a breath. But the swimmer seems lucky because most of the time it would like to seek it, it is almost there, clearly or vaguely, far away or near, forcefully or casually. But what does it matter? That's life. Serendipity is anywhere.

Also, much appreciated for those who have come during this period. They may lead me to chase the lights, walk with me through the mud, and adorn my life. But there are always some persons who never walked out of my memory. Oh, is that you? You're here? You're here, with the vitality of ice melting in spring, with the spirit of running after the wind, and with a light childish. Who are you? You are the one who can feel what I feel. Thank you for coming and lighting up my life.

And finally, thank you for the lights that have stuck with me for so many nights; thank you for the songs that shadow me throughout the day; thank you for the sunsets that appear on time in the evening; thank you for those birds that arrive as scheduled in the morning.....

It's getting dark. The wind is rising. I need to go back.

Ting Su

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Chapter 1 Introduction

This chapter introduces the general ideas of this thesis. It includes the problem statement and research significance, the research question, the scope of research, the methodology, and the thesis structure.

Problem Statement and Research Significance

With the further development of urbanization, ecological and environmental problems in many cities have gradually deepened, resulting in a variety of urban disasters, such as flood disasters, earthquakes, fires, extremely high risk, extremely low temperatures, and so on. Sponge City, as a means of urban planning for water management, can improve urban microclimate to a large extent, weaken flood disasters, reduce sewage runoff, purify water sources, and weaken the urban heat island effect, thus improving the overall service function of the ecosystem, creating a good ecological environment, and effectively improving the quality of life of residents. As you can see, Sponge City could help to achieve huge social benefits (Li & Dong, 2018). However, many projects in sponge cities, such as parks, squares, municipal roads, and pipe network renovation, belong to the implementation of urban infrastructure and have quasi-operational or non-operational characteristics. They cannot directly obtain returns, and there is no clear economic return mechanism. Therefore, Sponge City projects have traditionally been difficult to attract social capital (Jia et al., 2017). Its implementation is largely dependent on government funding. But the government's budget is limited, and it cannot devote all of it to the huge funding needs of Sponge City projects. Therefore, the implementation of sponge cities urgently needs the participation of social capital.

Public-private Partnership (PPP) model provides facilities or services by sharing benefits and risks between government and social capital partnership (Grimsey & Lewis, 2002; Spackman, 2002). It is, therefore, widely used in a series of infrastructure projects around the world (Kumaraswamy & Zhang, 2001; Carbonara et al., 2014; CNY et al., 2018), such as education, health care (Languille, 2017), culture (Ventura et al., 2016), highways, railways (Rouhani et al., 2018; Musso & Dalla Chiara, 2017; Boeing Singh & Kalidindi, 2006), water supply (Ameyaw & Chan, 2015), electricity (Akampurira et al., 2009), municipal sewage treatment (Yang et al., 2017), agriculture (Poulton & Macartney, 2012), information technology (Kuriyan & Ray, 2009), etc.

Now, the academic research on PPP in China's infrastructure implementation field mainly includes definition, connotation (Chen & Xia, 2010), feasibility and applicability (Chen & Xia, 2010), classification, function, advantage (Ye & Xu, 2013), operation process (Ye & Xu, 2013). 2013), Value for Money evaluation and pricing mechanism (He & Sun, 2010); Ye & Yang, 2012), profit distribution (Ye & Li, 2014), and risk mechanism (Chen et., 2012). The research on PPP in Sponge Cities mainly includes financing methods (Chen & Zhang, 2003), implementation points (Liu, 2016), implementation methods (Da et al., 2016; He et al., 2016), and investment management (Zhu, 2016). However, these studies mainly discuss PPP projects in sponge cities from the perspective of "feasibility", and rarely discuss the construction, operation, and maintenance of PPP projects in sponge cities from the perspective of "sustainability".

In addition, in the implementation in China, the implementation rate of Sponge City PPP projects is not high. In the China Public Private Partnership Center (CPPPC) project database, Sponge City PPP projects are distributed in three first-class industries: ecological construction and environmental protection, municipal engineering, and comprehensive urban development. As of August 12, 2022, the project database has collected 76 Sponge City PPP project-related projects. They are distributed in 21 provinces, autonomous regions, and municipalities. Four of the records were in a stagnant update state. Currently, the operation mode and return mechanism of China's Sponge City PPP projects are diversified, but the BOT mode is dominant. Sponge City PPP projects are mainly initiated by the government, and the mainstream of their payment method is government payment. There are 40 projects implemented by "government payment", accounting for more than 50% of the PPP projects in Sponge Cities. Therefore, if government funds are insufficient, Sponge Cities cannot continue to be implemented, developed, and play their positive effects. That means the development of sponge cities lacks sustainability.

Therefore, there is a literature gap and practical demand for the sustainability research of PPP projects in Sponge Cities. This paper intends to study the critical success factors of Sponge City PPP projects from the perspective of "sustainability". Therefore, the research question of this thesis is, "How do critical success factors of Sponge City PPP projects affect their sustainable development?"

Research Question

The research question of this paper is "How do critical success factors of Sponge City PPP projects affect their sustainable development?" This paper will analyze the critical success factors of Sponge City PPP projects from the perspective of "sustainability" from the following aspects.

- 1) Sort out the basic concepts of Sponge City and PPP, elaborate the theoretical basis of the analysis in this paper, and lay a conceptual and theoretical foundation for the following research.
- 2) Introduce the implementation status of Sponge City PPP projects in China and Xiamen, and elaborate the basic information of the project to be studied, "Xiamen Xiang' an Underground Comprehensive Pipeline Corridor PPP Project," in general, which gives readers a basic understanding of the discussed object in this thesis.
- 3) Put forward the "critical success factors" of Sponge City PPP projects to be studied in this thesis through the current research literature, the official operation guidance on PPP projects, and the experience of the implementation; Then, from the perspective of "sustainability", combined with the analysis theory mentioned above, the "critical success factors" of Xiamen Xiang' an underground comprehensive pipeline corridor PPP project are extracted and analyzed. Meanwhile, proposing suggestions for some critical success factors to improve the extensibility of its implementation experience.
- 4) Provide a conclusion on how critical success factors affect the sustainable development of Sponge City PPP projects.

Scope of the Research

This paper studies how Sponge City PPP projects in China, with the support of central and local government policies and limited funds, can achieve sustainable development of Sponge City PPP projects by reviewing of the implementation of critical success factors. The specific object of the research is "Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP project". The research perspective is "sustainability". The entry point of the study is the "critical success factors" of PPP projects in sponge cities. The study aims to improve the sustainability of Sponge City PPP projects.

Research Methodology

The principal methodologies are case study and content analysis of relevant documents associated with the case study.

Case Study

The PPP project case of Xiamen to be analyzed in this paper is "Xiamen Xiang 'an underground comprehensive pipeline corridor PPP project". Its data mainly come from China Public Private Partnership Center (CPPPC). CPPPC is an official communication platform established by the Chinese government to promote the development of PPP in China. It collects relatively complete and accurate data related to China's PPP cases, including the evaluation documents, execution documents, and contract documents of every step, including the scanned copies of the originals. Therefore, the required information can be obtained in most cases. In principle, it is optional to know the implementation details of critical success factors of Xiamen Xiang 'an underground comprehensive pipeline corridor PPP project through other methods such as interviews and questionnaire surveys.

Documents obtained in this thesis for the implementation details of critical success factors of Xiamen Xiang 'an underground comprehensive pipeline corridor PPP project include Xiamen Xiang 'an PPP Project - Value for Money Evaluation Report, Xiamen Xiang 'an Financial Affordability Demonstration Report - Financial Affordability Demonstration Report, Xiamen Xiang 'an underground comprehensive pipeline corridor PPP project implementation plan. The "critical success factors" are proposed based on the review and analysis of existing Sponge City and the official guidance of PPP projects, theories, research, and implementation experience. Therefore, after putting forward the "critical success factors", this paper only analyzes Xiamen Xiang 'an underground comprehensive pipeline corridor PPP project. In addition, Xiamen Xiang 'an underground comprehensive pipeline corridor PPP project is typical (see Chapter 4 for the specific introduction of Sponge City in Xiamen).

Literature Review

The literature reviewed in this thesis includes book monographs, academic papers, websites, news reports, and so on. From the kinds of literature, this thesis firstly attempts to understand the basic concept of Sponge City and its development process; secondly, it would like to understand the PPP application field, the PPP application status in Sponge City implementation, the PPP operation processes, and the specific details in promoting Sponge City projects; thirdly, this thesis attempts to understand the supporting theories of the analyses of this thesis. Finally, the literature review aims to understand the implementation progress and effect of Sponge City PPP projects in China through websites and news reports.

Structure of the Thesis

Chapter 1 introduces this thesis' background, significance, purpose, scope, and method. Chapter 2 reviews Sponge City and the situations in China, PPP, PPP on Sponge City, and supporting theory through the literature review. Chapter 3 introduces the operation processes and critical success factors of the Sponge City PPP projects. Chapter 4 first introduces the Sponge City situation in Xiamen and the general situation of the Xiamen Xiang'an underground comprehensive pipeline corridor PPP project. Then it will discuss the specific critical success factors of the Xiamen Xiang'an underground comprehensive pipeline corridor PPP project by drawing the case's details. Chapter 5 is the conclusions and deficiencies of this thesis.

Summary

This chapter introduces the research background, significance, and specific research content and scope. The next chapter will introduce the basic concepts and situations of Sponge City and PPP, and the relevant theoretical support behind this thesis.

Chapter 2 Literature Review

This Chapter will introduce the basic relevant concepts and situations of Sponge City, Public-private partnership, and the analytical theories.

Sponge City

This part introduces the concepts of Sponge City including its definition, connotations, goals, functions, and situations in China.

Definition and Connotations of Sponge City

"Sponge City" is an urban water resources management strategy that China draws lessons from the theory and practice of urban water resources planning and management in other countries (Nguyen et al., 2019). It incorporates the experience of the United States' best management practices (BMP) in the 1970s (Fletcher et al., 2015), the UK's sustainable urban drainage system (SUDs) (Fletcher et al., 2015), the blue-green city system (BGCS) method (Thorne et al., 2018), the low impact development (LID) method (Pyke et al., 2011), the Water sensitive urban design (WSUD) in Australia (Brown et al., 2009) and the low impact development urban design (LIDUD) in New Zealand (Chui et al., 2016), etc.

The concept of "Sponge City" mentioned in the Chinese government's strategic documents refers to the full play of the role of natural rainwater absorption and storage system in urban water system implementation and green space Urban development mode of natural purification (Guowu CNY Bangongting Guanyu Tuijin Haimianchengshi Jianshe de Zhidao Yijian [Guidance of the General Office of the State Council on Promoting the Construction of Sponge City], 2015).

In terms of the realization process, the implementation of "Sponge City" is based on the cross-scale ecological planning theory and method system, including macro, meso, and micro levels. Macroscopically, the implementation of "Sponge City" is to study the spatial pattern of the water system in a region or watershed, that is, to analyze the pattern of water ecological security, and to implement the pattern of water ecological security in the overall land use planning and the overall urban planning. At the meso level, it first focuses on how to effectively use the rivers, pits, and ponds in the planning area (urban area, township, and Village). Then it reasonably plans and forms

an entity "urban sponge system" in combination with the distribution of catchment areas and catchment nodes, and finally implements it in the land use control plan. At the micro level, "Sponge City" implementation refers to the "sponge body", namely the implementation of water ecological infrastructure implementation technology. Among them, low-impact development plays an important role and is one of the key implementation points (Yu et al., 2015). It mainly includes green infrastructure, such as urban water systems, green space, greenways, wetlands, local vegetation, and other systems, and the implementation of gray infrastructures, such as urban water supply and drainage infrastructure (Wei & Zhao, 2018).

It should be noted that low-impact development is one of the key points of "Sponge City" implementation, but it is not the whole of "Sponge City" implementation. There are essential differences between them. Low-impact development is an urban rainwater management concept that emphasizes reducing the cost of rainwater management by maintaining and protecting the natural hydrological function of the site through small control facilities scattered at the source (Eckart et al., 2017). It is more inclined to the rainwater management of a specific, small-scale site (Chaill, 2012). "Sponge City" is a concept on the level of urban planning.

Goals and Functions of Sponge City

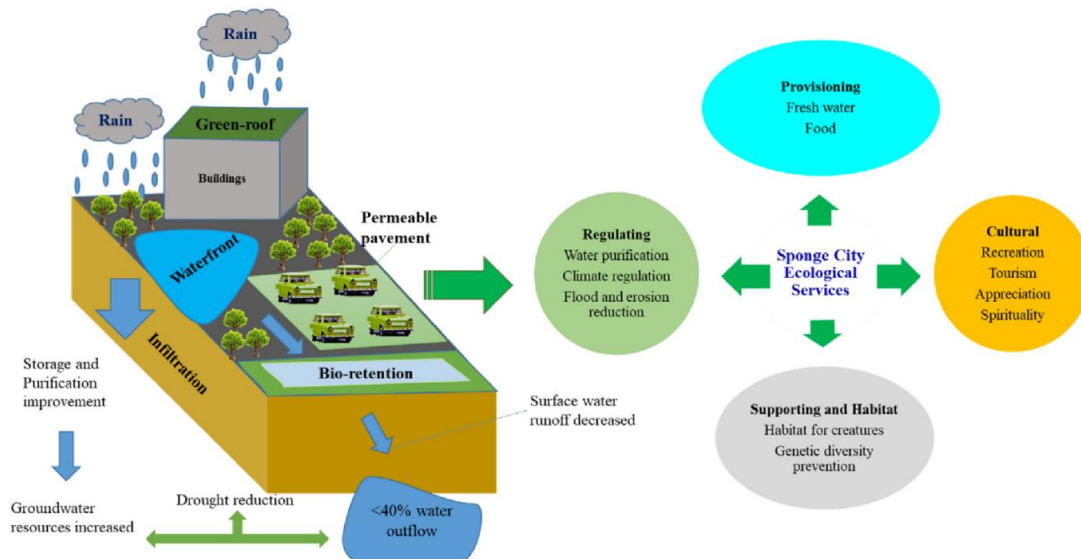


Figure 1 Schematic design of the Sponge City and Sponge City Ecological Services (Nguyen et al., 2019)

The implementation of "Sponge City" finally realizes the implementation of a complete functional system of the water system - supply services, regulation services, life-bearing services, and cultural and spiritual services (Figure 1 is the schematic diagram and functional system of "Sponge City"). These could enhance the overall service function of the ecosystem, comprehensively solve urban ecological problems and make the city more "flexible" (Ashley et al., 2013). It includes the implementation of a regional urban flood control system, biodiversity protection and habitat restoration, cultural heritage network and recreation network, local rainwater and flood management, water quality purification, groundwater supplement, brownfield restoration, biological habitat conservation, park green land implementation, and urban microclimate regulation (Yu et al., 2015).

Sponge City Projects in China

After Chinese scholars learned from the experience of other countries in water management to clarify the concept, technology, and other relevant contents of "Sponge City", in 2014, central ministries (the Ministry of Finance, the Ministry of Housing and Urban-Rural Development, the Ministry of Water Resources) jointly carried out the pilot work of Sponge City implementation supported by the central finance. These mainly are the relevant documents (such as the Guiding Opinions on Promoting the Construction of Sponge City (2015), the Technical Guidelines for Sponge City Construction, Etc.) for guidance and standardization. In April 2015 and April 2016, 30 pilot cities for Sponge City in China were selected through competitive evaluation (Figure 2). Meanwhile, the central government encourages cities to use the PPP model to implement sponge cities to a large extent. It was even explicitly proposed that higher central special funds would be provided to cities with a certain proportion of PPP models. Therefore, it is very common to adopt the PPP model to implement Sponge City nationwide, which is certainly not 100%.

So far, seven years later, data from China Public Private Partnership Center (2022) show that there are still high risks in applying the PPP model in Sponge City implementation. Even though it has successfully passed the repeated theoretical verification, it would still die prematurely in the implementation process, and the Zhuhai, Guizhou, Hunan, and Sichuan are the failure examples. These have forced people to re-examine what key steps should be paid attention to in implementing PPP in sponge cities. Therefore, this thesis analyses the critical success factors of Sponge City PPP projects through the successful case, the Xiamen Xiang'an underground comprehensive pipeline corridor PPP project.



Figure 2 Sponge City distribution (Zhao et al., 2022)

According to the implementation content, Sponge cities can be divided into six categories (Deng, 2016): public buildings, residential quarters, road squares, ecological water restoration, parks, and others. Residential quarters and public construction projects belong to commercial sponge engineering development projects, which the owners, with their funds, generally construct. The government does not participate in investment and construction. It is only responsible for putting forward construction requirements and performing supervision, and there is no shortage of construction funds.

Other projects are public welfare Sponge City projects initiated by the government, which are also the type of Sponge City discussed in this paper. According to the operation mechanism, public welfare Sponge City projects can be divided into non-operating and quasi-operating (Deng, 2016). A quasi-operational Sponge City project refers to a sponge project that can rely on the services and products provided by the project to obtain a certain return from the outside during the operation stage of the project. For example, Sponge City projects such as ecological water restoration and sewage treatment plants can recover a certain amount of costs through user payment during the operation period.

Non-operating projects refer to the products or services provided as public welfare, with low or no income in the operation process, such as municipal Sponge City infrastructures such as parks, green spaces, roads, and squares. The primary source of income for the projects is government payment or direct financial allocation. They mainly include the six construction elements of "seepage, stagnation, storage, purification, utilization, and drainage".

Public-private Partnership

This part introduces the definition of Public-private Partnership, Sponge City PPP projects in China, and PPP Sponge City worldwide.

Definition of Public-private Partnership

The concept of PPP originated in the United Kingdom in the 1990s, and its full name is "Public-private Partnership (PPP)". Due to the great differences in the political system, development level, cultural background, application environment, etc. of various countries and regions, the international definition of PPP has not yet formed a unified expression. The definition accepted by the international academic community is that the public sector, to increase the supply capacity and efficiency of public goods or services, establishes a long-term cooperative partnership with the private sector based on the concession agreement through franchising, purchase of services, and other means, which shares risks, complements advantages and benefits.

In China, PPP means a long-term cooperative relationship between government and social capital in public facilities and public services. Its general mode is that social capital takes the work of designing, constructing, operating, and maintaining facilities by obtaining reasonable investment returns, usually by the way of "user payment" and "government payment"; Government is responsible for supervising the price and quality of public facilities and public services to ensure the maximization of public interests (Deng, 2016). So equal cooperation and management, benefit and risk sharing are the main characteristics of PPP. Notably, this definition is emphasized the PPP application into infrastructure.

PPP is widely used in a series of infrastructure projects around the world (Kumaraswamy & Zhang, 2001) (Carbonara et al., 2014) (CNY et al., 2018), such as education, medical treatment (Languille, 2017), culture (Ventura et al., 2016), highway, railway (Rouhani et al., 2018) (Musso & Dalla Chiara, 2017), water supply (Ameyaw & Chan, 2015), electricity (Akampurira et al., 2009), urban sewage treatment (Yang et al., 2017), agriculture (Poulton & Macartney, 2012), information technology (Kuriyan & Ray, 2009), etc. At present, the academic research on PPP in the field of infrastructure implementation in China mainly covers the connotation (Chen & Xia, 2010), feasibility and applicability (Chen & Xia, 2010), classification, functions, advantages (Ye & Xu, 2013), operation process (Ye & Xu, 2013), value for money evaluation and pricing mechanism (He & Sun, 2010) (Ye & Yang, 2012), benefit distribution (Ye & LI, 2014) and risk mechanism (Chan et al., 2018).

Sponge City PPP Projects in China

So far, the number of Sponge City Projects in China is impressive, like only Beijing's reach of 5237 projects (Wang, 2022). However, projects using PPP mode are still limited. For example, the China Public Private Partnership Center only embodied 5 Beijing Sponge City PPP projects.

The academic classification of Sponge City projects mentioned above is slightly different from the classification of China Public Private Partnership Center (CPPPC) data basis (2022). Some of the projects essentially are the Sponge City projects, but they are not tabbed on "Sponge City". The Sponge City projects in CPPPC decentralize municipal engineering, ecological construction and environmental protection, comprehensive urban development, water conservancy construction, government infrastructure, and affordable housing projects. So, I went through all the decentralization areas to identify and make statistics on Sponge City Projects. The result is as the following Figure 3. The Sponge City Projects process in CPPPC is divided into three stages: preparation, procurement, and implementation. Figure 4 shows the processing situations of the Sponge City Projects in CPPPC.

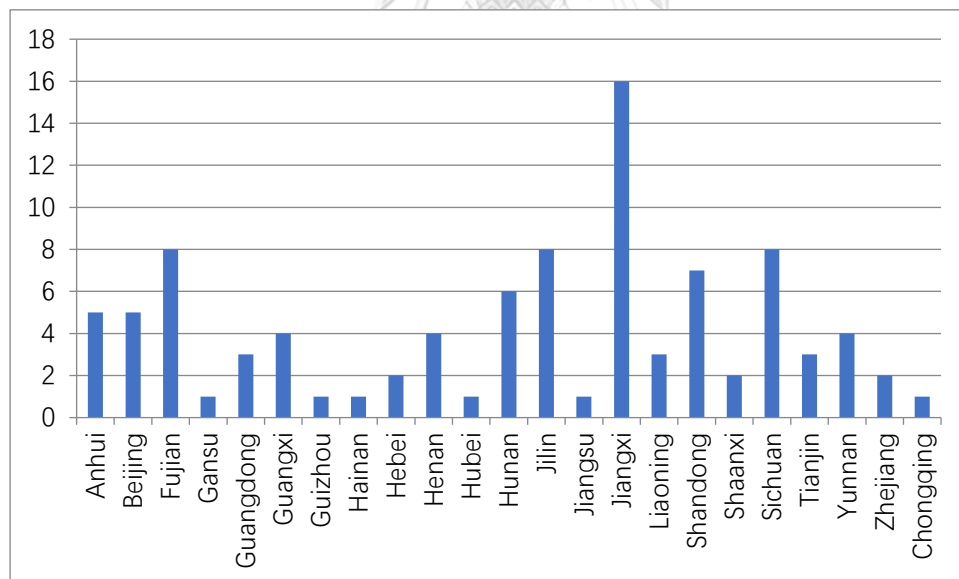


Figure 3 Sponge City PPP projects Amount in Different Provinces (Made by author)

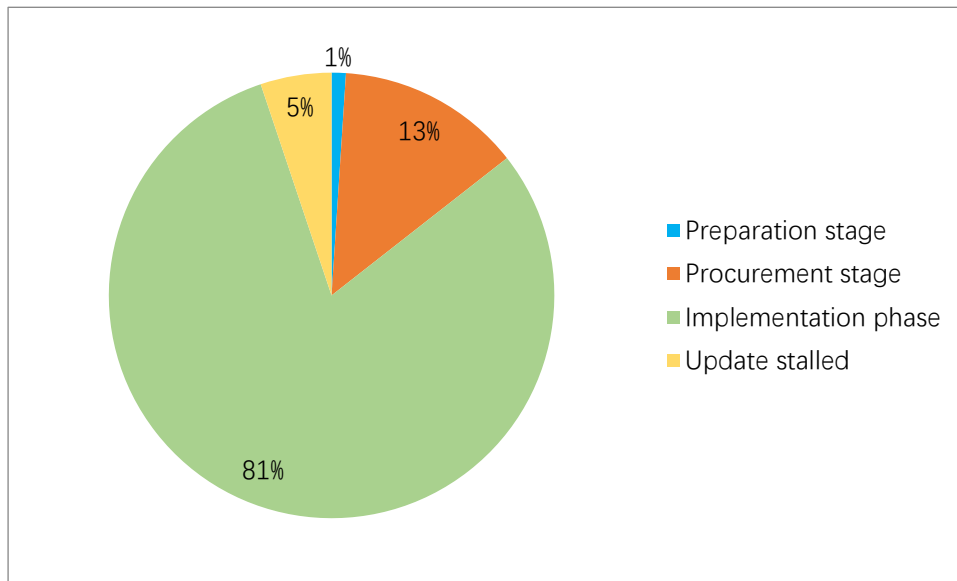


Figure 4 Process of PPP Sponge City Projects in China (Made by author)

PPP on Sponge City

Although Sponge City is a special term for water management in China, modern stormwater management in some countries has a history of 30 or 40 years in foreign countries. For example, since the 1990s, the United States has been comprehensively cooperating with social capital in the financing and operation process of watershed governance projects to improve the efficiency of project operation (Koehler & Koontz, 2008). Prince George's County in the United States is a typical example of an urban rainwater sponge reconstruction project. Through the signing of a cooperation agreement between the public and private parties, the projected income and risk-sharing provisions are agreed upon, and the joint venture project company is the operating body to carry out comprehensive cooperation in the financing, design, construction, and operation stages of the project implementation (Li & Wei, 2012). In Australia, urban stormwater management PPP projects are also very common. The application of PPP plays a positive role in the distribution of rights and responsibilities of partners, the improvement of project profitability, project asset management, and the realization of sustainability goals Taylor & Harman, 2016).

The increasing number and variety of PPP projects in China's sponge cities have promoted research on it. Research on PPP projects in sponge cities mainly includes financing methods (Chen & Zhang, 2003), implementation points, namely critical success factors (Liu, 2016), implementation methods (Da et al., 2016, He et al., 2016), investment management (Zhu, 2016), Value for money evaluation (Wang, 2018),

performance evaluation, risk management, payment and subsidy model (Wang, 2018), etc.

Ouyang et al. (2016) obtained the general framework of the PPP model of Sponge Cities by studying the PPP cases of Sponge Cities in Jinan, Guyuan, and Prince George's County (city but not project level). The critical implementation factors proposed (which can be equated to critical success factors) are operational modalities, reward mechanisms, propulsion mechanisms, and the selection of potential social capital. When discussing critical success factors, Yao & Lu (2018) put forward the participation mechanism of social capital, including access, operation, and return mechanisms, the risks mechanism for government and social capital, the performance appraisal system, and laws and regulations system.

Later in Wang's (2018) study, more critical success factors were added, such as the selection of social capital, value-for-money evaluation, and financial capability analysis. However, these discussions are only a conceptual proposal, explaining the importance of these factors and general thinking without providing specific and feasible solutions for each critical success factor. In addition, these critical success factors did not form a guiding system for the implementation of Sponge Cities PPP projects but listed the factors they considered necessary separately; that is to say, they did not reflect the correlation between these factors. In addition, these studies discuss the Sponge City PPP projects more from the perspective of "feasibility" and less discuss its impact and importance on the "sustainability" of the Sponge City PPP project regarding construction, operation, and maintenance.

Therefore, this thesis discusses the critical success factors of Sponge City PPP projects from the perspective of "sustainability" and fills in the literature gap on the sustainable development of Sponge City PPP projects. So, the research question of this paper is, "How do critical success factors of Sponge City PPP projects affect their sustainable development?" Meanwhile, the research question also consider the factors affecting PPP sustainable development (Figure 5) (Jomo et al., 2016), and the obstacles in the actual practice of China's PPP projects. For instance, there are imperfect system and weak social credit foundation, the investment return mechanism, and unperfect income model (Tang & Sun, 2017).

Consequently, this thesis discusses the critical success factors of Sponge City PPP projects, including value for money evaluation, financial affordability analysis, risk allocation, contract system, project transaction structure, return mechanism, procurement mode, performance appraisal, and supervision system. Based on relevant theories, this paper discusses the critical success factors of Sponge City PPP projects through the case of Xiamen Xiang 'an underground comprehensive pipeline corridor PPP project, and gives more specific considerations and implementation measures for

each. The conclusions reveal how the critical success factors affect the sustainable development of Sponge City PPP projects.

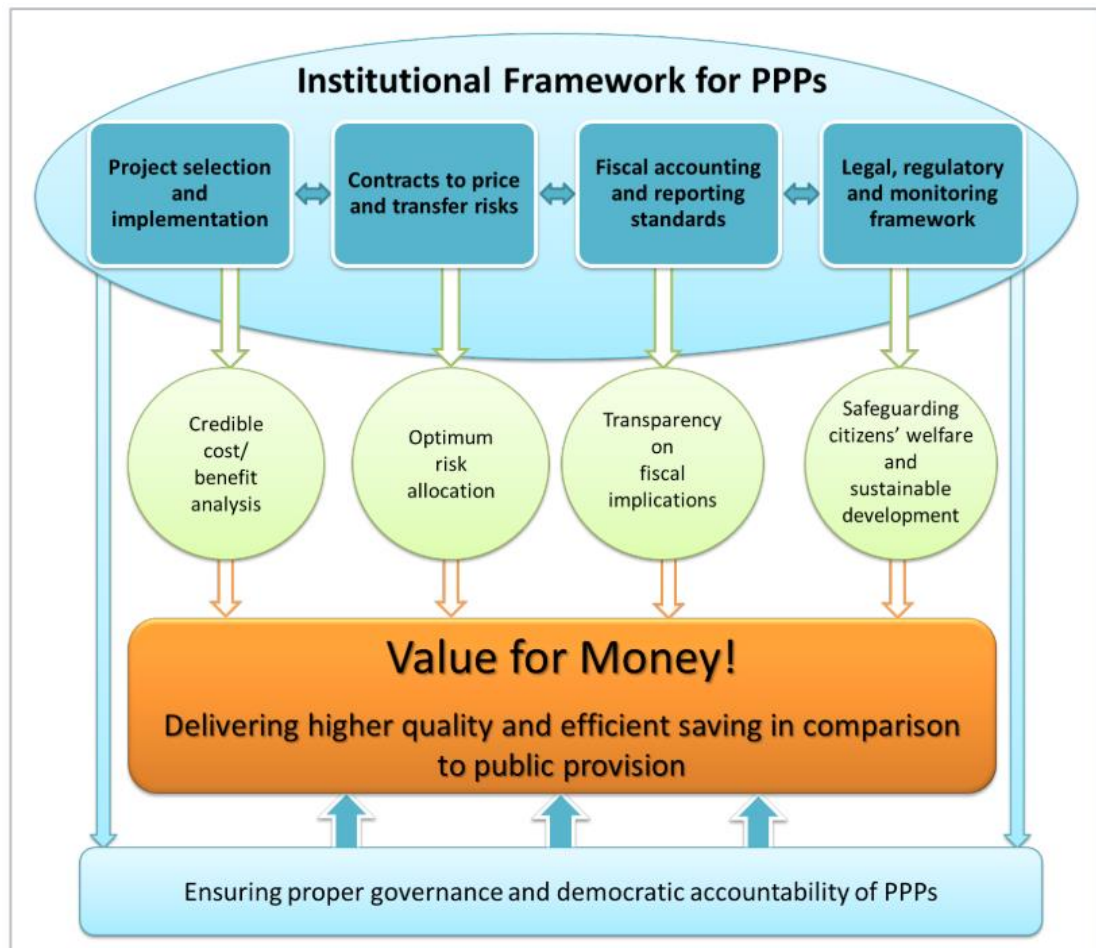


Figure 5 Key components of an enabling institutional framework for PPPs (Jomo et al., 2016)

Sponge City PPP Projects' Critical Success Factors

This thesis discusses the critical success factors of Sponge City PPP projects, including value for money evaluation, financial affordability analysis, risk allocation, contract system, project transaction structure, return mechanism, procurement mode, performance appraisal, and supervision system. They are distributed in the four stages of Sponge City PPP project identification, preparation, procurement, and handover. Among them, the identification stage includes value for money evaluation and financial affordability demonstration; the preparation stage includes operation mode, risk allocation, transaction structure and contract system; procurement stage and

selection of project procurement mode; the transitions phase includes performance evaluation and monitoring mechanisms.

The value for money evaluation is an internationally widely used evaluation system to evaluate whether the government and social capital cooperation model can be used for the public goods and services traditionally provided by the government. The financial affordability demonstration is to judge whether a project is suitable for the PPP model from the perspective of the government financial branch. Meanwhile, it requires that the proportion of the expenditure responsibility of the PPP project in the general public budget branch does not exceed 10% of each year. Risk allocation gives information on PPP projects' risk sharing. The contract system, project transaction structure, and return mechanism make regulations for the duties of different stakeholders. Procurement mode shows how to choose social capital as a partner. Performance appraisal and supervision systems give the standards to evaluate PPP projects. Please go to chapter three for the specific contents about the critical success factors of Sponge City PPP projects.

Relevant Theoretical Basis

The theories used to analyze the Xiamen Xiang'an case include sustainable development theory, public goods theory, cooperative surplus theory, and principal-agent theory.

Sustainable Development Theory

The concept of "sustainable development" was first introduced in the 1987 report of the World Environment Commission, *Our Common Future*. In 1992, the United Nations also solemnly mentioned the concept of "sustainable development", which eventually became an important concept in the study of various countries, calling on all countries to carry out reasonable practices based on the actual situation. "Sustainable development" includes social, ecological, economic, and other aspects.

Ecological sustainability refers to the balance between natural resources and the degree of exploitation and utilization. It is about seeking the best state of the ecosystem that can both support ecological integrity and fulfill human aspirations, but with greater emphasis on the ecosystem itself. Social sustainability refers to the improvement of human production methods and quality of life within the capacity of the ecosystem, with more emphasis on the latter. Economic sustainability expresses the pursuit of maximizing the net benefits of economic development within the

capacity of the ecosystem. These three aspects have a different emphases, but they influence each other. In practice, we focus on the balance of these three aspects.

Public Goods Theory

Public goods refer to non-competitive and non-exclusive social products; that is, they can be equally provided to each social member (Halcomb, 1997). The consumption behavior of public goods will not lead to the reduction of consumption of such public goods by other social members. Public products are not limited to physical products, such as roads, parks, public water conservancy, public welfare facilities, etc.; some non-physical products and services provided by the government are also public products, such as public social products such as public education, public health, social welfare and national defense, institutional public products such as public security, laws, traffic rules, administrative management, and efficient government governance, and public cultural products such as culture, art, and religion (Batina & Taylor, 2005).

Quasi-public products are between pure public products and private products. To a certain extent, they may be competitive or exclusive. They are divided into "club products" and "public resources". Quasi-public goods are usually provided by quasi-public organizations and can also be provided by private or social capital. Every consumer wants to enjoy the benefits brought by public goods for free. As long as there are public goods, the "free riders" are inevitable. However, the business objective of the private sector is to maximize profits, which makes it impossible for the private sector to provide free lunch (Carson et al., 1996).

The problem of "free riding" is inevitable. It is difficult for the market mechanism to play a role at this time. Pure public goods should be provided by government finance. If the government completely provides quasi-public goods, it will bring greater financial pressure and lower work efficiency; If the private sector provides them completely, the private sector will not be able to implement them because the low-profit quasi-public goods will be maintained, and finally, the supply will be abandoned (Albanese & Van Fleet, 1985). At present, the international community tends to use the PPP model to supply quasi-public goods (Cheng, 2019). On the one hand, it can absorb the investment of the private sector, ease the financial pressure and solve the financing problem. On the other hand, it can also improve the operational efficiency of the supply of quasi-public goods by giving full play to the management advantages of the private sector.

Cooperative Surplus Theory

As a model of government enterprise cooperation, PPP should generate a cooperation surplus. When the production standard of public goods or services is determined, the difference between the costs incurred by the public sector and the costs incurred under the model of public-private cooperation is the surplus of public-private cooperation. The difference between the net income obtained by cooperation and the net income obtained by non-cooperation is the motive force and purpose of the cooperative behavior. It is the benefit that the cooperative subject can get (An & Zheng, 2015). The cooperation surplus mainly comes from two channels. Firstly, cooperation expands the possible boundary of production, creating a force that cannot be reached by a single cooperation subject or its simple accumulation. Cooperation enables the cooperative subjects to concentrate their production activities on fewer operations, which can improve production proficiency and efficiency. Second, cooperation can make the actual output closer to the production possibility boundary. For example, cooperation can enable production factors to be used in production field, reduce the waste of resources, and improve the use efficiency of resources in production.

Generally, the PPP project cooperation surplus is the balance that the project contract subject conditionally transfers the element use right to the project partner for organization, implementation, and operation through the project contract. The income obtained is greater than the total income generated by the element owner's retention or single work. PPP cooperation surplus is the core issue that the government, social capital, and other participants are most concerned about. The creation and distribution of cooperation surplus interact and influence each other. The greater the cooperation surplus created by PPP, the more shares are available for distribution by each subject; At the same time, the rational distribution of cooperation surplus is the basis of coordination and cooperation between the main bodies. The main sources of PPP project cooperation surplus include the factor contribution of each subject, asset specificity, and institutional environment.

Principal Agent Theory

The principal-agent theory has been one of the most important theories in the field of organization and strategic management since the 1970s (Jesen & Mechling, 1976). In addition, the theory is also widely used in organizational and strategic decisions such as corporate governance mechanisms, incentives, property rights, enterprise performance, and diversification. According to this theory, the fundamental causes of agency problems are the divergence of interests, information asymmetry, incompleteness of contracts, and transaction costs between the principal and the agent.

The principal should set up appropriate incentive mechanisms or spend a certain amount of supervision costs on preventing the agent from deviating from the principal's interests, thereby reducing the conflict of interests between the principal and the agent.

In the PPP project, the local government is both the participant and the supervisor. The local government is the principal, and the social capital is the agent, so there is a principal-agent problem. The key to solving the principal-agent problem in the PPP project is restraining and encouraging the enterprises as agents. The local government needs to effectively supervise the PPP projects' bidding, construction, and operation. Meanwhile, the government should provide a suitable environment for social capital to participate in the PPP project, to reduce the opportunistic motivation of social capital. The principal-agent theory provides a theoretical basis for the following analyses of the factors that affect the participating levels of government and social capital in PPP projects.

Summary

This chapter first introduces the definition, connotation, and functions of Sponge City and briefly explains the similarities and differences between Sponge City and blue-green water management technology. Then it introduces the meaning of PPP and its application scope in infrastructure construction. Finally, the basic theories supporting this research are the sustainable development theory, public goods theory, cooperative surplus theory, and principal agent theory. The next chapter will introduce the critical success factors of Sponge City PPP projects.

Chapter 3 Critical Success Factors on Sponge City PPP Projects

The successful implementation of PPP projects in Sponge Cities is closely related to its actual operation mechanism. Therefore, this chapter first introduces the operation mechanism content of China's PPP projects and the critical success factors (also known as key success factors) of Sponge City PPP projects. Then this chapter makes analyses on Xiamen Sponge City PPP projects. Theoretically, the operational PPP process separates into five stages: project identification, project preparation, project procurement, project execution, and project handover (Figure 6). However, the operation process of Sponge City PPP projects in the China Public Private Partnership Center (CPPPC) database is actually divided into three stages: project preparation, procurement, and execution, which is not fundamentally different from the theoretical operating process.

As mentioned earlier, the main methodology of this research is the case study. More specifically, the thesis first reviews and conducts content analysis of key academic papers on critical success factors of Sponge City PPP projects. Then it reviews the current government's guidelines for the implementation of PPP projects named *PPP operation process*, which is acquired from the CPPPC database at the website <https://www.cpppc.org/xmczlc/299.jhtml>. This thesis will also review the specific practical experience of Sponge City PPP projects, which is available in the CPPPC database at the website of https://www.cpppc.org:8082/inforpublic/homepage.html#/. Using content analysis, the thesis will analyze and synthesize the key assessment on the PPP sustainable development, as shown in various papers, so as to learn the critical success factors.

Following this chapter, Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP Project will be studied according to the critical success factors obtained in this chapter. The information about it is the secondary data from CPPPC database at <https://www.cpppc.org:8082/inforpublic/homepage.html#/projectDetail/>. The specific documents used are Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP Project's value for money evaluation report (secondary data from CPPPC at <https://www.cpppc.org:8082/inforpublic/homepage.html#/preview/001720200118132228893cue0000ln7gwec>), Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP Project 's financial affordability demonstration report (secondary data from CPPPC at

<https://www.cpppc.org:8082/inforpublic/homepage.html#/preview/001720200118131742320cue0000v6u123h>), and Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP Project's implementation plan (secondary data from CPPPC at <https://www.cpppc.org:8082/inforpublic/homepage.html#/preview/001720200118105304396cue00000ramb7u>). The critical success factors of Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP Project are obtained through the interpretation of the contents of these documents. Most of these critical success factors are marked out directly in the documents, while the rest are obtained through reading the documents and combining the definition, connotation, and methods of critical success factors in this chapter. And then, chapter 4 would use the sustainable development, public goods, cooperative surplus, and principal agent theories mentioned in chapter two to analyze the Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP project' critical success factors.

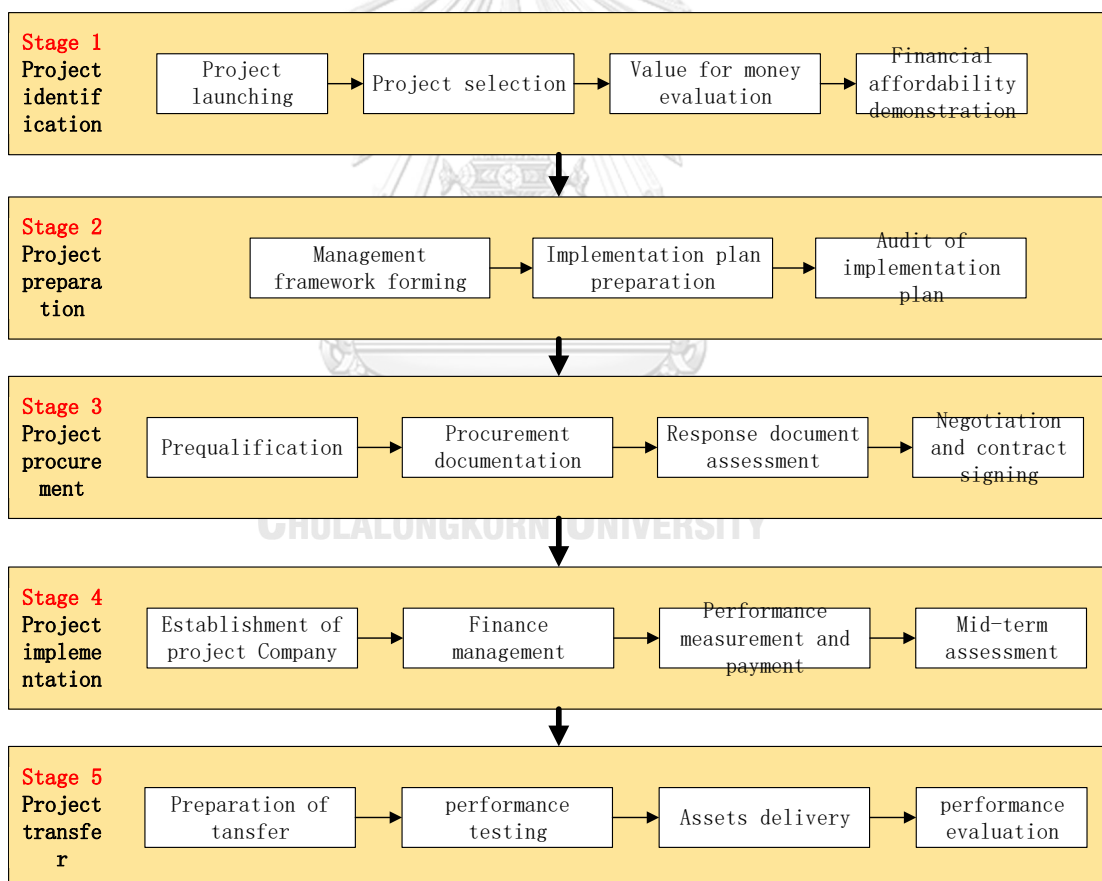


Figure 6 PPP Specific Operation Process (Zhang et al., 2016)

Researchers' conclusions regarding the critical success factors of Sponge City PPP projects are currently not unified. Some claim that the critical success factors include the general structure of PPP in sponge cities, PPP implementation scope, operation

mode, return mechanism, promotion mechanism, and social capital participation mechanism (Ouyang et al., 2016); some argue that they should include the mechanism for government and enterprises to share operational risks, performance appraisal system, and laws and regulations (Yao & Lu, 2018). Other opinions ask to include value for money evaluation, financial affordability analysis, and supervision system (Wang, 2018).

According to CPPPC data, the critical success factors of Sponge City PPP projects include value for money evaluation, financial affordability demonstration, risk allocation mechanism, project operation mode selection, project transaction structure (investment and financing structure and return mechanism), procurement mode, assessment and supervision system, and contract system in actual operation. The critical success factors of Sponge City PPP projects this thesis discussed include value for money evaluation, financial affordability demonstration, operation mode, risk allocation, contract system, project transaction structure and return mechanism, procurement method, performance appraisal, and supervision system by considering the research on the factors affecting the PPP sustainable development (Figure 5) (Jomo et al., 2016) and obstacles in the actual practice of PPP projects in China, such as imperfect system and weak social credit foundation, imperfect investment return mechanism and income model (Tang & Sun, 2017).

(1) Projects Identification Stage

The project identification stage is the first stage of the PPP project operation process. The main purpose is to screen out a qualified or even high-quality PPP project, including four steps: project initiation, project screening, value for money evaluation, and financial affordability demonstration. Either government or social capital could trigger PPP projects, but the government generally initiates them. In practice, the operation of PPP projects is complex, with many steps and a long cycle. It is often difficult for the government to complete the entire operation process alone, which requires the participation of professional consulting teams, such as legal consultants, technical consultants, financial consultants, environmental consultants, etc. Then the financial department and the competent industry department will screen. At this stage, the critical success factors of the Sponge City PPP projects focus on the evaluation of value for money and the demonstration of financial affordability.

Value for Money Evaluation

The value for money (VFM) evaluation is an international evaluation system to

evaluate whether the government and social capital cooperation model can be used for the public goods and services traditionally provided by the government. There are two main evaluation methods. One is to use the Public Sector Comparator (PSC), and the other one is competitive bidding, which includes qualitative and quantitative aspects. The basic indicators of the evaluation can be roughly summarized as six basic indicators: the integration degree of the whole life cycle, risk identification and allocation, performance orientation and innovation, the capacity of government institutions, financing availability, and potential competition. Indicators such as industry demonstration, expected use of indicators, etc., can be added according to the specific implementation plan of the project. Generally, in practical operation, there is some difficulties because quantitative analysis needs to be calculated based on the benchmark cost of similar projects. In China, PPP projects mainly rely on competitive bidding by qualitative evaluation (Mao, 2017). Under sufficient conditions, quantitative analysis is encouraged to increase the comprehensiveness and accuracy of value for money evaluation. Qualitative analysis generally adopts the expert scoring method, which employs experts from different fields to form an expert group to evaluate the whole project comprehensively and objectively. The total score is calculated by the weight given to the importance of the basic indicators. Projects with a score of more than 60 are allowed to use the PPP model.

Financial Affordability Demonstration

The financial affordability demonstration is to judge whether a project is suitable for the PPP model from the perspective of the government financial branch and ensure that the proportion of the expenditure responsibility of the PPP project in the general public budget branch does not exceed 10% each year. The demonstration of financial affordability is mainly carried out through four steps: financial responsibility identification, government expenditure measurement, financial affordability demonstration, and information disclosure (Figure 7).

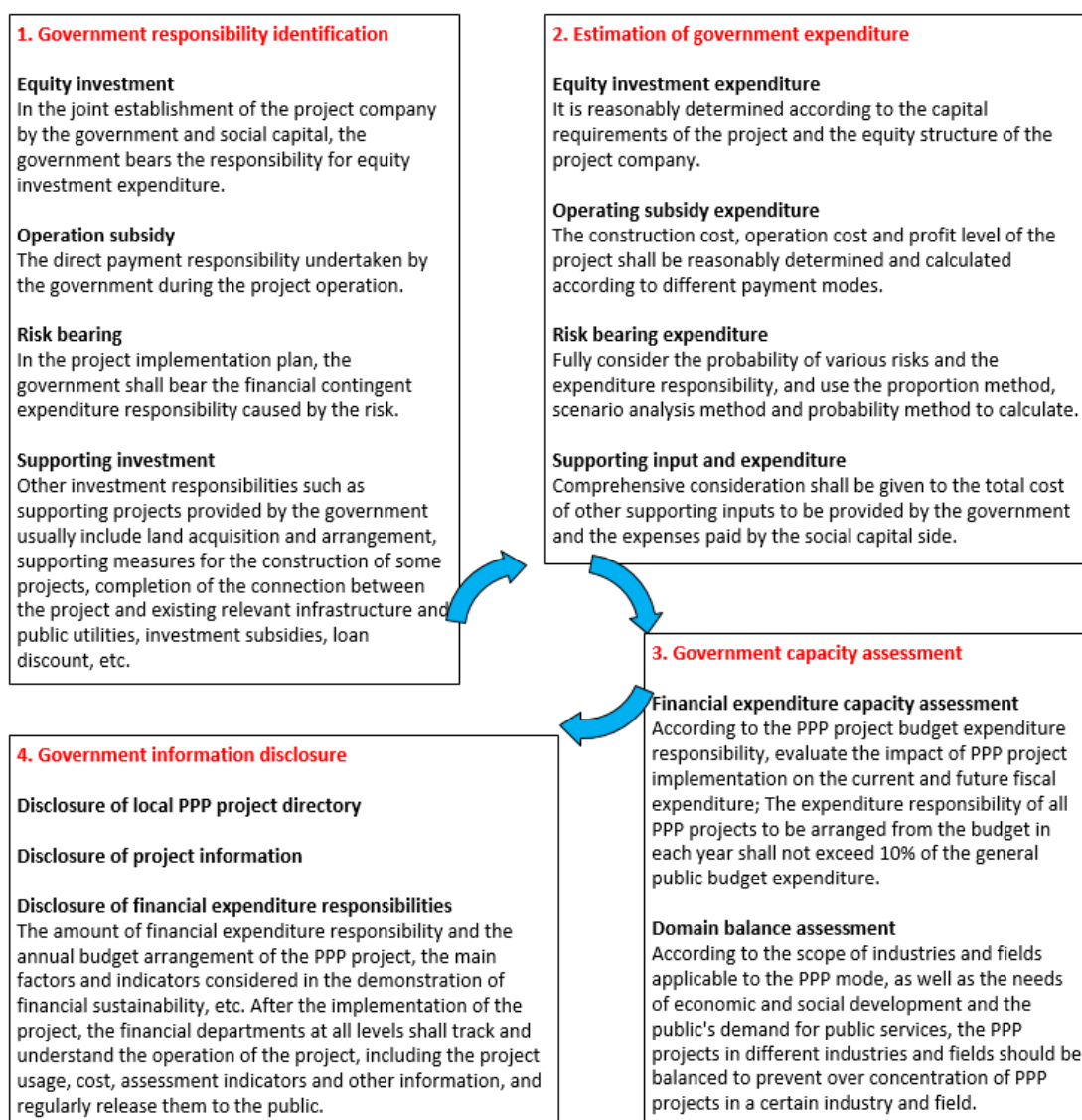


Figure 7 Demonstration of financial affordability

(2) Projects Preparation Stage

Project preparation is the second stage of the PPP projects operation process, including management structure establishment, implementation plan preparation and implementation plan review.

The establishment of the management structure is mainly divided into macro and micro levels. At the macro level, local governments at or above the county level establish special coordination agencies for PPP projects involving finance, development and reform, planning, environmental protection, banks, and other

departments. They are mainly responsible for project review, organization and coordination, inspection and supervision. At the micro level, the government authorizes particular functional departments to act as the specific implementation agency of PPP projects, which are mainly responsible for the preliminary preparation of the project, the particular implementation in the medium term and the handover in the later stage (Cao, 2016). The PPP project implementation plan is prepared by the project implementation agency, which can select qualified professional consulting agencies to complete the preparation of the implementation plan through public bidding and other ways. After the implementation plan is prepared, if it passes the value for money evaluation and financial affordability verification, it can be submitted to the government for review. If it fails in the review, PPP model will not be accepted in the projects. At this stage, the critical success factors of the Sponge City PPP projects focus on the operation mode, risk allocation, and return mechanism.

Operation Mode on Sponge City PPP Projects

According to the ownership relationships of the projects and the characteristics of China's infrastructure projects (Wang, 2004), the operation mode of Sponge City PPP projects can be divided into three categories: franchising, outsourcing, and privatization (Table 1).

Table 1 Operation mode of Sponge City PPP projects

Operation Mode	Content
Outsourcing	Component Outsourcing: Service Contract, Management Contract
	Turnkey: DB, DBMM, O&M, DBO
Concession	TOT: PUOT, LUOT
	BOT: BLOT, BOOT
	Others: DBTO, DBFO
Divestiture	Full Privatization: PUO, BOO
	Partial Privatization: Equity Transfer, Others

The government generally funds the outsourcing mode. The social capital party is usually only responsible for project construction or entrusted by the government to operate and manage the project on its behalf to maintain the regular operation of the project. In such projects, social capital generally bears less risk. Most of them obtain corresponding returns through government payment. Its specific operation models include Service Contract, Management Contract, Design-Built (DB), Design-Built-Main Maintain (DBMM), Operations & Maintenance (O&M), and

Design-Built-Operate (DBO).

In the concession mode, the government department and the social capital party generally sign the franchising contract. The social capital party partially or fully contributes to the construction and is responsible for the operation and management of the later stage of the project. According to the income during the operation period of the project, the government department may charge the social capital party a franchise fee or give an operating subsidy to maintain the balance between the profitability and public welfare of the project. The ownership of such projects belongs to the government, and the project risks are reasonably shared by the government and social capital. Specific operation models are Purchase-Update-Operations-Transfer (PUOT), Lease-Update-Operations-Transfer (LUOT), Built-Lease-Operations-Transfer (BLOT), Built-Owning-Operations-Transfer (BOOT), Design-Built-Transfer-Operations (DBTO), Design-Built-Financing-Operations (DBFO).

In the divestiture mode, the social capital party shall be fully responsible for the investment, construction, operation, and maintenance of the project and obtains investment income through operating fees under the supervision of the government. The ownership of such projects belongs to the social capital party, and the project risk is entirely borne by it. Purchase-Update-Operations (PUO), Built-Owning-Operations (BOO), Equity transfer, and others are specific operation models.

There are many factors influencing the choice of PPP project operation mode, including project income, appropriate procurement model (Tang & Sun, 2017), and basic framework of project risk allocation (B. Liu et al., 2017), government PPP experience such as technical management and supervision level, financial capacity and credit (Cui, 2019), intention (Tang & Sun, 2017), willingness to take risks (Zhang et al., 2017), social capital financing ability, technical level, risk tolerance and so on. Based on the summary of the selection of PPP operation mode and combined with the characteristics of Sponge City PPP projects, such as the numerous subprojects involved, complex technologies, and the high degree of cooperation between various departments, the influencing factors considered in the selection of operation mode of Sponge City PPP projects are obtained (Figure 8). It includes four aspects: Sponge City project features, government perspective, social capital perspective, and external environment.

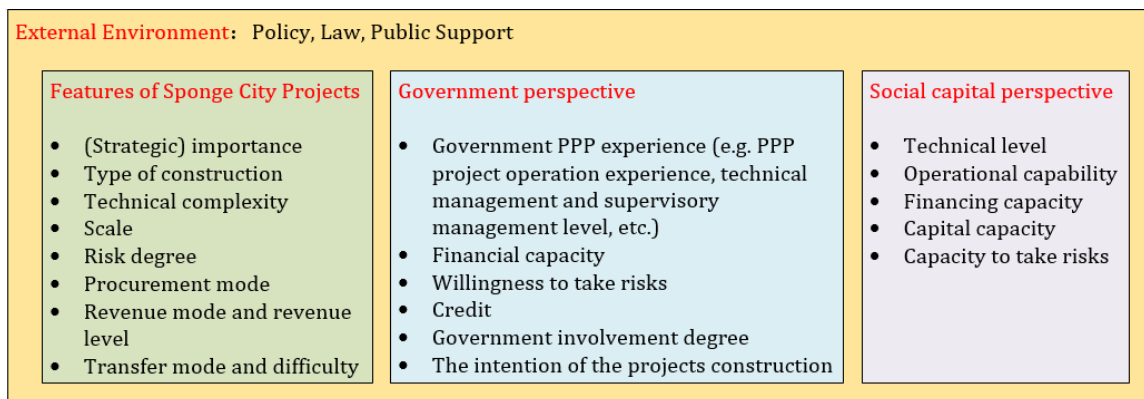


Figure 8 Influencing factors of choosing operation mode of Sponge City PPP projects

Risk and Risk Allocation Principles of Sponge City PPP Projects

This part will introduce the Sponge City PPP projects' key risks and their risk allocation basic principles.

Key Risks of Sponge City PPP Projects

Sponge City PPP projects have more risk factors than general engineering projects. Different researchers have different views on the key risks. Some Research identifies political and policy risks, such as government decision-making errors, succession, default, environmental damage, project design defect risk, construction cost overrun risk, and operational risk as key risk factors (Wang et al., 2022). Others believe that the key risk factors are government credit risk, construction delay, and cost overruns (Hong et al., 2020). Considering the practice of Sponge City, this thesis identifies key risk factors of the Sponge City as preliminary risk, construction risk, operation risk, handover risk, and other risks in five categories (Figure 9).

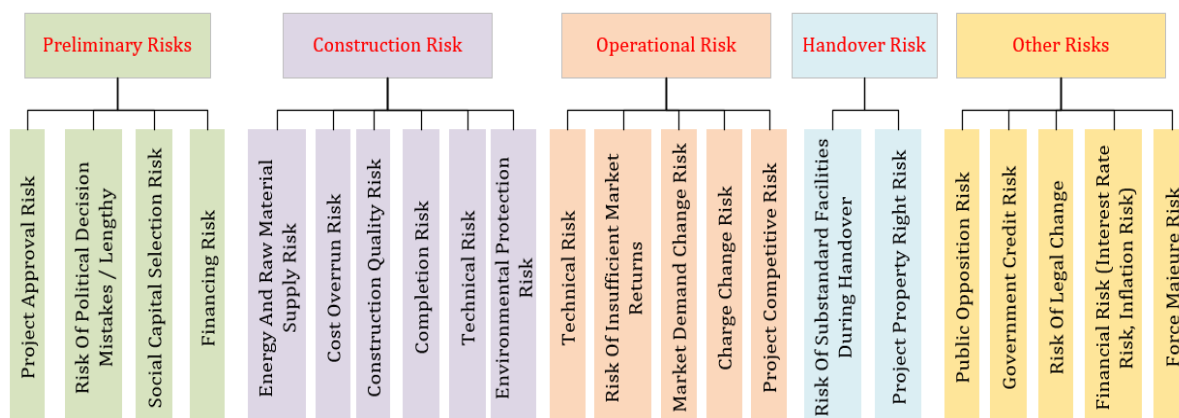


Figure 9 Key risk of Sponge City PPP projects

Principles of Risk Allocation for Sponge City PPP Projects

There are generally three principles for the Sponge City PPP project's risk allocation: the principle of risk allocation optimization, the principle of risk return equivalence, and the principle of risk controllability.

1. Risk allocation optimization principle

The government and the project company have different management capabilities for different risks. The allocation of project risks should give full play to the risk management advantages of the risk bearers. Therefore, the risk-bearing party should have control over the risk and be able to avoid or reasonably transfer the risk effectively. For example, if the government transfers the risks it can manage effectively to the project company, the project company would need to pay more for the risks. This goes against the aim of risk control.

2. Risk and the return equivalence principle

In risk allocation, it is also necessary to ensure that the party taking the risk has greater economic benefits or incentives to control the risk and that the party taking the risk is the most efficient. Risk allocation is meaningful only if the risk bearers get higher risk returns from risk sharing. If the risk management cost of a risk taker is greater than the risk return, it will affect his willingness to take risks. Therefore, in the terms of the contract, the risk taker should be guaranteed to obtain an income level matching the risk.

3. Risk control principle

Generally, if the risk finally occurs, the risk-bearing party shall not transfer the losses incurred from there to the other party. However, with time going, some risks may change unpredictably by the government and social capital, leading to an increased probability of the risk occurrence or an increase in financial losses when the risk occurs. To control the risk loss within the reasonable tolerance of the risk taker, the upper limit of risk loss should be set in the project contract according to the project participants' financial, technical, management ability, and other factors. Otherwise, social capital may not guarantee the supply efficiency of public goods or services, and the government may refuse to perform, which will affect the partnership between the two parties and ultimately lead to the failure of the PPP projects.

Transaction Structure and Return Mechanism

In Sponge City PPP projects implementation, there are both existing construction projects and new projects. Because the underground comprehensive corridor project in Xiamen Xiang'an to be discussed belongs to new projects, only the transaction structure of new PPP projects is discussed here. It is more appropriate for new PPP projects in sponge cities to adopt the BOT operation mode (Wang, 2018). The government designates relevant departments to be responsible for the whole life cycle of PPP projects, generally the municipal Housing and Urban-Rural Development Bureau, as the specific implementation agency. It selects the most suitable social capital through different procurement methods. The selected social capital and the government-funded institution entrusted by the government jointly fund the project implementation company, and the proportion of government investment shall not exceed half. For public welfare and technical projects such as Sponge City PPP projects, the government's share should be lower, ranging from 10% to 30%, to give more space to private capital.

After determining the social capital side, both parties will draw up and sign the contract according to the projects' legal regulations and specific requirements. Then, under the constraint of the contract, the project company shall be responsible for the design, financing, construction, operation, and maintenance during the PPP cooperation period. Since the final ownership of the assets of the Sponge City PPP projects belong to the government, the project company shall hand them over to the government free of charge after the contract expires. The transaction structure of Sponge City PPP projects on the BOT model is shown in figure 10.

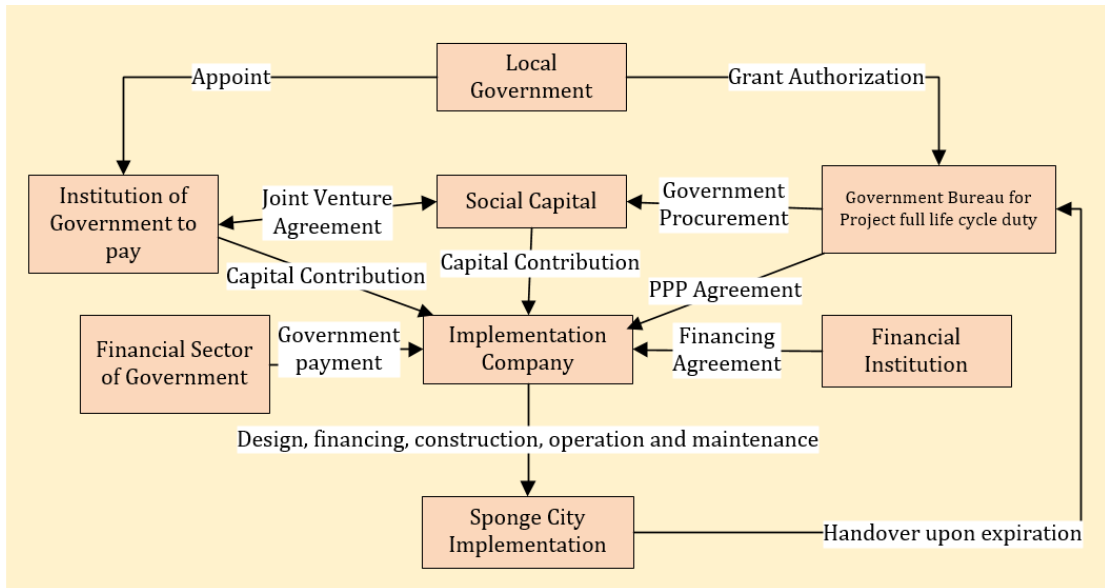


Figure 10 Transaction structure of Sponge City PPP projects on the BOT model

The project return mechanism mainly describes the source of funds for social capital to obtain investment returns. The establishment of a reasonable investment return mechanism can ensure the positive and stable promotion of cooperation between the government and social capital. In the return mechanism (Lyu & Zhang, 2015), Sponge City PPP Projects include user payment, feasibility gap subsidy, and government payment (Figure 11).

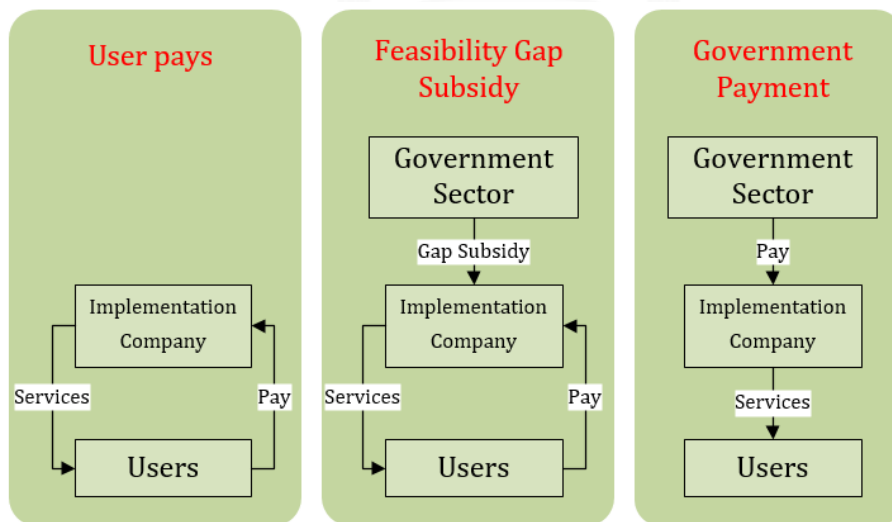


Figure 11 Return mechanism of Sponge City PPP Projects

Government payment is the primary payment mechanism in projects with the solid public welfare, which means that the government directly pays to purchase public goods or services. The key to this payment method is to ensure a stable source of funds and a standardized payment mechanism. The government needs to promise in the contract that the government payment will be included in the annual financial budget.

User payment generally applies to operational projects, such as municipal water supply and highways. During the operation period of such projects, the final consumers can pay for public goods and services to return stable capital income to social capital. In this way, special attention should be paid to the pricing of public goods. If the charges are too low, the project company will not be able to obtain reasonable income. It will dampen the enthusiasm for social capital participation. On the contrary, if the price level exceeds the user's affordable level, it will cause strong opposition from the public, and the project will not operate sustainably. Therefore, when determining the user's payment standard, an adjustable range should be set in consideration of the project cost, profit, social and economic benefits, and other comprehensive factors to ensure the regular operation of the project.

Feasibility gap subsidy means that when there is a gap between the user's payment and the cost recovery and expected return of the project company, the government can give certain subsidies to the project company through financial subsidies, preferential loans, investment shares, etc., to make up for the gap beyond the user's payment. The key to this way of return is to ensure the timely and full implementation of subsidies and to determine scientifically and reasonably the number of subsidies and other government support.

However, most Sponge City PPP projects are in public solid welfare features. So far, the payment methods are mainly government payment and feasibility gap subsidy.

Contract System of Sponge City PPP Projects

The legal system of Sponge City PPP projects in China is not perfect, and the incompleteness of legally effective PPP agreements may easily lead to opportunistic risks for the government and social capital (Xu, 2022). Therefore, it is necessary to discuss the contract system of the Sponge City PPP project for the smooth progress of the Sponge City PPP project.

The contract system comprises a series of interrelated contracts with a specific structure (Luo, 2014). According to the contract system of PPP projects, the basic

contract system of Sponge City PPP projects can be obtained from the stakeholders' perspective (Figure 15). Stakeholders of Sponge City PPP projects mainly include the government, social capital, project companies, financing institutions, contractors, suppliers, operators, and purchasers. Sponge City PPP agreements are the core of the contract system and the basis for all other contracts.

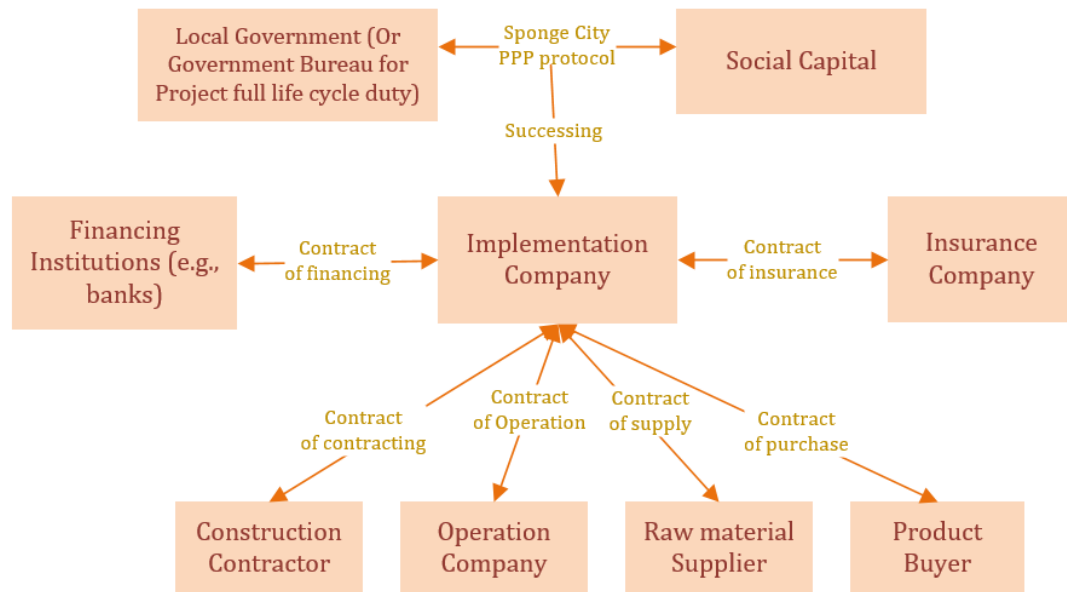


Figure 12 Contract system of Sponge City PPP projects

(3) Projects Procurement Stage

Project procurement refers to the government's procurement of social capital. The project procurement stage is the third stage of the PPP project operation process, including four steps: prequalification, procurement document preparation, response document review, negotiation, and contract signing (Wang & Zhou, 2013). In practice, the operation of this phase is incorporated into the process of social capital selection in the first phase of the PPP project identification phase.

PPP project procurement methods include open bidding, invited bidding, competitive negotiation, and competitive negotiation, single-source procurement. The purchaser can select the most appropriate procurement method according to the project characteristics, progress, procurement time, and other conditions, but it needs to meet the requirements of laws, regulations, and other normative documents.

Public bidding is the main way of government procurement. As long as the

procurement projects reach the amount above the standard of public bidding, public bidding should be adopted in principle. The tenderer shall issue a tender announcement to unspecified legal persons or other organizations. Open bidding has a wide selection range and strong competitiveness, which is conducive to the government choosing the best partners with strong comprehensive strength, but the scope of application is limited. It is mainly applicable to projects where the core boundary conditions and technical and economic parameters in the procurement demand are clear and complete, where the procurement process is not changed, and where there are disadvantages such as long bidding time, strict procedures, inflexibility, etc.

Invited bidding refers to the tender inviting specific legal persons or other organizations to bid within a particular scope. The tender sends invitations to more than three potential bidders to ensure competitiveness. Then the tender determines the successful bidder according to legal procedures and bid evaluation standards in the bidding documents. Invitational bidding has the advantages of less bidding cost, a short cycle, and a small workload of bidding and evaluation. However, because the tenderer has the right to choose the competitive candidates for bidding, there is a greater possibility of unfair competition in the project, so the scope of application is small. It usually applies to projects with concrete particularity, such as projects with high confidentiality requirements or fewer qualified suppliers.

Competitive negotiation is the negotiation between the government and qualified suppliers to procure goods, projects, and services. The suppliers submit response documents and final quotations according to the requirements of the negotiation documents. The purchaser determines the procurement method of successful suppliers from the successful candidates submitted by the negotiation team. Competitive negotiation gives the supply and demand parties an equal opportunity to communicate so that both parties can negotiate on specific project issues. This procurement method is conducive to reducing the preparation time and unnecessary work in the early stage of the project, improving efficiency, reducing procurement costs, and reducing procurement risks. However, in the final selection of competitive negotiation as a procurement method, price is often regarded as the most important evaluation standard.

Generally, the supplier with the lowest price is the final winner, which overemphasizes the price and ignores the qualification and ability of the supplier. In the whole process of PPP project investment, construction, operation and handover, the management level of social capital and construction, and operation are required to be very high. The principle of winning the bid with the lowest price is difficult to achieve the unity of "quality, price, and efficiency" of project procurement.

The procurement process of competitive negotiation is the same as that of competitive negotiation. The difference between the two is only in the quotation competition stage. Competitive negotiation uses the "the one with the lowest price wins" method to determine the winner. Competitive negotiation pays more attention to the comprehensive strength of suppliers. Price is no longer the only determinant. The technical ability, financing ability, innovation ability, and quotation of suppliers are all criteria for evaluation by setting different weights for different evaluation factors and inviting experts to score. Suppliers with high scores will become the final bid winner. This is more conducive to saving procurement time, clarifying procurement demand, effectively controlling vicious competition, and selecting the most suitable social capital than other methods. It is the procurement method selected by most PPP projects at present.

Single-source procurement refers to the procurement mode in which the purchaser purchases goods, projects, and services from a specific supplier. In PPP project procurement, few cases apply to procurement from a single source. Unless unforeseen emergencies occur, additional procurement cannot be made from other suppliers, and the total amount of additional procurement funds does not exceed 10% of the original contract procurement amount. Single-source procurement should be avoided as far as possible.

Currently, the procurement methods of PPP projects in sponge cities in China are mainly competitive negotiation and public bidding.

(4) Projects Implementation and Handover Stage

The fourth stage is the project implementation stage. It includes project company establishment, financing management, performance monitoring, payment, and mid-term evaluation (Zhang et al., 2016).

In the project implementation stage and the handover stage, the leading role is the social capital party, and the main responsibility of the government side is to supervise and manage the project performance, legality, and compliance. A project company is a business entity with an independent legal personality jointly funded and registered by the government and social capital. It is the specific implementation unit of the PPP project and is mainly responsible for the investment, construction, operation, and maintenance of the PPP project.

The social capital or project company is responsible for financing PPP projects, including designing financing schemes, institutional contracts, contract signing, and

financing prices. Project performance is the behavior and result of the project team's operation of the project. Project performance evaluation is an important part of project management. The quality of products and services provided by the project company during the process of the PPP project, financial effects, resource utilization, employee satisfaction, etc., all need to be monitored by the government through the establishment of a complete and systematic project output performance indicator system.

The main payment obligations undertaken by the government are mainly some PPP projects that adopt the mechanism of government payment and feasibility gap subsidy return. The government payment obligations are closely linked with the local government's financial budget. The payment obligations should be integrated into the government budget at the same level in combination with the medium and long-term financial planning of the local government; The project implementation organization shall regularly (generally 3-5 years) conduct a mid-term evaluation of the projects that have been put into operation, focusing on the project operation and the compliance, adaptability and rationality of the project contract.

In the handover stage, when the PPP project adopts BOT, TOT, LOT, and other operation methods, the project company needs to transfer the project assets to the project implementation agency or other institutions designated by the government according to the contract after the expiration of the project franchise period. It mainly includes four steps: handover preparation, performance test, asset delivery, and performance evaluation. The most important of the four steps is performance testing. The government receiver shall set up a working group to conduct the test according to the previously determined test scheme and standard. If it fails to meet the standard, the project company may be required to repair it. In this stage, the key success factors of the Sponge City PPP projects focus on performance appraisal and supervision mechanisms. In this stage, the key success factors of the Sponge City PPP projects focus on performance appraisal and supervision mechanisms.

Performance Evaluation Mechanism of PPP in Sponge City

The performance appraisal system of Sponge City PPP projects is the core element to ensure the project's success. Different assessment standards shall be formulated according to the stages of the construction period and the operation and maintenance period (Table 2). The assessment and scoring shall be done by combining daily assessment, quarterly assessment, and random inspection. Then the rewards and punishments shall be carried out according to the final scoring results.

Table 2 Performance evaluation of the PPP project in Sponge City

Performance evaluation of PPP project in sponge City	
Completion acceptance assessment	1) Meet the national and industrial construction scope and quality standards 2) Authenticity, integrity and compliance of completion data (including various approval documents, design drawings, construction instructions and contract agreements) 3) Whether appropriate operation and maintenance plan is formulated 4) Effect of various facilities
Operation performance assessment	1) Facilities maintenance 2) Ecological benefits, including direct ecological benefits and indirect ecological benefits 3) Promotion value, such as PPP project experience and replicability of PPP project model
Stakeholder satisfaction	1) Public sector satisfaction, including the use efficiency of financial funds and the satisfaction of sponge city construction projects 2) Private sector satisfaction, including return on investment, return mechanism, social reputation, policy support and financial subsidies 3) Social public satisfaction, including sponge city construction project satisfaction and public opinion expression channel satisfaction

Supervision Mechanism of PPP in Sponge City

The Sponge City PPP projects involve a wide range of stakeholders and need to be jointly supervised by multiple parties. Its supervision system is mainly divided into three parts: administrative supervision, performance supervision, and public supervision, covering the whole cycle of the PPP project.

Administrative supervision is the general term of the administrative power conferred by laws and regulations on the administrative organs to supervise, inspect, reward, and punish the project company, employees, and related parties and order rectification. Administrative supervision is the most important supervision mode for the implementation of the preliminary work of the PPP projects. The initial stage is mainly the examination and approval of the preparatory work, such as project initiation, planning, social capital selection and the project company's establishment.

Performance supervision is mainly to supervise and manage the contract performance of the project company during the cooperation period by the competent government departments and regularly evaluate and assess the operation of the project company. This supervision mode's effectiveness is mainly due to the joint negotiation between the government and social capital based on the equal civil and commercial contractual relationship. The scope of supervision is limited to the rights and obligations defined

in the project agreement. The government should perform its due obligations while exercising its regulatory power according to the contract.

Public supervision should be introduced to ensure that the completed project can better meet the needs of the masses. The Sponge City PPP project is a public infrastructure construction project that will have a great impact on the lives of the masses and is closely related to the interests of the masses. We can establish an effective public communication and supervision mechanism, such as a publicity system of major issues, the public feedback, and complaint system, etc., to achieve the effect of public supervision.

Administrative supervision, performance supervision and public supervision are not distinct and independent but intertwined systems. In the project construction stage, administrative supervision is the main way of supervision. After the project enters the operation period, the administrative supervision will sometimes appear inadequate on some key issues, such as the evaluation of the follow-up operation effect. Then performance management and public supervision based on the project agreement will occupy a dominant position.

Summary

This chapter introduced the critical success factors of Sponge City PPP projects in different operating steps of PPP projects. The project's identification stage includes value for money evaluation and financial affordability demonstration. In the project preparation stage, operation mode, risk and risk allocation principles, transaction structure and return mechanism, and contract system are included; the project procurement is stage three. The performance evaluation and supervision mechanism are in the project implementation and handover stage. The next chapter would discuss these critical success factors of Xiamen Sponge City PPP projects in detail by using the sustainable development, cooperative surplus, and principal agent theories mentioned in chapter two.

Chapter 4 Case Study on Xiamen Xiang'an Underground Comprehensive Pipeline Corridor PPP Project

This chapter will discuss the critical success factors of Xiamen Xiang'an underground comprehensive pipeline corridor PPP projects in detail by using the sustainable development, public goods, cooperative surplus, and principal agent theories mentioned in chapter two. Here first introduces the general situation of this project.

Sponge City in Xiamen

Xiamen city lay in the first batch of Sponge City implementation pilot cities in China. Implementing Sponge City throughout the city, Xiamen has selected Hailang Maluanwan District (20km²) and Xiang'an New City District (15.4km²) as the pilot areas for Xiamen's national Sponge City implementation (Xiamen Urban Planning & Design Institute, 2020). Three Sponge City PPP projects are embodied in the CPPPC database (2022), Maluanwan New Town Inner Bay Water Ecological Restoration and Supporting Works PPP Project, Xiamen Xiang'an Southern New Town Underground Comprehensive Pipeline Corridor PPP Project, and Xiamen Xiang'an New Airport Area Underground Comprehensive Pipeline Corridor PPP Project. The former two are in the stage of procurement. The last one is in the implementation stage, which is the object of the case study in this thesis. Its basic overview is as follows.

Comprehensive corridor pipe is indispensable to Sponge City (Wu, 2019). In January 2015, the Ministry of Finance and the Ministry of housing and urban-rural development issued a notice on organizing and applying for the pilot city of an underground comprehensive pipe gallery in 2015. Xiamen was successfully selected as the pilot city of the comprehensive pipe gallery in 2015. It is the first PPP project in Xiamen as a pilot city of an underground comprehensive pipe gallery, and the first PPP project completed in Xiamen. In the CPPPC database (2022), among all the individual construction projects and pipe gallery construction projects of Sponge City construction, the financing volume of the underground comprehensive pipe gallery PPP project in Xiamen Xiang'an New Airport Area Underground Comprehensive Pipeline Corridor PPP Project is the largest, reaching about CNY 1.04 billion.

Xiamen Xiang'an New Airport Area Underground Comprehensive Pipeline Corridor PPP Project has many innovative achievements. For example, operation performance scoring indicators have been prepared to effectively avoid the tendency of the project company to focus on construction and ignore operation; based on the relatively mature system of forced access, and paid use of the underground comprehensive pipe gallery in Xiamen, the innovation of return mechanism with reasonable risk distribution has been formed. For most quasi-operational and non-operational Sponge City PPP projects, implementing Xiamen Xiang'an New Airport Area Underground Comprehensive Pipeline Corridor PPP Project can provide them with the necessary practical experience in effectively avoiding risks and achieving sustainable operation in a long-term cooperation.

Therefore, it is typical to analyze the Xiamen Xiang'an New Airport Area Underground Comprehensive Pipeline Corridor PPP Project. The planning and construction of the underground comprehensive pipe gallery PPP project in Xiamen Xiang'an Underground Comprehensive Pipeline Corridor PPP Project are shown in the following figure and table. Figure 13 shows the distribution of pipe corridor in Xiang'an District of Xiamen City; Figure 14 is the design of underground pipe gallery; Figure 15 specific conditions of pipelines (Xiashi News, 2021). Table 3 is the brief situation of Xiamen Xiang'an Underground Comprehensive Pipeline Corridor PPP Project.



Figure 13 Distribution of Pipe Corridors in Xiang'an District

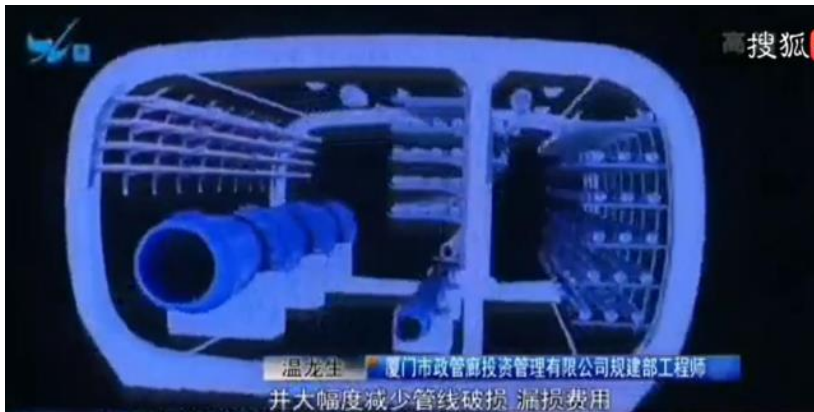


Figure 14 Design of Underground Pipe Gallery



Figure 15 Specific Conditions of Pipelines

Table 3 Brief Introduction of Xiamen Xiang 'an New Airport Area Underground Comprehensive Pipeline Corridor PPP Project

Project Overview	Xiamen Xiang'an new airport area integrated pipe gallery PPP project is located in Xiang'an District, Xiamen. The road where the pipe gallery is located includes Xiang'an East Road and Dadeng bridge sea crossing section, huandeng North Road, xiaku North Road, henger Road, airport expressway (formerly Bayi Avenue), Yingbin Avenue, Dadeng middle road and Airport North Road. The total implementation length of the new integrated pipe gallery is 19746 meters. The estimated static total investment of the project is 1367.46 million CNY (excluding the investment in self owned pipelines of pipeline operators). The pipelines to be included include: 110kV and 220kV high-voltage power, 10kV power, communication cable (including wired and traffic), water supply pipe and medium water pipe, and some roads are included in rainwater, sewage and gas pipelines. It is proposed to establish a joint venture project company on behalf of the social capital and the government to be responsible for the design, investment and financing, implementation, operation and maintenance of the project (referring to the pipe gallery and ancillary facilities).		
Scope of Cooperation	It is proposed to establish a joint venture project company on behalf of the social capital and the government to be responsible for the design, investment and financing, implementation, operation and maintenance of the project within the specified scope (referring to the pipe gallery and ancillary facilities).		
Period of Cooperation	20 years	Operation mode	BOT
Procurement Method	Public bidding	Total project investment	104.137 million CNY
Return Mechanism	Feasibility gap subsidy		

The following part will discuss the Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP Project critical success factors by using sustainable development, cooperative surplus, and principal agent theories.

Discussions on Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP Project

This part will use sustainable development theory, public goods theory, cooperative surplus theory and principal agent theory mentioned in chapter two to discuss Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP Project by following the critical success factors. But it will not include the operation mode factor for it do not have a typical experience.

Value for money evaluation on Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP Project

In the value for money (VFM) evaluation, Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP Project adopts both qualitative and quantitative evaluation.

In a qualitative analysis of VFM, the Xiamen Xiang 'an Underground Comprehensive Pipe PPP project used an expert scoring method. Five experts in the fields of project management, finance, law, engineering, and finance were selected to score. There are four adding evaluation factors: project scale, expected service life, types of main fixed assets, and accuracy of cost measurement in the whole life cycle besides the standards mentioned in chapter 3: the degree of integration in the whole life cycle, risk identification and allocation, performance orientation and innovation, government institutional capacity, financing availability, potential competition degree and evaluation factors. Table 4 shows the details of these factors and proportions.

Finally, the qualitative evaluation result of the project value for money is judged according to whether the final evaluation score (the total weighted sum of the final score of each index and the weight is the qualitative evaluation score result) is in the "qualified grade" of value for money. If the score is below 60, it is deemed unqualified; that is, the value for money evaluation of the project fails. Items with a score of 60 or greater are evaluated by value for money. Xiang 'an Underground Comprehensive Pipeline Corridor PPP Project 's final score is 89. Appendix 1 shows the specific scoring criteria and details.

Table 4 Qualitative Standards for VFM

Evaluation Index	Weight
Integration degree of the whole life cycle	15%
Risk identification and allocation	15%
Performance oriented and innovation encouraged	15%
Degree of potential competition	15%
Government's institutional capacity	10%
Financibility	10%
Project size	5%
Expected service life	5%
Category of main fixed assets	5%

Quantitative evaluation of value for money (VFM) is mainly used to quantify the value for money, that is, to calculate the difference between the public sector comparative value (PSC) and the net present value of cost (PPPs) of government expenditure during the whole life cycle of a PPP project. Value for money is an essential basis for the government to determine the procurement mode of the target project. The government is advised to adopt PPP mode if the value exceeds zero. If the value is less than zero, it is recommended that the government adopt the traditional procurement model. The VFM quantitative evaluation results of Xiamen Xiang'an area show that its PSC value is much higher than the PPPs value, so it conforms to the implementation mode of PPP mode. The specific items included in the PSC and PPPs are as follows. Appendix 2 shows detailed data.

Xiamen Xiang'an Underground Comprehensive Pipe PPP project:

- a) **Public sector comparison value (PSC)** = Raw public sector comparison value (Raw PSC) + competitive neutrality + transferred risk + retained risk = 1749538600 CNY
- b) **The net present value (PPPs) of the cost of government expenditure in the whole life cycle of the PPP project** = investment responsibility expenditure + operating subsidy expenditure (procurement expenditure limit * (1-5%)) + risk bearing expenditure (retained risk) = 1534326500 CNY
- c) **VFM value** = PSC - PPPs = 215.2122 million CNY > 0

Discussions on Value for Money Evaluation

Economy, society, and environment are the three pillars of sustainable development, and the pursuit of sustainable development is the overlapping part of the demands of these three fields. Sustainable economic development in concept of sustainable economic development is the ability of an economy to support an ideal level of economic activity in the long term. In addition to stakeholders' capital capacity, the project's overall planning and surplus value in cooperation between government and social capital also ensure the project's sustainability. Xiamen Xiang'an Underground Comprehensive Pipeline Corridor PPP project considered the possibility and magnitude of economic sustainability by viewing the full life cycle management, namely the full life cycle integration degree and the full life cycle cost measurement accuracy in Table 4 evaluation criteria.

First, the efficiency mechanism of full life cycle management (LCM) views that the upfront investment of infrastructure often determines and influences the durability and operating costs of the subsequent life cycle. When the initial stage design is reasonable, material quality is reliable, and maintenance investment is stable, the durability of the facility and operating costs will be guaranteed. On the contrary, if, in the construction phase, the social capital blindly reduces the quality of materials in the pursuit of low cost, or ignores the preventive maintenance investment, then the durability of the facility and operating costs will be affected. In this Xiamen case, the construction and operation of infrastructure are tied together and given to the same social capital, which can make social capital's decisions to maximize the total profit in the whole life cycle. Since the construction phase's investment would affect the operational phase's cost, the bundling features of this Xiamen case can motivate the social capital to internalize the impact of the construction phase on the operating cost and to focus on the overall efficiency quality of the infrastructure from the initial phase.

Second, full life cycle management can improve economic and environmental efficiency. In a full life cycle management, social capital has a good will to develop the core professional technologies and accumulate project management experience in design, construction, financing, operation, and maintenance, which support improving PPP projects' efficiency. In addition, full life cycle management has formed a correct incentive structure to control costs and improve efficiency. This can avoid the "performance project" and excess capacity behavior frequently committed by the traditional public sector and the resulting phenomenon of whole cost amplification. The PPP model bundles design, construction, operation, and maintenance into a package contract, which is very beneficial to achieve the goal of environmental protection and sustainable development. In the PPP model, there is a direct economic

incentive to consider design, full life cycle operating costs, and final disposal costs in addition to the initial capital investment. Although the initial investment of some projects is high, the operation and maintenance cost in the full life cycle is low, thus reducing the total cost; more resources will be invested in the design stage of the contract, forming a more optimized scheme, which not only does not sacrifice the capital use value of the whole life cycle of the project but also meets the environmental protection requirements.

In short, from the perspective of cooperation surplus theory, value for money evaluation from qualitative and quantitative dimensions, the feasibility of PPP projects, and the surplus value of cooperation between the public sector and social capital are judged in advance. This is conducive to the project's sustainability, reflected in the following aspects. The first one is to integrate risk transfer arrangements. The government and social capital share the risk according to the optimization principle, and the government transfers the risk to social capital scientifically and reasonably. Second, it could control the whole life cycle cost. Social capital should be responsible for integrating of design and construction costs with the operation, maintenance, and overhaul costs and encourage them to considerate cost minimization in the whole life cycle to achieve efficiency improvement. Third, it could provide information for social capital to make cost and capital planning in advance within the whole life cycle. This improves cost predictability and reduces the risk of a lack of operation and maintenance funds after the completion of the project. Fourth, it can promote social capital innovation. The government should formulate detailed output descriptions and focus on result-oriented rather than input- and process-oriented, to encourage social capital to innovate in procurement competition and project implementation. Lastly, it encourages social capital to improve the utilization rate of assets, creates various sources of income by using a single project, or achieves economies of scale through the overall utilization of multiple projects undertaken by the social capital to reduce government fees.

However, compared with the typical international national PPP value for money evaluation elements (Figure 16), Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP project could be better. For example, in the qualitative evaluation, the market failure problem is not really considered. The "degree of potential competition" in the evaluation index seems to consider this. Still, it thinks about the project's attraction to social capital rather than whether there will be sufficient market competition after the project is completed and put into use. In addition, the fixed discount rate was used in the quantitative evaluation regardless of the cooperation years, which could not reflect the capital cost of procurement at that time nor the particular circumstances of environmental upheavals, such as COVID-19. Finally, although each evaluation criterion gives what it should look like within a specific score value, its definition of "look" is vague, leading to a big difference in the

scoring results due to the different understanding of the scoring experts.



Country	Evaluation Execution Time	Risk Management	Discount Rate	Qualitative Evaluation	Judgment Method Of Project Feasibility
Britain	At the annual budget stage, carry out the evaluation at the plan formation stage; at the obc stage before the ojeu sends the notice, carry out the project evaluation; at the end of the obc stage and before the completion of the financial financing, start the evaluation at the procurement stage	Confirm whether the risk transfer scheme can be realized through the qualitative assessment in the first two stages; in the third stage, it is still necessary to reconfirm whether the project risk sharing scheme is appropriate and deliverable	Calculated by the actual discount rate based on the social time preference discount rate, the discount rate used to return the cash flow is 3.5% (applicable to the period of 0-30 years, and the period of more than 30 years uses a lower discount rate with the increase of the period)	The first two stages consider the feasibility, usefulness and realizability of pfi project, in the final stage of qualitative assessment, consider whether there is market failure, efficient procurement process and risk transfer	On the basis of qualitative and quantitative evaluation, make an overall judgment. If the pfi scheme is proved to be feasible, the procurement shall continue
Australia	After receiving the bid proposal conforming to the RFP	Identify risks, estimate consequences and probability of occurrence, and calculate var=var=risk consequences x probability of occurrence+accidental factors	It is formulated based on the specific situation of the project and according to the market risk-free rate of return+risk premium to reflect the systematic market risk (risk premium is not considered when the government assumes all systematic risks)	Qualitative assessment of the certainty, social benefits, design effectiveness, etc. Of operation and service delivery	Evaluation of bids based on PSC, both quantitative and qualitative factors shall be taken into account in the final decision to award the contract
Canada	Formal evaluation starts after the submission of the bidding scheme; after the bidding scheme is selected, a new round of evaluation will be conducted before the end of financial financing according to the contract	Risk management similar to Australia	The discount rate is determined separately for each project to reflect the current procurement capital cost, rather than setting a fixed discount rate at the legislative or regulatory level	According to the objectives defined by the project, qualitatively assess the extent to which public procurement and PPP procurement meet their respective objectives	Evaluate the bidding scheme based on PSC cost; but cost is not the only factor

[Note: PSC is the comparative value of public sector; PFI is private initiative financing; OJEU is the official announcement of the European Union; OBC is the outline plan; RFP,

Figure 16 Comparison of PPP value for money evaluation factors in typical countries (Zhang et al., 2016)

Financial Affordability (FAA) Demonstration and Its Discussions on Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP Project

As mentioned in chapter three, the responsibility of financial affordability can be identified as four aspects: equity investment expenditure responsibility, operating subsidy expenditure responsibility, risk bearing expenditure responsibility, and supporting input expenditure responsibility. The situations of the Xiamen case are as follows.

- 1) The equity investment liability is CNY 30 million, and the proportion of government investment accounts for 10% of the project company's registered capital of CNY 30 million.
- 2) The operation subsidy expenditure liability was calculated as CNY 1351508.09 million.
- 3) In the expenditure responsibility of risk bearing, the risk of the project is identified as construction risk, operation risk, revenue and market risk, government/political risk and force majeure risk. However, it is difficult to determine the occurrence probability of various risks of the project, so scenario assumptions such as "basic," "adverse," and "worst" are made according to various events and variables that affect risks, and the result is CNY 8.931 million. Details of the liability for risk-taking expenditure are shown in Appendix 3.
- 4) In the Xiamen Sponge City Underground Comprehensive Pipe PPP projects, the supporting investment expenditure liability is the corresponding road development expenditure, which is 0. Therefore, during the project cooperation period, the total fiscal expenditure responsibility is CNY 205.96901 million, and the present value of the annual expenditure responsibility is CNY 138.87501 million.

Table 5 Government's risk bearing items

Risk Type	Risk Detail
construction risk	Geological conditions
	The land cannot be delivered in time
	Water, electricity, access roads, construction sites and other supporting arrangements
	Restrictions on the use of waters and sea areas
	Protection of Archaeological Relics
Operational risk	Operation and maintenance cost overrun (price adjustment)
Revenue or market risk	Small scale of pipeline corridor
	Changes in charging standards
	Insufficient charging capacity
	Insufficient financial budget
	Government default/early termination
Government/Political Risk	Expropriation
	Approval delay
	Project change proposed by the government
	Policy/law changes
	Other changes in the political environment
Force Majeure	Force Majeure

The calculation of financial affordability (financial revenue and expenditure of Xiamen City) is based on the Xiamen Municipal Bureau of Finance, which is the expenditure data of the public budget of Xiamen City from 2010 to 2015. Based on the sample data, the average growth rate of 6 years is 16.46%, and the annual growth rate is estimated in the following years. For this project, the government expenditure responsibility in 2020 accounts for the highest general financial expenditure of Xiamen City at the same level, which is 1.23%, far lower than the requirement of "ensuring that the expenditure responsibility of PPP projects in each year does not exceed 10% of the general public budget branch". This conforms to the PPP implementation method. The details of the financial affordability (FAA) measurements are shown in Appendix 4.

PPP sustainable development (Jomo et al., 2016) mentioned the need to "build capacity to enter into PPPs" to reduce the risk of failure of PPP projects and improve their sustainability. Therefore, the argument of financial affordability is necessary. Meanwhile, studies have shown that sufficient funds can greatly reduce the failure risk of Sponge City PPP projects (Hong et al., 2020). In the analysis of the financial affordability of the Xiamen project, the financial expenditure of this Sponge City PPP

project is far less than the financial affordability, which is conducive to its implementation and sustainable operation and maintenance.

Like the value for money evaluation system, the argumentation criteria of financial affordability are highly similar across China. China adopted the Australian PSC framework, including Raw PSC, Competitive Neutrality, Transferred Risk, and Retained Risk. It contains Transferred Risk, Retained Risk. Internationally, some countries such as New Zealand adopted the financial capacity demonstration, which only has Transferred Risk but Retained Risk. The two systems' relative advantages and disadvantages are insignificant when the risks need to be adjusted.

Risk Allocation Mechanism in Xiamen Xiang 'An Underground Comprehensive Pipeline Corridor PPP Project

In principle, the social capital parties usually are allocated technical risks such as design, construction, operation, and maintenance; and government usually takes risks such as laws, policies, and minimum requirements, and risks such as force majeure, financing are reasonably shared by the government and social capital.

Principles of Risk Allocation in Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP Project

The risk sharing of the Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP project is mainly distributed by contract. Reasonable risk distribution is essential for the continuation of the PPP project. The risk distribution between the government and social capital in the PPP model is mainly based on eight principles: equity, criterion of liability, risk income equivalence, effective control and minimum risk cost, risk upper limit, direct loss bearing principle, the dynamic principle of risk sharing, and risk preference principle.

The principle of fairness is mainly reflected in the following aspects. It emphasizes the balance of the rights and obligations of the contract terms and the risks derived from the contract. Additionally, it is not only concerned about the benefits of the contract subject due to risk events but also the risk losses faced by the contract subject.

The principle of imputation is to determine the attribution of responsibility according

to a specific solid-state to solve the problem of bearing responsibility. It determines the composition of the liability for breach of contract, the content of the burden of proof, the reasons for exemption, and the scope of damage compensation. PPP contracts are "contractual" and "administrative", and the diversity of reasons for liability caused by risk factors makes the liability attribution in PPP contracts extremely complex. Considering the characteristics of PPP contracts, they can be adjusted by the comprehensive application of administrative law and civil law. The liability for breach of civil contract is based on the obligations agreed in the contract. The principle of liability fixation in the contract law of China mainly includes the principle of strict liability (no fault liability) and the principle of fault liability. The liability for breach of an administrative contract is based on the obligation of restricting the administrative subject and the counterpart in the administrative contract. The standard administrative liability principles include fault liability principle, fault presumption principle, illegal liability principle, and strict liability principle. The principle of presumption of the fault has a wide range of applicability, and most of the imputation of administrative responsibility applies to this principle. When determining the liability imputation of PPP risk sharing, a unified imputation framework, including the administrative imputation principle and civil imputation principle, can be established according to the risk type to define the fault Party of the contract clearly and fully.

The principle of reciprocity between risk and benefit is that the biggest beneficiary of the economic benefits obtained from managing a particular risk should bear the risk. When an entity must bear the risk loss, it should also have the right to enjoy the benefits brought by the risk change, and the degree of risk undertaken by the entity matches the income. If the cost of risk acceptance is higher than risk return, the risk transfer cannot occur voluntarily. If the risk is imposed on a party and the party has appropriately handled the risk, there should be an opportunity to repay the party. Risk sharing is meaningful only if all participants can benefit from risk sharing. This requires that the risk information of both parties should also be symmetrical, otherwise the risk sharing cannot be optimized. In practice, achieving complete symmetry of risk sharing is difficult, so some scholars argue that it is unnecessary to achieve total balance.

The principle of effective control and minimum risk cost means that the risk should be allocated to the party in the most favorable position to control the risk and control the risk at a small fee; that is, the risk sharing should be symmetrical with the control ability of all parties involved; the risk should be allocated to the party that can best manage the risk and reduces the risk. Meanwhile, risk sharing shall minimize the total cost of risks undertaken by all parties in the project life cycle. According to this principle, the government, which can influence regulations, policies, laws, and other regulations, is in a more favorable position than the private social capital party to

identify, evaluate and control these risks. So, the public government party should mainly allocate these institutional risks. The non-institutional risks, such as the risks brought by the market environment and their operations, are mainly borne primarily by private institutions. However, it is not easy to realize this principle when applied because it is only limited to the risk that it is easy to judge which party has more control. There are some risks that neither party has control over in the PPP project, such as force majeure risk. For the risks that both parties have no control over, risk occurrence possibility and the cost shall be allocated by the willingness of social capital and government.

The principle of an upper limitation means in the case that some risks may have unexpected changes or the damage caused by the risks is much greater than previously estimated; one party shall not be allowed to bear these nearly unlimited risks alone because the enthusiasm of the risk bearers in managing the project will be affected. Therefore, the principle that there should be an upper limit for the risks undertaken shall be followed. The upper limit of the risk that the project participants can bear is related to the financial ability to bear the risk, the technical ability to deliver the project, the management ability, and other factors.

The principle of direct loss bearing means that the party who is the immediate victim when the risk occurs shall be allocated that kind of risk. Because parties whose interests may be damaged would take more active measures to avoid such risks, direct victims' internal motivation and enthusiasm to prevent and control such risks would improve the efficiency of risk management.

The dynamic nature of risk sharing means that with the development of the project, when the internal and external conditions change, it is necessary to redefine the risk-sharing pattern. This is mainly caused by the long-life cycle of the PPP project and the conflicting objectives of all parties. The risk shared by the private and government should be renegotiated every three years to adjust the risk-bearing capacity of both parties. The dynamic nature of risk sharing reflects that the PPP agreement has the nature of an incomplete contract. It is precise because the parties cannot exhaust all risks during a contract negotiation, that renegotiation clauses are designed in the contract to realize the adjustment of risk sharing. This makes risk sharing more flexible, but if the design is improper, it may increase the cost of renegotiation.

The risk preference principle means that the project participants should bear the risk with the largest risk preference coefficient to maximize the overall satisfaction of the project. If the project participants have the largest preference coefficient for a certain risk, the project participants are most suitable to bear the risk. However, in practice, it is very difficult to accurately determine the preference coefficient of project

participants for a certain risk.

Risk Allocation Process

Based on the risk allocation principle of PPP projects, specific risks are allocated according to the following risk allocation process (Figure 17).

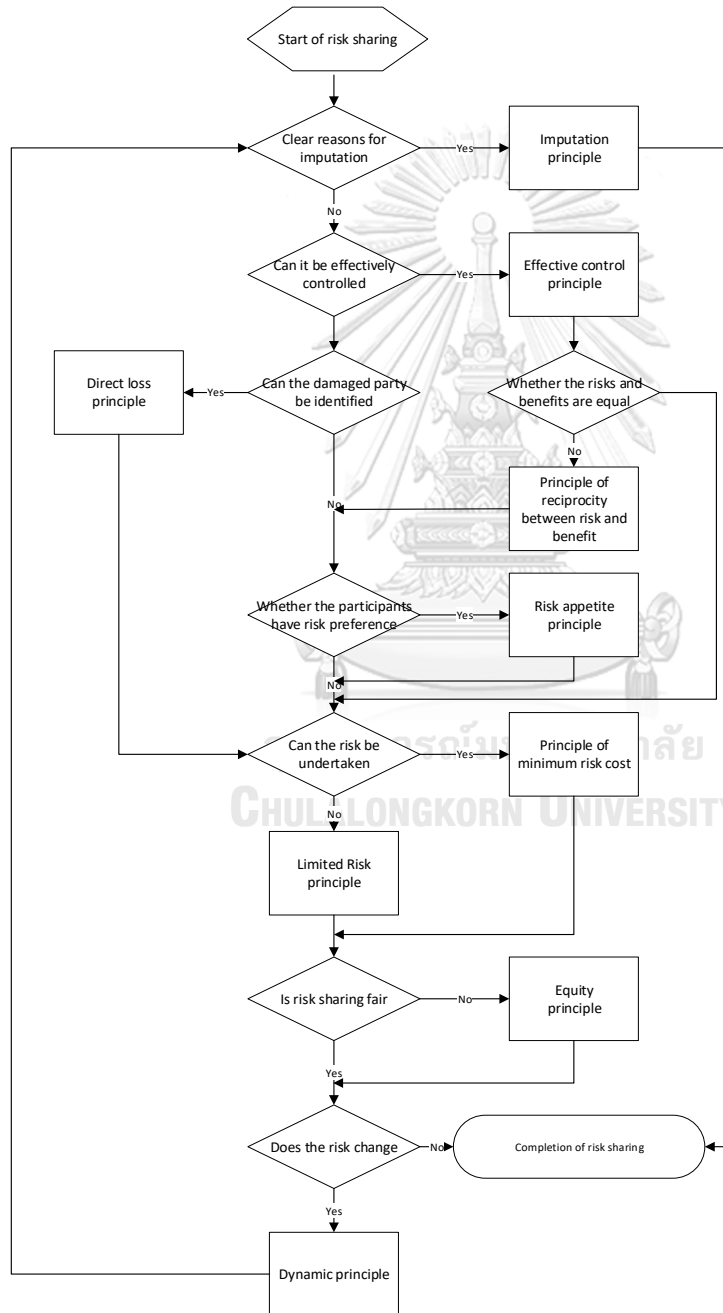


Figure 17 Risk allocation process

Risk Allocation Results

Table 6 shows the risk allocation results of the Xiamen Xiang'an Underground Comprehensive Pipeline Corridor PPP project. The space utilization of the comprehensive pipeline gallery has intensive requirements. There will be mutual interference between pipelines in different industries, including the pipeline itself and the interference caused by emergency conditions such as safety accidents of specific pipelines. Therefore, the risk allocation between the project company and the pipeline unit entering the gallery shall be specially considered in the risk allocation. The results of risk allocation are very similar to those mentioned at the beginning of this section. The project company mainly bears design, construction, finance, operation, maintenance, and other commercial risks. Policy and legal risks are mainly borne by the government. Political, macroeconomic, and force majeure risks shall be reasonably shared by the government and the project company. For the details of each item, please check appendix 5.

Table 6 Risk allocation results of the Xiamen Xiang'an pipeline PPP project

Risk type		Government's Duties	Project Company's Duties	Pipeline Company's Duties
Construction risk	Geological conditions	√	√	
	The land cannot be delivered in time	√		
	Water, electricity, access roads, construction sites, and other supporting arrangements	√		
	Restrictions on the use of water and sea areas	√		
	Interference from road construction		√	
	Company Propose project		√	

	change			
	Construction/procurement cost overrun		√	
	Construction delay		√	
	Construction quality is not up to standard		√	
	Site safety/environmental protection		√	
	Protection of Archaeological Relics	√	√	
Operational risk	Technical defects		√	
	Commissioning		√	
	Equipment/facility failure		√	
	Increased operation and maintenance costs	√	√	
	Service quality is not up to standard		√	
	Operator Default/Early Termination		√	
	Residual value risk		√	
	Security management		√	√
	Environmental protection		√	√
	Interference of corridor access pipeline		√	√

	Corridor access pipeline accident		√	√
Financial risk	Financing failure		√	
	High financing cost		√	
	Change in interest rate		√	
	Debt service risk		√	
Revenue or market risk	Small scale of pipeline corridor	√		
	Changes in charging standards	√	√	
	Charging capacity	√	√	
	Insufficient financial budget	√		
	Inflation	√		√
Government/political risk	Government default/early termination	√		
	Expropriation	√		
	Approval delay	√		
	Project change proposed by the government	√		
	Policy/law changes	√		
	Other changes in the political environment	√	√	√

Force majeure	Force majeure	√	√	
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Discussions on Risk Allocation in Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP Project

Risk management of PPP projects is indispensable to meet the requirements of sustainable economic development in the concept of sustainability for an economy's ability to support an ideal level of economic activity in the long run. Management of risks enables stakeholders to ensure that their economic, technical, and other aspects cannot exceed the limits of their capabilities and keep alert to all kinds of important risks so that the project can be implemented, operated, and maintained in accordance with the original plan. The principle and process of risk allocation of Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP project can reduce the cost of risk caused by the uncertainty of the PPP project to the greatest extent, to ensure the whole life cycle of the project. Moreover, the rationality of risk types and proportions to be undertaken by stakeholders can effectively leverage the surplus value of PPP cooperation.

In the principle of risk allocation, Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP project has carried out an operable expansion of the PPP risk allocation principle (see the first part of this section). Through the principle of liability, the principle of direct loss, the principle of minimum risk cost, the principle of risk preference, and the principle of risk upper limit, the risk is clearly optimized. All risks are controlled to the greatest extent through the principle of fairness and dynamic principle, and to a certain extent, the sensitivity of risk changes is maintained. The risk allocation process (Figure 17) prioritizes various principles, making the risk allocation more reasonable. In fact, only from the risk allocation process is unreasonable to directly apply the principle of liability to end the allocation of risk when there is a clear cause of liability, because not every stakeholder can bear the responsibility it needs to bear. But considering the strict requirement of the Xiamen Xiang 'an project on the qualification of social capital in the steps of social capital selection, it is reasonable. Because each chosen social capital can independently assume its share of the responsibility.

Secondly, Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP project ranked "whether the risk can be effectively controlled" in the order of "specifying the cause of responsibility", which takes precedence over all other

principles except the "principle of liability fixation". This shows that Xiamen Xiang'an's project risk allocation first pays more attention to risk control. It is meant for other principles, such as risk-return equivalence and fairness, only when the risk is controlled and the project is successfully implemented. Otherwise, the project implementation will fail, and all the preparation and investment in the early stage will waste resources. In addition, when the cause of responsibility cannot be clarified, the parties shall be given the maximum choice of risk preference to ensure they can bear the risk. This is conducive to the risk control of all parties. The Xiamen Xiang'an project also attaches great importance to fairness. In this process, the fairness of risk allocation is confirmed twice through the "risk-return equivalence principle" and "fairness principle". Finally, Xiamen Xiang'an is sensitive to changes in various situations through the "dynamic principle" so that it can quickly adjust the risk allocation and ensure the smooth progress of the project.

However, the scientific process of the risk allocation is only a sufficient and unnecessary condition for the success of the project risk allocation. The simple qualitative analysis of the Xiamen Xiang'an Project need to achieve accurate control of the risk, which is extensive risk control. We can determine the proportion of the risks the stakeholders will bear to a certain extent. In that case, we may can control the risks more accurately so that the risks can be effectively controlled and a better combination with the lowest risk cost can be achieved to the greatest extent.

At present, in China, the quantitative methods for risk allocation of the Sponge City PPP model include the Sponge City PPP projects risk sharing mechanism based on improved TOPSIS method and utility theory (Xu, 2021) and the Sponge City PPP projects risk sharing mechanism from the perspective of game theory (Zhou, 2020). Although these methods can be calculated to obtain specific numerical proportions, they are complex and time-consuming. So, the following content is trying to explore a method of risk determination that combine qualitative and quantitative advantage, named multicriteria comparison in different proportions method.

Multicriteria comparison in different proportions method draws on the principle of the multicriteria methodology (Biggiero & Laise, 2003) for determining the organizational structure. The specific ideas and operations are 1) Score each option under each weighting criterion. 2) Establish a concordance matrix to measure the Synergy degree between each option. 3) Establish a discordance matrix to measure the conflict degree between each option. 4) Establish outranking matrix by joint concordance and discordance matrix.

Following is a numerical example of multicriteria comparison in different proportions method (Figure 18). Firstly, different schemes (G_x) are scored according to different criteria (C_x), and the persons scoring can be experts or stakeholders. Secondly,

according to the scoring results, compare all schemes in pairs. For example, when G1 and G2 are compared, $C1 (G1)=2 < C1 (G2)=4$, $C2 (G1)=4 > C2 (G2)$, $C3 (G1)=3 > C3 (G2)=2$, $C4 (G1)=4 < C4 (G2)=5$, $C5 (G1)=3 > C5 (G2)=2$, it can be concluded that G1 is inferior to G2 in C1 and C4, and superior to G2 in C2, C3 and C5. Third, calculate the weighted score superior to other schemes. For example, $C (G1, G2) = Wc2 + Wc3 + Wc5 = 0.2 + 0.2 + 0.2 = 0.6$. Fourth, when $C (Gi, Gj) > 0.5$, then use 1 to record it as a satisfaction; for else results, use 0 to record it, which means do not satisfy. Fifth, calculate the discordance (conflict degree) of each evaluation factor in different schemes, for example, $D (G1, G2) = \max [(4-2), (3-4), (2-3), (5-4), (2-3)] = 2$. The maximum value obtained is used as the threshold value of the conflict degree of each scheme. If it is less than the threshold value, it means that the degree coordination test has passed and is recorded as 1, otherwise it is recorded as 0. Compare the Concordance test result with the Discrepancy test result. When both results are 1 (pass), they pass, Otherwise, 0 will be recorded as failed. Lastly, get the priority of each scheme. Scheme G1 takes precedence over others.

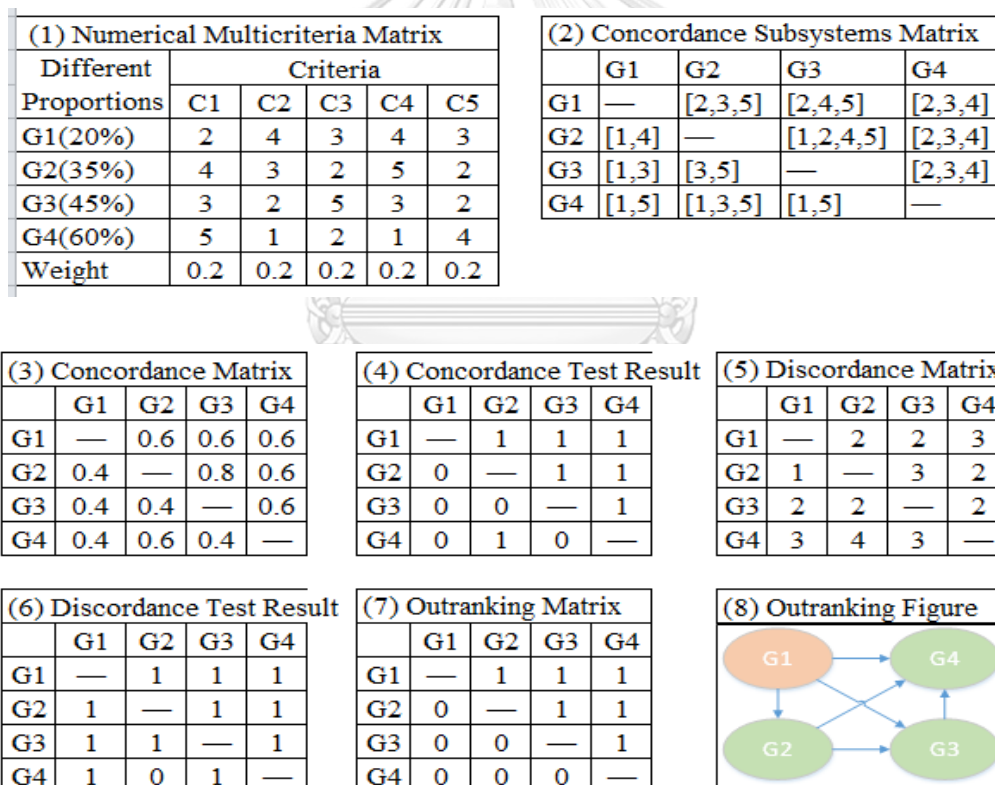


Figure 18 A numerical example of multicriteria comparison in different proportions method

Although it is set here as the comparison between different scales of the same stakeholder, after getting the proportion of all single stakeholders in various types of risks, we can compare the results of stakeholders again to check whether their results

will conflict with this method.

Transaction Structure, Contract System and Return Mechanism and Its Discussions on Xiamen Xiang 'An Underground Comprehensive Pipeline Corridor PPP Project

This part discusses the transaction structure, contract system, and return mechanism of Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP Project.

Transaction Structure and Contract System

In the Xiamen Xiang'an Underground Comprehensive Pipeline Corridor PPP project, Xiamen Municipal Government authorizes Xiamen Municipal Engineering Management Office to act as the implementation agency of the Project, responsible for social capital procurement, project agreement signing, and subsequent supervision. According to the project agreement, Xiamen Municipal Engineering Management Office has granted the project company the right to be responsible for the investment, financing, construction, operation, and maintenance of the underground comprehensive pipe gallery project in Xiamen Xiang'an New Airport. The project company undertakes the investment and financing construction of the underground comprehensive pipe gallery project, provides comprehensive pipe gallery services to the pipeline unit through operation and maintenance, collects corridor access fees and daily maintenance fees from the pipeline unit according to the authorization and relevant management systems of Xiamen, and obtains feasibility gap subsidies from Xiamen Finance according to the return mechanism of the project. Figure 19 shows the specific structure. According to the relationship between stakeholders in the transaction structure, the corresponding contract system was formed (Figure 20).

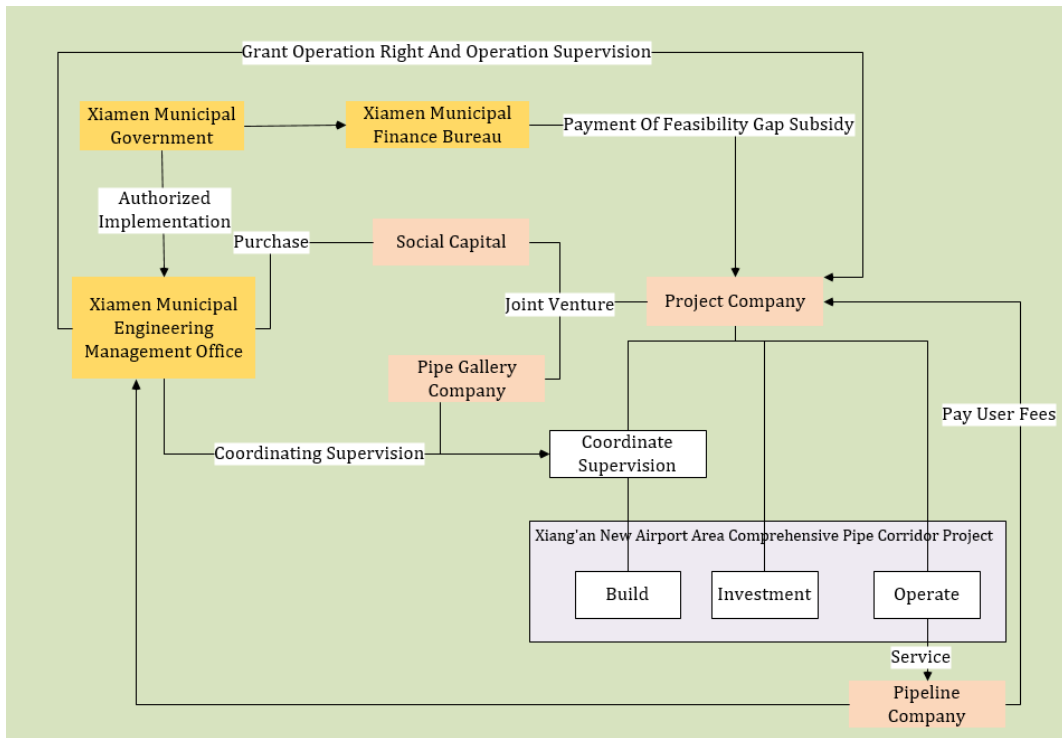


Figure 19 Transaction Structure of Xiamen Xiang'an Underground Comprehensive Pipeline Corridor PPP project

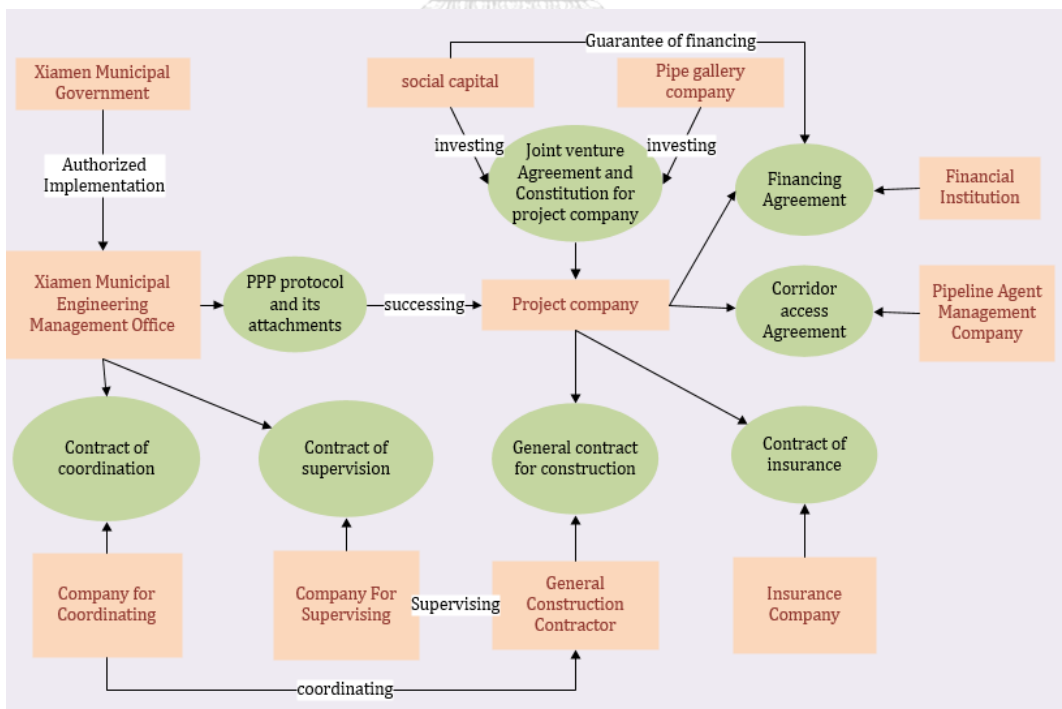


Figure 20 Contract System of Xiamen Xiang'an Underground Comprehensive Pipeline Corridor PPP project

From the point of view of the principal agent theory, the transaction structure and contract system of the Xiamen Xiang'an pipeline PPP Project are reasonable. The principal agent theory is one of the main contents of contract theory in institutional economics. It mainly studies that under an express or implicit contract, one or more actors designate, hire, and authorize other actors to serve them, and pay them the corresponding remuneration according to the quantity and quality of the services provided by the latter. The authorizer is the principal and the authorized is the agent. The principal-agent theory is based on the asymmetric information game theory, which will cause losses to the entrusting party, the agent, or both parties and affect the life cycle of the cooperation project.

Therefore, it is necessary to clarify the relationship of power and responsibility between the principal and agent through transaction structure and contract to ensure that all parties' work is carried out in an orderly manner. It is the guarantee of sustainable development of PPP projects. Xiamen Xiang'an pipeline PPP Project emphasizes the transaction subject, transaction content, transaction mode and pricing in the principal-agent contract. The transaction structure in the Xiamen Xiang'an case (Figure 19) well explains that the local government and relevant government departments, as the principal, are mainly responsible for authorization and supervision of the agent's exercise of rights. Social capital, as the agent, is mainly responsible for the implementation, operation, and maintenance of the project. The project contract structure is shown in figure 20. In this case, the transaction structure does not explain the interest distribution relationship between stakeholders. There is a dedicated project company and companies' shareholder return mechanism as supplements, which will not be discussed here.

From the perspective of the transaction cost theory, the harmonious cooperative relationship between the government and social capital is conducive to controlling the cooperation cost of the project, especially the ex-post cost. A clear definition of responsibilities enables them to make clear the importance and urgency of different events, effectively complete the progress of their own side, and promote the project's overall progress. At the same time, it lays the foundation for controlling project risk efficiently. This is an important reason for the project's smooth implementation, operation, and maintenance. However, it can be clearly seen from the contract system (Figure 19) that the project company and each company involved directly sign a separate contract, which is a typical flat management structure. The initial cost is likely to rise due to the tedious negotiations in the early stage. The complexity should be reduced as far as possible to ensure the clarity of rights and responsibilities.

In addition, in the project with the flat management structure, the government has an absolute advantage in the discourse power and is in the central position. The government and its related affiliated agencies basically grasp every link to the

implementation of the PPP project in Sponge City. This kind of “centralized” control controls the progress of the project from the top down. This kind of control itself has advantages and disadvantages. In the performance reward and punishment system with vague evaluation standards, that is, under the condition of the immature evaluation system, it can supervise the project in time to ensure the expected effect of project construction. However, in the performance reward and penalty system with clear indicators, the high-intensity centralized control is not conducive to innovation. It will even inhibit the social capital in the PPP cooperation project technology, management, and operation advantages of the play, thus weakening the original intention of the PPP project cooperation to play to the benefit of all parties. At that time, Sponge City, as a new thing in China, was not mature either in technology or evaluation system, so centralized control was reasonable and necessary. In this case, it ensured the smooth and healthy development of the project.

Return Mechanism of Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP Project and Its Discussions

The reward mechanism of this project is "user payment and feasibility gap subsidy". The user fee of the comprehensive management gallery includes the entrance fee and the daily maintenance fee. Xiamen has a mature management gallery payment mechanism, and most situations have rules to follow. The feasibility gap subsidy shall be paid from the beginning of the project construction period (the first year) to the end of the cooperation period. The specific calculations method are as follows. Firstly, in the first and second years, the project company can obtain a fixed amount of feasibility gap subsidy (special subsidy), tentatively CNY 200 million. Second, from the third to the 12th year, the project company's total income includes construction investment recovery and daily maintenance income. The daily maintenance part reflects the maintenance effect of the project through the evaluation reward and punishment coefficient ranging from 0.8 to 1.2. Third, since the 13th year, the total income of the project company only includes the income from routine maintenance. Fourth, the feasibility gap subsidy amount is the difference between the total income of the project company and the user fee (receivable amount) calculated by the project company according to the scope of government authorization and the charging standard. In addition, this project also has a clear formula price adjustment method, which will not be detailed here.

From the perspective of public goods theory, user payment of Xiamen Xiang 'an pipeline PPP project is helping to improve the quality of this service. Although in PPP

projects such as highways, user payment can reduce the "congestion" of public goods, such as pipelines, which every household must use, the intention of reducing the use cannot be realized to reduce the congestion. However, the "congestion" can be reduced by increasing the flow and bandwidth of the pipeline itself at the cost of the user. The user ladder payment approach reduces the "negative externalities" and allows payers to control their use of the pipeline within the scope of their real needs. At the same time, it also helps residents to understand the social cost of public services. Forcing demanders and suppliers to face the true opportunity cost of providing public services can establish a close link between demand and supply. As a result, more resources are available for the public services people really need and are willing to pay for, and public services are delivered more efficiently.

From the perspective of society's sustainable, Xiamen's feasibility gap subsidy guarantees to meet residents basic needs for the public goods pipeline and ensures social equity. Now there is a view of "urban operation"; that is, the government uses market means to carry out capitalization operation and management of various resources and assets in the city under the condition of market economy. When the government adopts the so-called "commercialization" model, and the pipeline company ultimately sets price, it will inevitably pursue the maximization of benefits. Thus, the price may only be affordable for some public. Therefore, a pipeline, a public good, is necessary for the public. Hence, its price is more determined by the government on behalf of the interests of citizens, leading to the pipeline units' free or cheap access to the corridor failing to achieve good operation. Therefore, this inevitable funding gap requires the government to provide subsidies to protect the basic needs of the public. If the user payment in Xiamen Xiang'an pipeline PPP project is a kind of "urban operation", then the "feasibility gap subsidy" is to control the intensity of "urban operation". Xiamen Xiang'an has balanced the two payment mechanisms to ensure the citizens' demand for infrastructure and promote the sustainable development of society.

Procurement mode of Xiamen Xiang'an Underground Comprehensive Pipeline Corridor PPP Project and Its Discussions

The procurement refers to the government's procurement of social capital; that is, the selection of PPP partners, and they are bound to each other through PPP agreements. Xiamen Xiang'an Underground Comprehensive Pipeline Corridor PPP project adopts the way of public bidding for procurement. The initial assessment of the eligibility conditions for social capital includes the legality of social capital, technical

qualifications, technical experience, capital strength, and financing ability. Appendix 6 shows the details. In the final selection of social capital, the evaluation criteria include construction management, operation, maintenance, facility transfer plan, financial plan, and business quotation. Table 7 shows the secondary rating standards under these criteria and their proportion. We can clearly see that the assessment of the capacity of construction, operation, and maintenance accounts for more than 50%, while the proportion of commercial quotations accounts for only 30%.

Table 7 Evaluation criteria of choosing social capital

	Scoring factors	Full score
Construction management	Project construction management team	6
	Construction resource input scheme	6
	Quality, safety, civilization, and environmental protection measures	6
	construction organization	8
Operation and maintenance	Operation organization	6
	Routine maintenance	7
	Emergency response	7
Facility handover plan	Facility handover plan	8
Financial programme	Bank credit	1
	Financial plan during construction	5
	Financial plan during operation	4
	Legal programmes	6
Commercial quotation	Commercial quotation	30

In the study of the sustainable operation of PPP projects, sufficient funds can greatly reduce the failure risk of PPP projects in Sponge Cities (Hong et al., 2020). Therefore, in the capital strength of the qualification conditions for social capital, it is required that the net assets of enterprises should be higher than RMB 500 billion. About 50% of the initial budget capital of the Xiamen Xiang'an Corridor PPP project. Meanwhile, according to the previous analysis of financial affordability, the capital invested by the government in this project only accounts for about 2% of Xiamen's financial resources every year. This is a great guarantee for the smooth progress of the project.

From the perspective of cooperative surplus theory, proper procurement of Xiamen Xiang'an pipeline PPP project lays the foundation for the sustainable development of the whole project. First, Xiamen Xiang'an PPP project pays attention to the "value for money" of the basic economic work. In this project, the proportion of commercial quotation only accounts for 30%, so the quotation no longer has the right of one vote negation as in the previous selection of social capital but attaches great importance to the ability of social capital to build and operate the project and selects the social capital that can best guarantee the smooth progress of the project. Secondly, public bidding is a way that can be adopted if the procurement project meets the standard of public bidding amount. Xiamen Xiang'an pipeline PPP project has clear and complete core boundary conditions and technical and economic parameters in the procurement requirements, and the characteristics of the project that does not change in the procurement process fully meet the requirements of public bidding. The selection of public tenders is wide and competitive, which makes Xiamen Xiang'an PPP project in line with the requirements of the bidders for full selection. Public bidding can avoid the secondary bidding of the general construction contractor, that is, the franchise project investor who has been selected through bidding can construct, produce, or provide by himself according to law, but can no longer select the design, construction unit or equipment provider through bidding. Meanwhile, the main core conditions of the project were determined in advance through the bidding documents, which reduced the uncertainty of communication and consultation and made the process more controllable without special approval. This ensures that the project can run smoothly based on maximum efficiency.

Finally, although the evaluation criteria of social capital selection are in line align with the project's, the evaluation process is always inseparable from the link of expert evaluation. However, although this link is gradually standardized in China, there are still a lot of problems. For example, the professional setting of the expert database is not refined, the discretion is too large, and the number of industry experts is insufficient, which will produce significant or even reverse results on the score results.

Performance Evaluation of Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP Project and Its Discussions

The Xiamen Xiang'an Underground Comprehensive Pipeline Corridor PPP project mainly uses a specific-ratio reward system. According to the stage of the construction period and operation and maintenance period, different assessment standards are formulated. Daily assessments, quarterly assessments, and spot checks are adopted for evaluation. Then rewards and punishments are carried out according to the final scoring results. The assessment content includes all kinds of project indicators after the completion of the project and the actual effect after the operation. Xiamen Xiang'an underground comprehensive pipeline corridor PPP project, introduces a third party for complete acceptance.

Upon the completion of the Xiamen Xiang'an Project, the government will conduct the complete acceptance in accordance with the country's, Fujian Province's, and Xiamen city's relevant construction standards. If the project fails to meet these standards, the government has the right to refuse the acceptance inspection. Additionally, on the premise that the entire cooperation period remains unchanged, the project operation period and payment cycle shall be postponed accordingly until the project company improves and meets the acceptance standards as required. The project management corridor, ancillary facilities and related equipment shall comply with the design, technical specifications and standards and the relevant requirements in the corridor entry agreement. To encourage the project company to innovate and improve the operation level, the PPP project contract is to be comprehensively evaluated through the index system of environmental benefit, energy consumption and material consumption, facility and equipment integrity rate, problem feedback and processing timely rate, user complaint rate, and other aspects. After passing the evaluation, the reward will be given in accordance with the proportion stipulated by the policy.

In terms of the integration of the objectives of the principal and the agent, the performance evaluation of Xiamen Xiang'an underground comprehensive pipeline corridor PPP project is favorable to the actual operation effect after the project investment, which can not only reduce the transaction costs of both parties but also improve the overall utility of the company. In the theory of principal and agent, it is possible to maximize the interests of both parties only when the objective fusion of principal and agent is realized under asymmetric information.

An important logic is mentioned in the target fusion of principal and agent: the interest restriction relationship is formed between the principal and agent so that both sides can generate incentive compatible constraints. The agent's interest maximization behavior also realizes the principal's interest maximization. The harder the agent works, the more residual income it gets, with the more potent incentive to work. Both the principal government side and the agent social capital side have different proportions of property rights; in the Xiamen case, the social capital side has as much as 90% of the property rights. Although it is an information asymmetric game, the interests of both parties are closely linked by the social capital's interest and the high-cost nature that damages the interests of the principal under the high property rights.

Specifically, in the Xiamen case, the high-cost nature of harming the principal's interests means that the principal will not accept the projects that fail to meet the relevant acceptance standards as mentioned above and will postpone the start date of the project operation period and the payment cycle accordingly on the premise that the whole cooperation period remains unchanged until the agent makes improvements as required and meets the accepted standards. As an important economic source of the project, delayed operation under the condition of unchanged cooperation period will cause the agent to suffer huge economic losses.

Therefore, the social capital of the agent will not easily damage the rights and interests of the entrusting party, which can guarantee the quality and service efficiency of the entrusting party's social capital for the underground comprehensive pipe gallery of public goods. Compared with China's traditional project implementation, which mainly provides funds through financial subsidies, this reward and punishment system avoids the corrupt bureaucracy of "taking more money and doing less work" by the agent to a large extent.

In addition, from the perspective of the fairness of the principal agent, the PPP project of Xiamen Xiang 'an underground comprehensive pipeline corridor PPP project has introduced a third-professional agency to make the performance evaluation more targeted, professional, and fair. The third-party professional organization, the entrusting party, and the agent have no mutual restrictive interest relationship. Therefore, when evaluating the project, the project can be paid more attention to professionalism and the evaluation standard to eliminate the concern of the entrusting party's unfair evaluation in the traditional way of directly evaluating the agent.

Public Supervision of Xiamen Xiang 'an Underground Comprehensive Pipeline Corridor PPP Project

The supervision of the PPP project of Xiamen Xiang 'an Underground Corridor includes three levels: administrative supervision, performance management, and public supervision, covering the complete life cycle of the PPP project. Administrative supervision and performance management are more measured by the performance appraisal mentioned in the previous section, so this thesis will not repeat the details here but only discuss public supervision.

Public participation in the Xiamen Xiang'an Underground Comprehensive Pipeline Corridor PPP project almost permeates the whole life cycle of Sponge City implementation. The public can supervise the progress and quality of the implementation effect. First, the Xiamen case solicited opinions from the public extensively in the planning stage. It collected ideas and suggestions from the people in ways like questionnaires, WeChat public accounts, and telephone hot line. Second, the Xiamen case investigated the stakeholders' needs in detail during the design phase. For example, the designers investigate the demands of the owners of all projects in the factory, community, and village, like whether there are problems such as poor landscape greening effect, waterlogging, and whether they want to use rainwater resources and improve the green image of the factory. Industrial enterprises and real estate owners can participate in the scheme discussion, design drawing review, project disclosure, etc., and put forward their own construction needs in time. Thirdly, the public could supervise the completion progress, quality, and operation effect. Through publicity, the public can be informed of the reconstruction process, policy theory, fund ratio, implementation plan, etc., to actively participate in the implementation of Sponge City. If they find problems, they can report to the relevant company at any time, and the agent construction and supervision company would supervise the rectification.

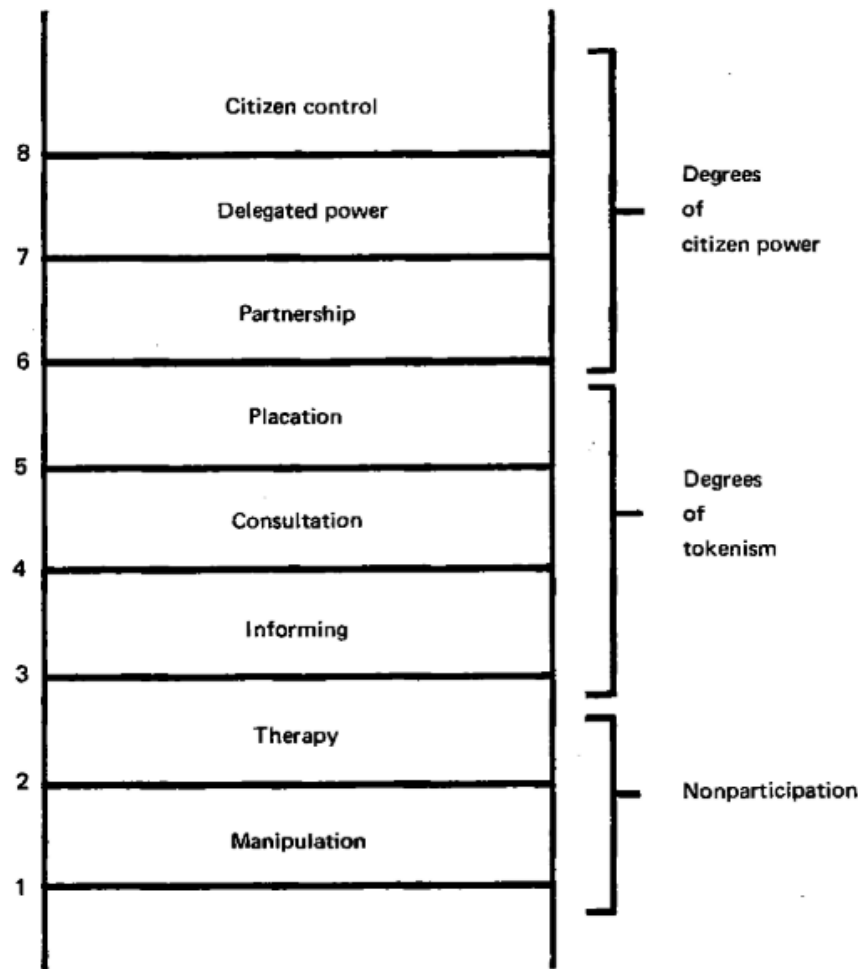


Figure 21 Eight on a Ladder of Citizen Participation

Social sustainability is an important pillar of sustainable development theory, which means inclusive, just, and resilient society. Citizens have the right to speak, and governments are willing to listen and respond. In the Xiamen case, although facially the masses seem to participate in the whole life cycle, it still only in the "degree of tokenism (Figure 21)" (Arnstein, 1969). The public are allowed to speak, but the final decision-making right was not in their hands.

But it is worth noting that all the public participation in Xiamen Xiang'an is based on the publicity of the Sponge City contents. For example, the public could strengthen their awareness and understanding of Sponge City through media, training, lectures, visiting, and other ways. Xiamen even took the lead in compiling a school-based curriculum for elementary and middle school students in Sponge City, and Sponge City implementation courses were carried out in primary and middle schools of the city. These can improve the degree of public participation to some extent.

However, compared with the past way of the government directly issuing and implementing the order, the current form of slightly adjusting the inquiry and issuing the order can give the public a buffer time to accept the policy, thus reducing the direct conflict between the government and the public. It makes the policy more humanized and hence more effective for the sustainable development of society. Therefore, the public participation of Xiamen Xiang'an promotes the development of the system and form of Chinese public participation to a certain extent.

Summary

This chapter discusses the critical success factors of Xiamen Xiang'an comprehensive underground Pipeline PPP projects using the sustainable development, public goods, cooperative surplus, and principal agent theories mentioned in chapter two. But one of the critical success factors, operation mode, was omitted, for it has nothing special. The conclusions of this thesis are presented in the next chapter. The implementation effects of Sponge City PPP projects are shown in the following figures (None, 2018).



Figure 22 Interchange, elevated three-dimensional traffic Sponge City transformation measures



Figure 23 Construction of residential areas (former, and after-construction)

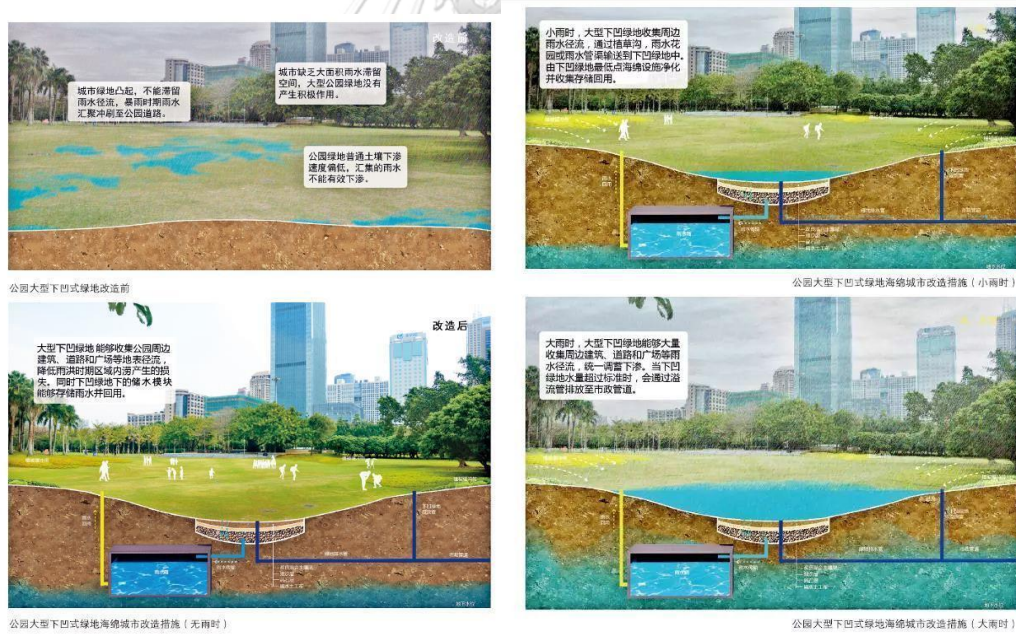
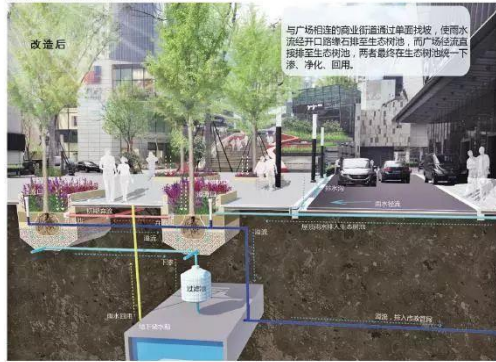


Figure 24 Comparison of the large sunken green space in the park (former, after-construction, light raining and heavy raining)



城市广场（无地下空间）改造前



城市广场（无地下空间）海绵城市改造措施（添加雨水收集设施）



商业街区改造前



商业街区海绵城市改造措施（添加雨水收集设施）

Figure 25 Sponge City transformation of business district



Chapter 5 Conclusions

This chapter will give the conclusions after the discussion in chapter 4 and discuss this thesis's deficiencies and prospects.

Conclusions

On the perspective of sustainability, using sustainable development, public goods, cooperative surplus, and principal agent theories discussed the critical success factors of the Xiamen Xiang 'an underground comprehensive pipeline corridor PPP project, namely value for money, financial affordability demonstration, transaction structure, and contract system, return mechanism, risk allocation, performance appraisal, and supervision mechanism. This thesis draws the following conclusions.

First of all, in the evaluation of value for money, the integration and evaluation of the Xiamen Xiang 'an underground comprehensive pipeline corridor PPP project's full life cycle, namely the implementation, operation, and maintenance, is conducive to social capital's control of the construction cost of Sponge City. Then it is easier to achieve sustainable development with low full life cycle cost.

In the demonstration of financial affordability, the low proportion of expenditure of the Xiamen Xiang 'an underground comprehensive pipeline corridor PPP project in the financial expenditure is conducive to the resistance of the PPP project of Sponge City to the high intensity risk so that it can achieve sustainable development.

It is beneficial to the sustainable development of the Xiamen Xiang 'an underground comprehensive pipeline corridor PPP project, to clarify the power and responsibility of entrusting party and agent in the transaction structure and contract system. In addition, for the Xiamen Xiang 'an underground comprehensive pipeline corridor PPP project without a mature evaluation system, the absolute right of the discourse of the entrusting party is conducive to the project achieving the expected effect.

When determining the return mechanism of the project company for the Xiamen Xiang 'an underground comprehensive pipeline corridor PPP project, the "ladder user payment" and "feasibility gap subsidy" can improve the effective allocation of public resources and ensure the fairness of public goods for the quasi-operational and operational projects.

In the risk distribution of the Xiamen Xiang 'an underground comprehensive pipeline corridor PPP project, the corresponding risks should be given priority by the provisions of the right and responsible party in the contract. Secondly, the risks without clear rights and responsibilities should be distributed according to the risk preference of the stakeholder, which is conducive to risk resistance and sustainable development of the project. But only if the party can afford it.

It is beneficial to the sustainable development of the Xiamen Xiang 'an underground comprehensive pipeline corridor PPP project, to pay more attention to the construction management and operation maintenance in the standard of procurement mode instead of just considering the commercial quotation.

The performance appraisal mechanism of the Xiamen Xiang 'an underground comprehensive pipeline corridor PPP project by the actual operation effect of the project can form the entrusting party and the agent's interest restriction, and the high-cost nature of damaging each other's interests is conducive to the orderly progress of the project by the original planning.

In the PPP project of the Xiamen Xiang 'an underground comprehensive pipeline corridor PPP project, public participation in supervision is conducive to improving the social support rate of the project development. This is good for the society sustainable development.

Deficiencies and Prospects

Due to the limitation of time and the author's cognitive level, this paper only uses qualitative methods to briefly discuss the critical success factors of the Xiamen Xiang 'an underground comprehensive pipeline corridor PPP project from the perspective of sustainability, namely value for money, financial affordability demonstration, transaction structure, contract system, return mechanism, risk allocation, performance appraisal, and supervision mechanism and draw relevant conclusions. From the perspective of sustainability, it would be better if qualitative and quantitative methods could be used to determine the relationship between these mentioned critical success factors and the impact of each factor on the sustainable development of PPP projects in sponge cities.



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Abbreviation List

Public-private Partnership (PPP)
China Pubic Private Partnership Center (CPPPC)
Best management practices (BMP)
Sustainable urban drainage system (suds)
Blue-green city system (BGCS)
Low impact development (LID)
Water sensitive urban design (WSUD)
Low impact development urban design (LIDUD)
Value for money (VFM)
Public Sector Comparator (PSC)
Design-Built (DB)
Design-Built-Main Maintain (DBMM)
Operations & Maintenance (O&M)
Design-Built-Operate (DBO)
Purchase-Update-Operations-Transfer (PUOT)
Lease-Update-Operations-Transfer (LUOT)
Built-Lease-Operations-Transfer (BLOT)
Built-Owning-Operations-Transfer (BOOT)
Design-Built-Transfer-Operations (DBTO)
Design-Built-Financing-Operations (DBFO)
Purchase-Update-Operations (PUO),
Built-Owning-Operations (BOO)
Built-Operations-Transfer (BOT)
Public sector comparison value (PSC)
Life cycle management (LCM)
Financial Affordability (FAA)



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Appendix

Appendix 1 Scores details of Xiamen Sponge City Underground Comprehensive Pipe PPP project

Number	Evaluation Index	Weight	Scoring Reference Standard	Reason of Expert Scoring	Weighted Scoring Result
1.	Integration degree of the whole life cycle	15%	<ul style="list-style-type: none"> ■ 81~100—the project data shows that the design, financing, construction and all operations and maintenance will be integrated into one contract; For the stock projects, the PPP model is adopted, and at least financing and all operations and maintenance are integrated into one contract. ■ 61~80—the project data shows that the design, financing and construction as well as the operation and maintenance of core services or most non core services will be integrated into one contract; PPP mode is adopted for stock projects. At least the operation and maintenance of financing and core services to most non core services will be integrated into one contract. ■ 41~ 60 shows that design, financing, construction and maintenance will be integrated into a single contract, 	The design (detailed design of construction drawings), construction financing, operation and maintenance of the project are all integrated into one contract. thirteen point three	13.3

<p>excluding operation; Or financing, construction, operation and maintenance will be integrated into one contract, but excluding design; For the stock projects, the PPP model is adopted, and only the operation and maintenance will be integrated into one contract.</p> <ul style="list-style-type: none"> ■ 21~40=The project data shows that financing, construction and maintenance will be integrated into one contract, excluding design and operation. ■ 0~20=The project data shows that three or fewer links, such as design, financing and construction, will be integrated into one contract. 	<p>The risk identification of this project is deep and the risk allocation framework is clear. Risks such as insufficient land use, insufficient access, and government politics are borne by the government. Commercial risks such as design, construction, finance, operation and maintenance are mainly borne by the project company, and force majeure risks are reasonably shared by the government and the project company. Special attention should be paid to the mutual interference between pipelines in different industries due to the</p>
<p>2. Risk identification and allocation</p> <ul style="list-style-type: none"> ■ 81~100=project data shows that more in-depth risk identification has been carried out, and it is expected that most or all of the major risks will be clearly and reasonably allocated between the government and social capital partners. ■ 61~80=the project data shows that more in-depth risk identification work has been carried out, and it is expected that most of the major risks can be clearly and reasonably allocated between the government and social capital partners. ■ 41~60=the project data shows that preliminary risk identification has been carried out, and it is expected that these risks can be clearly and reasonably allocated between the government and social capital partners. ■ 21~40=The project data shows that preliminary risk 	<p>11.8</p>

<p>identification has been carried out, and it is expected that these risks will be difficult to be clearly and reasonably allocated between the government and social capital partners.</p> <ul style="list-style-type: none"> ■ 0~20=the project data shows that the risk identification has not been carried out or the risk has not been clearly identified. 	<p>intensive use of the space of the comprehensive pipe gallery. Therefore, the risk allocation between the project company and the pipeline unit entering the gallery should be considered. This part can refer to the allocation principle of the maintenance and management responsibilities of the pipe gallery in the Administrative Measures of Xiamen Urban Comprehensive Pipe Gallery, At the same time, it must be further clarified in the corridor access agreement signed by the project company and the corridor access pipeline unit in the future.</p>
<p>ance oriented and innovati on encoura ged</p> <p>3. Perform 15%</p> <ul style="list-style-type: none"> ■ 81~100=most of the performance indicators are in line with the specific situation of the project, comprehensive, reasonable, clear and clear. The project output description puts forward relatively comprehensive, clear and measurable output specification requirements, without any requirements on how to deliver. ■ 61~80=most of the performance indicators are in line with the specific situation of the project, comprehensive, reasonable and clear. The output 	<p>The pipe gallery operation has not been applied for a long time in China, and there is no mature performance evaluation index. It is mainly set by introducing a mature performance evaluation system from abroad and combining with the exploration and summary of domestic pipe gallery operation. The completion standard of this project should meet the standards</p>

<p>specifications of the project are comprehensive, clear and measurable, and there are a few requirements on how to deliver.</p> <ul style="list-style-type: none"> ■ 41~60=the performance indicators are relatively consistent with the specific situation of the project, but are not comprehensive and clear enough, lacking some key performance indicators. The output specification requirements of the project are not comprehensive, clear and measurable, and there are a few requirements on how to deliver. ■ 21~40=the set performance indicators are relatively consistent with the specific situation and clear, but the main key performance indicators are set. The output specifications of the project are not comprehensive, clear and measurable, and there are many requirements on how to deliver. ■ 0~20=performance indicators are not set or do not conform to the specific conditions of the project, unreasonable and unclear. The output description of the project basically does not specify the output specification requirements, or mainly requires how to deliver. 	<p>of Xiamen Gulang Cup Project. The operation and maintenance standards set up a performance appraisal and payment mechanism, which helps to mobilize the enthusiasm of the project company to improve its operation and management capabilities. twelve point one</p>
<p>4. Degree of potential 15%</p>	<p>The project covers both construction and operation. The Xiamen Municipal Government has strong payment capacity, and the pre qualification</p>

<p>competition</p> <p>enterprises participating in the project promotion meeting.</p> <ul style="list-style-type: none"> ■ 61~80= The project will have a great potential to cause competition between social capital (or its consortium), and it is expected that the degree of competition can be further improved through subsequent measures. 41~60=the potential of the project to cause competition between social capital (or its consortium) is average, and it is expected that the degree of competition can be improved by taking measures subsequently. ■ 21~40=The potential of the project to cause competition between social capital (or its consortium) is small, and it is expected that the degree of competition may be improved through subsequent measures. ■ 0~20= The potential of the project to cause competition between social capital (or its consortium) is small, and it is expected that the degree of competition will not be improved in the future. 	<p>conditions of the project are set reasonably, attracting a large number of potential investors.</p>
<p>5. Government's institutional capacity</p>	<p>10.0</p> <p>Xiamen Municipal Government has a deep understanding of the essence of PPP spirit. Although it has little experience in operating PPP projects, it has achieved a high level of PPP project operation and management capability by entrusting professional</p>

	<ul style="list-style-type: none"> ■ 41~60=the PPP concept of the government is average, and the PPP capacity of relevant government departments and institutions of the project is average. ■ 21~40=The PPP concept of the government is relatively lacking, and the PPP capacity of relevant government departments and institutions of the project is relatively lacking and not easy to obtain quickly. ■ 0~20=the PPP concept of the government is lacking, and the PPP capacity of relevant government departments and institutions of the project is lacking and difficult to obtain 	<p>consulting institutions. In addition, Xiamen Municipal Government has a strong financial payment capability.</p>
<p>6. Financiality 10%</p>	<ul style="list-style-type: none"> ■ 81~100=the project is expected to be highly attractive to financial institutions, or financial institutions with strong strength have clearly expressed their interest in the project. ■ 61~80=the project is expected to be highly attractive to financial institutions. ■ 41~60=It is estimated that the attraction of the project to financial institutions is average, which can be improved through further preparation. ■ 21~40=It is estimated that the project has a poor attraction to financial institutions, and further preparation can improve the attractiveness. ■ 0~20=It is estimated that the attraction of the project to financial institutions is very poor. 	<p>The project is located in Xiamen, 9.2 which has strong financial strength, and the feasibility gap subsidy of the project can be included in the financial budget of Xiamen, so it has good financing.</p>
<p>7. Project 5%</p>	<p>81~100=the investment of new projects or the fair</p>	<p>The investment amount of this project 4.8</p>

<p>size</p> <p>value of assets of stock projects is more than 1 billion CNY.</p> <ul style="list-style-type: none"> ■ ■ • 61~80=the fair value of the investment in new projects or stock projects is between 200 million CNY and 1 billion CNY. ■ 41~60=the fair value of the investment in new projects or stock projects is between 100 million CNY and 200 million CNY. ■ 21~40=the fair value of the investment of new projects or the assets of stock projects is between 50 million CNY and 100 million CNY. ■ 0~20=the fair value of the investment in new projects or stock projects is less than 50 million CNY. ■ (Note: The amount can be reset according to the specific project type, location and other factors.) 	<p>is 1.779 billion CNY (estimated in the project feasibility study), more than 1 billion CNY. Attractive to investors.</p>
<p>8. Expected service life</p> <p>5%</p> <p>81~100=the expected service life of the asset is more than 40 years.</p> <p>61~80=expected service life of assets is 31~40 years.</p> <p>41~60=the expected service life of the asset is 21~30 years.</p> <p>21~40=expected service life of assets is 11-20 years.</p> <p>0~20=the expected service life of the asset is less than 10 years.</p> <p>(Note: The length of service life can be reset according to the specific project type, location and other factors.)</p>	<p>The service life of the pipe rack is longer, more than 100 years.</p> <p>4.5</p>

<p>9. Category of main fixed assets</p>	<p>5%</p>	<ul style="list-style-type: none"> ■ 81~100=more than three asset categories of the project. ■ 61~80=the project is a combination of two types of more complex or technically demanding assets. ■ 41~60=the project is a combination of two types of moderately complex assets, or a number of similar asset packaging projects. ■ 21~40=the project is a combination of two types of assets with lower complexity, or the project is a more complex asset. ■ 0~20=The project only includes a relatively simple asset. 	<p>4.4</p> <p>he project is mainly aimed at the main body of the pipe gallery and its ancillary facilities. The type of fixed assets is relatively single. However, due to the construction of the comprehensive pipe gallery under multiple municipal roads in a large area, the network connectivity is good, and it also includes 110KV and 220KV high-voltage power, 10KV power, communication cables (including cable and traffic), water supply pipes, reclaimed water pipes, and rainwater Sewage and gas pipelines have high asset integration in practice.</p>
<p>10. Accuracy of the whole life cycle cost calculation</p>	<p>5%</p>	<ul style="list-style-type: none"> ■ 81~100=relevant information of the project shows that the whole life cycle cost of the project has been well understood and recognized, and it is very likely to be accurately estimated. ■ 61~80=relevant information of the project shows that the full life cycle cost of the project has been well understood and recognized, and is likely to be accurately estimated. ■ 41~60=relevant information of the project shows that the life cycle cost of the project has been well 	<p>4.0</p> <p>The costs of design, construction, financing, operation and maintenance of this project have been evaluated and calculated by professionals. However, due to the lack of operating experience, the accuracy of operation and maintenance cost prediction is relatively lacking.</p>

<p>understood, but it is still uncertain whether it can be accurately estimated.</p> <ul style="list-style-type: none"> ■ 21~40=relevant information of the project shows that the understanding and understanding of the whole life cycle cost of the project is not comprehensive and clear enough. ■ ๖๐ 0~20=relevant information of the project shows that the whole life cycle cost of the project is basically not understood and recognized. 	89.0
Total	100%



Appendix 2 Value for Money quantitative evaluation results

PSC, VFM计算表

No.	项目	单位	1 2016	2 2017	3 2016	4 2019	5 2020	6 2021	7 2022	8 2023	9 2024	10 2025	11 2026	12 2027	13 2028	14 2029	15 2030	16 2031	17 2032	18 2033	19 2034	20 2035	
一 建设成本																							
1.1	工程建安费用	万元年	49151.80	49151.80	21065.06	21065.06																	
1.2	工程监理费用	万元年	4915.18	4915.18	2106.51	2106.51																	
1.3	建设利息	万元年	8187.15	8187.15	3503.78	3503.78																	
1.4	建设期小计	万元年	62254.12	62254.12	26680.338	26680.338	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
二 运营成本																							
2.1	日常运营费	万元年	-	-	133	133	266	266	266	266	266	266	266	266	266	266	266	266	266	266	266	266	266
2.2	日常维修费	万元年	-	-	188	188	376	376	376	376	376	376	376	376	376	376	376	376	376	376	376	376	376
2.3	职工工资	万元年	-	-	257	257	257	257	257	257	257	257	257	257	257	257	257	257	257	257	257	257	257
2.4	大修费	万元年	-	-	381	381	721	721	721	721	721	721	721	721	721	721	721	721	721	721	721	721	721
2.5	管理费用	万元年	-	-	65	65	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130
2.6	运营成本小计	万元年	-	-	1005	1005	1752	1752	1752	1752	1752	1752	1752	1752	1752	1752	1752	1752	1752	1752	1752	1752	1752
三 第三年收入																							
3.1	入场费	万元年	-	-	436	871	1524	1524	109	218	382	382	318	318	318	318	318	318	318	318	318	318	318
3.2	运营补贴	万元年	-	-	110	221	337	552	125	250	437	624	81	163	244	326	407	488	570	651	733	814	814
3.3	第三方收入小计	万元年	-	-	546	1092	1911	2077	234	468	819	1006	400	481	563	644	725	807	888	970	1051	1132	1132
四 初期PSC(十二三)																							
五 竞争性社会资本																							
5.1	运营支出补贴	万元年	-	-	348	291	462	462	462	462	462	462	462	462	462	462	462	462	462	462	462	462	462
5.2	购电	万元年	-	-	513	136	637	823	1017	1217	1425	1509	1509	1509	1509	1509	1509	1509	1509	1509	1509	1509	1509
5.3	运营维护成本	万元年	0.00	0.00	20.09	20.09	35.03	35.03	35.03	35.03	35.03	35.03	35.03	35.03	35.03	35.03	35.03	35.03	35.03	35.03	35.03	35.03	35.03
5.4	竞争性社会资本(5+6+2+3)	万元年	-	-	841	407	1064	1250	1444	1644	1852	1936	1936	1936	1936	1936	1936	1936	1936	1936	1936	1936	1936
六 可转移风险																							
6.1	自行运营投资	万元年	87.77	87.77	87.77	87.77																	
6.2	运营维护成本	万元年	70.22	70.22	70.22	70.22																	
6.3	运营维护成本	万元年			9	9	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
6.4	运营维护成本	万元年			21.78	43.56	75.22	75.22	75.22	75.22	75.22	75.22	75.22	75.22	75.22	75.22	75.22	75.22	75.22	75.22	75.22	75.22	75.22
6.5	运营维护成本(50%承担)	万元年	157.99	157.99	188.81	210.68	91.99	91.99	21.22	26.68	34.87	34.87	31.88	31.88	31.88	31.88	31.88	31.88	31.88	31.88	31.88	31.88	31.88
6.6	可转移风险小计	万元年																					
七 运营成本																							
7.1	运营维护成本(溢价)	万元年			881.11	43.56	75.22	75.22	5.46	10.92	19.10	19.10	15.92	15.92	15.92	15.92	15.92	15.92	15.92	15.92	15.92	15.92	15.92
7.2	运营维护成本(50%承担)	万元年			21.78	43.56	75.22	75.22	75.22	75.22	75.22	75.22	75.22	75.22	75.22	75.22	75.22	75.22	75.22	75.22	75.22	75.22	75.22
7.3	运营维护成本	万元年	19.25		338.19	338.19																	
7.4	运营维护成本小计	万元年	19.25	0.00	339.78	43.56	75.22	75.22	5.46	10.92	19.10	117.64	114.46	172.21	114.46	114.46	114.46	114.46	114.46	114.46	114.46	114.46	114.46
PSC(四+五+六+七)																							
折现率 6.24%																							
PPPs 153432.65 万元年																							
VFM (PPP-PSC) 21521.22 万元年																							

Appendix 3 Rules of Responsibility for Risk-taking expenditure on financial capacity

Risk Type	Risk Detail	Assumpti on Base	Risk Loss Scenario	Remarks
constructi on risk	Geological conditions		0	The probability of occurrence is small, and the loss is considered as 0
	The land cannot be delivered in time		0	The probability of occurrence is small, and the loss is considered as 0
	Water, electricity, access roads, construction sites and other supporting arrangements		0	The probability of occurrence is small, and the loss is considered as 0
	Restrictions on the use of waters and sea areas		0	The probability of occurrence is small, and the loss is considered as 0
	Protection of Archaeological Relics		0	The probability of occurrence is small, and the loss is considered as 0
Operation al risk	Operation and maintenance cost overrun (price adjustment)	Operatio n and maintena nce revenue B	Scenario 1: 10% price adjustment loss in the 10th year; Scenario 2: price adjustment in the 16th year, Scenario 3: no price adjustment; Probability 5%, 15%, 80%	
Revenue or market risk	Small scale of pipeline corridor		0	The probability of occurrence is small, and the loss is considered as 0
	Changes in charging		0	The probability of occurrence is small, and the loss is

	standards			considered as 0
	Insufficient charging capacity	Annual third-party income	10% loss per year; 50% share	
	Insufficient financial budget		0	The probability of occurrence is small, and the loss is considered as 0
	Government default/early termination	Compensation cost for termination of breach of contract: 77 million CNY	5%, default loss 1%; 15%, default loss 3%; 80%, no breach of contract; There are three situations in the year of loss: 5% in the third year, 80% in the sixth year and 15% in the thirteenth year	
Government/Political Risk	Expropriation		0	The probability of occurrence is small, and the loss is considered as 0
	Approval delay		0	The probability of occurrence is small, and the loss is considered as 0
	Project change proposed by the government		0	The probability of occurrence is small, and the loss is considered as 0
	Policy/law changes		0	The probability of occurrence is small, and the loss is considered as 0
	Other changes in the political environment		0	The probability of occurrence is small, and the loss is considered as 0
Force Majeure	Force Majeure		0	The probability of occurrence is small, and the loss is considered as 0

Appendix 4 Financial affordability (FAA) demonstration details

PPP计算表		财政承受能力 (FAA) 测算表																					
No.	科目	单位	现值	合计																	20		
				Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031		2032	2033
一	政府性支出(PPP)	万元/年	138875.01	20,019	20,000	9,246	8,420	17,098	16,941	18,272	18,155	17,979	17,967	18,009	18,049	777	759	741	723	731	713	685	677
	政府出资责任		2823.92	3,000																			
	运营补贴责任		135158.09	17,000	20,000	8,911	8,365	17,003	16,837	18,238	18,115	17,929	17,908	17,953	17,934	719	700	681	662	643	624	605	586
	风险承担支出责任		893.00	19	-	335	55	96	104	34	40	49	59	57	115	59	60	60	61	88	89	90	91
二	一般预算支出	亿元/年	758.35	883.17	1028.53	1197.82	1394.97	1624.57	1891.97	2203.37	2566.03	2888.38	3480.25	4053.07	4720.18	5497.08	6401.87	7455.57	8682.70	10111.81	11776.14	13714.41	
三	占比		0.40%	0.00%	0.80%	0.70%	1.23%	1.04%	1.04%	0.97%	0.82%	0.70%	0.60%	0.52%	0.45%	0.02%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.00%



Appendix 5 Risk allocation results of Xiamen Xiang' an Project

Risk Type	Government Undertaking	Project Company Undertaking	Pipeline Company Undertaking	Risk Undertaking methods and countermeasures
construction risk	√	√		The comprehensive pipe gallery is an underground project, which is very likely to cause construction risks due to geological conditions. The project company has a stronger ability to judge and control geological risks than the government. Therefore, the project company bears the risk liability with an upper limit. The government shall bear the risks that are beyond the estimated range of experienced social capital or beyond the online social capital.
	√			If the project cannot be started or the construction period is delayed, the government shall bear the responsibility and give necessary allowance or compensation to social capital.
	√			

Restrictions on the use of waters and sea areas	√			Considering the particularity of the cross sea section
Interference from road construction	√			Possible interference factors include process conflict, subgrade treatment quality, site occupation, etc. As the project company needs to sign a construction agency contract with the entrusted construction agency (project management) unit, its main risks should be borne by the project company, and the project company needs to carry out such risks in the construction agency contract
Company Propose project change	√			If the change proposed by the project company after meeting the delivery requirements and obtaining the consent of the government causes an increase in the actual investment, the government shall not increase its expenditure responsibility to the project company;
Construction/p rocurement cost overrun	√			The government provides detailed standards, and the project company bears the risk of overspending on the basis of the quotation
Construction delay	√			The time point for payment of the fees to the pipeline access unit and the government's feasibility gap subsidy is postponed accordingly
Construction quality is not up to standard	√			The project company shall be responsible for the repair until the acceptance is qualified, but the government reserves the right to accept the partial and overall project at a discount.
Site safety/environmental protection	√			

	Protection of Archaeological Relics	√	√				
Operational risk	Technical defects		√				
	Commissioning		√				
	Equipment/facility failure		√				
	Increased operation and maintenance costs	√	√				Set risk ceiling in combination with price adjustment mechanism
	Service quality is not up to standard		√				Combined with performance appraisal mechanism
	Operator Default/Early Termination		√				Respond in early termination compensation
	Residual value risk		√				Handover and recovery overhaul to ensure the availability of equipment and facilities
	security management		√			√	According to the principle of liability fixation, it is necessary to distinguish the design, construction and operation management reasons of the pipeline corridor or the pipeline itself, which should be given priority consideration in the corridor access agreement, especially the third party liability, and the purchase of relevant pipeline insurance can be
	environmental protection		√			√	

	Interference of corridor access pipeline	√	√	√	required
	Corridor access pipeline accident	√	√	√	
financial risk	Financing failure	√	√		It is necessary to combine the requirements of shareholder guarantee of social capital party for financing during the construction period
	High financing cost	√	√		
	Change in interest rate	√	√		
	Debt service risk	√	√		
Reve nue or market risk	Small scale of pipeline corridor	√			The scale of corridor access is subject to such factors as regional planning and development, replacement of technological progress, model of government concession granting, etc., which are uncontrollable risks of the project company. It is suggested that the government should bear them and reflect them in the return mechanism.
	Changes in charging standards	√	√		The change of charging standard is reflected in the return mechanism in real time. After the establishment of the project company, it is recommended that the project company also participate in the formulation of relevant charging standards.
	Charging capacity	√	√		At the same time, the charging capacity is subject to the subjective initiative of the project company in operation, the coordination and support of the government and the authorization management requirements, as well as the management system of the corridor access pipeline unit. Therefore, this risk should be shared between the

							government and the project company. Except for the fees that are not authorized or explicitly exempted by the government, other operating risks should be borne by the project company.
	Insufficient financial budget	√					The project has an upper limit on the government's expenditure responsibility in the design of the return mechanism. Therefore, as long as the financial affordability is demonstrated, the risk is relatively small.
	inflation	√			√		The inflation factor is reflected in the price adjustment mechanism.
Government default/early termination	Government default/early termination	√					Respond in early termination compensation
	Expropriation	√					
	Approval delay	√					
	Project change proposed by the government	√					Reflect in the adjustment of investment changes
Political Risk	Policy/law changes	√					
	Other changes in the political environment	√	√			√	Respond in early termination compensation
	Force Majeure	√	√				Respond in early termination compensation
Force Majeure							

Appendix 6 Qualification of Social Capital

The social capital participating in the procurement of this project must meet the following conditions:

1. It must be a domestic enterprise legal person that is legally established and validly existing;
2. It has good bank credit, financial status and corresponding investment, financing and debt paying ability. For a limited time, the audited net assets of the enterprise were more than RMB 1.5 billion (inclusive);
3. First class or above qualification for general contracting of municipal public works;
4. Within 5 years before the deadline for submission of prequalification application documents: at least one PPP performance of highway, bridge, municipal road, tunnel, rail transit or underground comprehensive pipe gallery project with an investment amount of more than 500 million CNY (inclusive) (subject to PPP, BOT, BOOT, B00 contract or franchise agreement or letter of acceptance);
5. Provide a letter of commitment that there are no illegal or bad records in business activities in the past three years;
6. In case of non consortium bidding, the bidder shall meet the qualification requirements in (1), (2), (3), (4) and (5) at the same time;
7. This procurement accepts the bid of a consortium, and the consortium members shall not exceed two. The leading party agreed in the consortium agreement must at least meet the qualification requirements of Article (1), (2), (3), (4) and (5) at the same time.
8. The other member of the consortium other than the leading party must at least meet the qualification requirements of (1) and (5) at the same time, and the audited total assets of the enterprise as of December 31, 2014 are more than five billion CNY (inclusive); Or, within 5 years prior to the deadline for submission of prequalification application documents, he/she has more than 5km of pipeline corridor operation and management performance (subject to the contract signing or project operation service fee payment certificate or letter of acceptance).
9. Each party of the consortium must sign a consortium agreement in the format specified in the prequalification announcement, specifying the main rights and obligations of the leading party of the consortium and the other party; The equity contribution proportion of the leading party in the future project company agreed in the consortium agreement must exceed 20% (exclusive) and not exceed 70% (inclusive); Each party of the consortium shall not participate in the prequalification alone or in any other consortium in its own name; After the consortium passes the prequalification, the main terms of its members' composition, equity ratio, division of responsibilities, etc. shall not be changed.
10. Other restrictions required by laws and regulations.

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AWARD RECEIVED	None