IMPLEMENTATION OF TRANSNATIONAL PUBLIC PRIVATE PARTNERSHIPS: KEY ISSUES AND DEVELOPMENT OF A MODEL TO ACHIEVE PROJECT EXCELLENCE

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CERTIFICATE OF ORIGINILITY

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it reproduces no material previously published or written, nor material that has been accepted for the award of ant other degree or diploma, except where due acknowledgement has been made in the text.

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ABSTRACT

Public–Private Partnership (PPP) is popularly used around the world as a 'key vehicle' to implement large and complex infrastructure projects. An increasing trend of transnational PPP (TPPP), along with economic globalisation and intergradation and the 'Belt and Road' Initiative, has been observed in the infrastructure industry. However, the project result is influenced by several issues, whilst the pursuit of excellence is a challenging task for all stakeholders. Although many studies in the PPP context have been conducted, research that focuses on the transnational context is inadequate. To efficiently and effectively promote project management in TPPP projects, the key issues that influence TPPP project excellence should be understood clearly, which is the aim of the current research. By using the logical framework method, the key issues to achieve TPPP project excellence were identified as three different categories: risk management process, project success and sustainability. Specifically, the four objectives were identified to focus on the three key factor categories and TPPP project excellence: (1) to identify the critical risk factors (CRFs) and develop a risk management process model for TPPP projects; (2) to identify the critical success factors (CSFs) and specific success factors for TPPP projects; (3) to identify the critical sustainability factors and develop a TPPP project sustainability index; (4) to develop a TPPP project excellence model and identify the significant influences of key issues on TPPP project excellence.

The objectives were achieved via a comprehensive literature review, questionnaire surveys, statistical analyses, case studies and modelling methodologies. The review of the related literature identified 42 risk factors, 27 success factors and 45 sustainability factors. In terms of risks, intuitionistic fuzzy analytic hierarchy

process (IFAHP) was adopted for ranking the importance amongst the various risk factors. Bargaining game theory was used in the risk allocation process. A case study was conducted to show the practicality of the proposed risk management model. For CSFs, a comparative study was conducted between TPPPs and domestic PPPs (DPPPs). Results showed the ranking of CSFs and the differences in CSFs between TPPPs and DPPPs. For the sustainability of the TPPP projects, fuzzy synthetic evaluation (FSE) was used to establish the TPPP project sustainability index and evaluate the sustainability level of these projects. In the last stage, the partial least squares–structural equation model (PLS–SEM) technique was implemented to identify the influences of these key issues on TPPP project excellence. The PLS–SEM results indicated that (1) partnership risk factors have a significant negative influence on TPPP project excellence, (2) two critical success categories, namely, financial and economic, and social success category have significant positive influences on TPPP project excellence and (3) environment sustainability factors would have a significant positive influence on TPPP project excellence. Results of the analysis are further validated by TPPP experts to confirm credibility and reliability.

This study provides valuable contributions to the TPPP body of knowledge and assists policy makers, government officials and private investors promote TPPPs in the Belt and Road countries. The key aspects and significant influences of these issues on project excellence are crucial in implementing TPPP projects to a high level of success.

LIST OF RESEARCH PUBLICATIONS

The following provides a list of research publications that the author of this thesis made during her Ph.D. study, and, as shown within the text, chapters of this thesis have been fully or partially published in those that are directly relevant to this thesis.

A. Referred Journal Papers (Published/accepted)

Papers Derived Directly From This PhD Study

1. **Yu, Y.,** Chan, A. P., Chen, C. & Darko, A. (2017). Critical Risk Factors of Transnational Public–Private Partnership Projects: Literature Review. *Journal of Infrastructure Systems,* 24, 04017042.

2. **Yu, Y.,** Osei-Kyei, R., Chan, A. P. C., Chen, C., & Martek, I. (2018). Review of social responsibility factors for sustainable development in public–private partnerships. *Sustainable Development,* 26(6), 515-524.

3. **Yu, Y.,** Darko, A., Chan, A.P., Chen, C. and Bao, F., (2018). Evaluation and Ranking of Risk Factors in Transnational Public–Private Partnerships Projects: Case Study Based on the Intuitionistic Fuzzy Analytic Hierarchy Process. *Journal of Infrastructure Systems*, *24*(4), p.04018028.

4. Chen, C., **Yu, Y.,** Osei-Kyei, R., Chan, A. P. C., & Xu, J. (2019). Developing a Project Sustainability Index for Sustainable Development in Transnational Public Private Partnership Projects. *Sustainable Development.* sd 1954. (*Accepted*)

Papers Published During the Course of Study

1. **Yu, Y.,** Martek, I., Hosseini, M. R., & Chen, C. (2018). Demographic variables of corruption in the chinese construction industry: Association rule analysis of conviction records. *Science and engineering ethics,* 1-19.

2. Osei-Kyei, R., Chan, A. P., **Yu, Y.,** Chen, C., & Dansoh, A. (2019). Root causes of conflict and conflict resolution mechanisms in public-private partnerships: comparative study between Ghana and China. *Cities,* 87, 185-195.

3. Bao, F., Martek, I., Chen, C., Chan, A.P. and **Yu, Y.,** (2018). Lifecycle performance measurement of public-private partnerships: a case study in China's water sector. *International Journal of Strategic Property Management*, *22*(6), pp.516-531.

4. Darko, A., Chan, A.P.C., Gyamfi, S., Olanipekun, A.O., He, B.J. and **Yu, Y.,** (2017). Driving forces for green building technologies adoption in the construction industry: Ghanaian perspective. *Building and Environment*, *125*, pp.206-215.

5. Osei-Kyei, R., Chan, A. P., Yao, Y., & Mazher, K. M. (2019). Conflict prevention measures for public–private partnerships in developing countries. *Journal of Financial Management of Property and Construction*, *24*(1), 39-57.Osei-Kyei, R., Chan, A. P., **Yu, Y.,** Chen, C., Ke, Y., & Tijani, B. (2019). Social Responsibility Initiatives for Public-Private Partnership Projects: A Comparative Study between China and Ghana. *Sustainability*, 11(5), 1338.

B. Referred Journal Papers (Under review for the first or second time)

1. **Yu, Y.,** Darko, A., Chen, C., Chan, A.P., and Xu, J. (under review). Risk Allocation in Transnational Public-Private Partnerships Projects: Case Study Based on the Bargaining Game Theory. *Engineering, Construction and Architectural Management,* Manuscript ID: ECAM-09-2018-0363.

C. Referred Conference Papers (published)

2. Chen, C., **Yu, Y.,** Xu, J. (2017). Evaluation of Risk Factors in Transnational Public-Private Partnership under Intuitionistic Fuzzy Analytic Hierarchy, *Proceedings of International Conference on Strategy Management*, Chengdu, China.

3. **Yu, Y.,** Chen, C., Chan, A.P., and Darko, A. (2017). Critical Risk Factors for Transnational Public-Private Partnership Projects: A Literature Review, *Proceedings of 22nd International Conference on Advancement of Construction Management and Real Estate.* Melbourne, Australia: CRIOCM 2017 Organizing Committee.

4. **Yu, Y.,** Chen, C., Li, H.J. (2018), Business Continuity of International Construction for Contractors, *Proceedings of RICS-COBRA 2018 Conference.* London, United Kingdom.

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CHAPTER 1 INTRODUCTION[1]

1.1 INTRODUCTION

This chapter describes the background of this research, outlines the problem statement, states the research aim and objectives, discusses the project's significance and value and provides the thesis structure.

1.2 BACKGROUND

1.2.1 Brief introduction of Public–Private Partnership

Public–private partnership (PPP) is considered a 'key vehicle' for implementing large and complex infrastructure projects in many countries and regions. Although PPP is popularly used around the world, no single widely accepted definition is available. The World Bank defines PPP as 'a long-term contract between a private party and a government entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility, and remuneration is linked to performance' (WorldBank, 2017). PPP combines competitive tendering and flexible negotiation to achieve considerable efficiency and improved monitoring (Aliu et al., 2014, Chan et al., 2009b) and share project risks and benefits between the public and private sectors (Bing et al., 2005). The

[1] This chapter is partially based upon:

Yu, Y., Chan, A. P., Chen, C. & Darko, A. 2017. Critical Risk Factors of Transnational Public–Private Partnership Projects: Literature Review. *Journal of Infrastructure Systems,* 24, 04017042.

Yu, Y., Osei-Kyei, R., Chan, A. P. C., Chen, C., & Martek, I. (2018). Review of social responsibility factors for sustainable development in public–private partnerships. *Sustainable Development,* 26(6), 515-524.

Yu, Y., Darko, A., Chan, A.P., Chen, C. and Bao, F., 2018. Evaluation and Ranking of Risk Factors in Transnational Public–Private Partnerships Projects: Case Study Based on the Intuitionistic Fuzzy Analytic Hierarchy Process. *Journal of Infrastructure Systems,* 24(4), p.04018028.

Chen, C., Yu, Y., Osei-Kyei, R., Chan, A. P. C., & Xu, J. 2019. Developing a Project Sustainability Index for Sustainable Development in Transnational Public Private Partnership Projects. *Sustainable Development.* sd 1954. (Accepted)

current study adopted the World Bank's definition of PPP.

Although PPP was widely implemented in the late 1990s, private investment in public infrastructure can be traced back to the 18th century in European countries (Tang et al., 2010). Since the 1990s, the private sector has been actively involved in the implementation and operation of public infrastructure, particularly in developed economies/countries (Morrison, 2016). Thereafter, PPP has expanded over the years with many governments, particularly from developing countries/economies, seeking to enhance infrastructure growth and development through this scheme (Osei-Kyei, 2017).

PPP has been used in over 85 countries for procuring economic and social infrastructure projects (Regan et al., 2009). Given the potential of PPP, many countries, such as the UK, the US, Australia and China, are increasingly adopting the PPP concept as an effective means to deliver infrastructure projects (Hodge and Greve, 2007). Following the successful implementation of PPP in developed countries/economies, including the UK, Australia and Hong Kong (Bing et al., 2005, Javed et al., 2013, Shen et al., 2006), PPP has also become appealing to developing countries, such as China, Ghana and Lebanon (Xu et al., 2010b, Robert et al., 2014, Jamali, 2004). Fig. 1.1. shows the trend of PPP project implementation from 1990 to 2016. An increasing trend can be observed between 1990 and 2012, which peaked in 2012, followed by a decline between 2012 and 2016. Understandably, PPP has been adopted to enhance investment in global infrastructure development because of the economic crisis in 2008 (Yu et al., 2017). Although a decline occurred after 2012, a stable growth is expected in the long future because of the huge infrastructure gap around the world (World Bank, 2017).

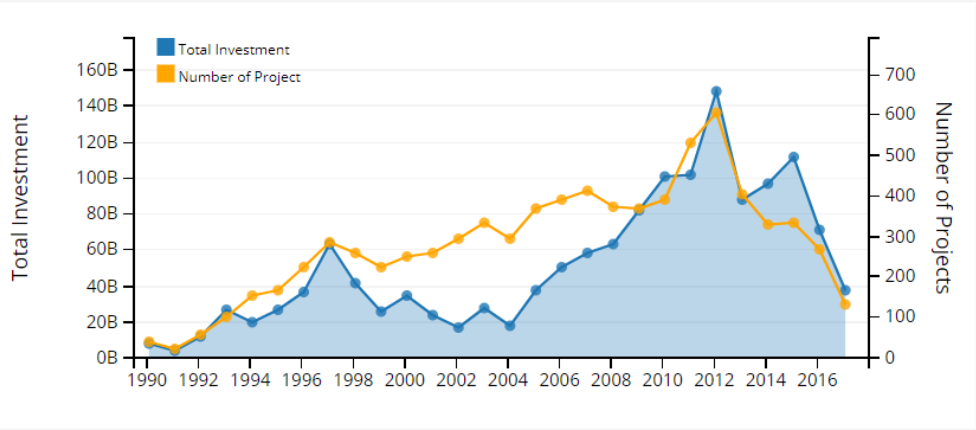


Fig.1. 1 Investment and number of PPP infrastructure projects in 1990–2016 (Source: World Bank, Retrieved 30 March 2018)

The different types of PPPs include the build–operate–transfer (BOT), design–build–operate (DBO) and concessions. Meanwhile, the most common PPP models are the design–build (DB), design–build–maintain (DBM), design–build–operate (DBO) or build–transfer–operate (BTO) (also known as design–build–operate–transfer (BOOT)) and build–own–operate (BOO) models (Oyegoke et al., 2009). PPPs can also be used for existing services and facilities in addition to new ones (Gunnigan and Rajput, 2010). These agreements have been used in a wide range of sectors to procure different types of assets and services, such as transport, water and waste, power, social and government infrastructure (World Bank, 2017). PPPs can be divided into domestic PPP (DPPP) and transnational PPP (TPPP) on the basis of whether private investors are from the project host country or other countries. Particularly, TPPP means foreign private sectors investing in PPP projets in another country, whereas DPPP means investors participating in PPP projects in their home countries. In the current study, TPPP is a partnership in which a government agency collaborates with foreign investors to develop infrastructure. TPPP is defined as a 'continuous and relatively institutionalized trans-boundary interactions between public and private actors that formally strive for the provision of collective goods, whereas private actors can be for-profit and/or civil society organisations

(Schäferhoff et al., 2009). Given the extensive adoption of the PPP strategy in infrastructure development, researchers have shown their interest in PPPs in previous decades. However, only a few studies on TPPP have been conducted. The current research focuses on the implementation of TPPP projects and attempts to identify the key issues and development of a TPPP project excellence model.

1.2.2 Belt and Road Initiative

1.2.2.1 Introduction of the Belt and Road Initiative

In October 2013, the Chinese government proposed the 'Belt and Road' Initiative (B&R). B&R refers to the Silk Road Economic Belt (SREB) and 21st Century Maritime Silk Road (MSR) (NDRC, 2015). The primary aim of this development initiative is to promote economic cooperation and orderly free-flow of economic factors and resources amongst many countries from different regions, including Europe, Middle East, South Asia and Africa (NDRC, 2015). B&R seeks to revive trading and economic collaboration amongst countries along the ancient silk trading routes. The SREB component of B&R aims to foster economic integration and connectivity amongst countries in Central Asia, Africa, Middle East and Europe through the building of international transport networks, such as roads, corridors, telecommunications and railways (PR, 2015). The proposed international land routes under B&R include the new Eurasia land bridge, China–Mongolia–Russia corridor, China–Central Asia–West Asia corridor, China–Indonesia peninsular, China–Pakistan corridor and Bangladesh–China–India–Myanmar corridor (NDRC, 2015). These international routes will serve as cooperation platforms to foster trades and investments amongst countries.

The MSR component of B&R aims to foster economic integration and investments

by connecting the major sea ports amongst countries along the Silk Road routes (NDRC, 2015). Through the MSR initiative, China will be able to connect with major sea ports in countries in Southeast Asia, Africa and Europe by using the South China Sea, South Pacific Ocean and Indian Ocean (Kevin, 2016). However, B&R covers trades and infrastructure networks, cultural and academic/research exchanges and technical and scientific cooperation in such fields such as artificial intelligence, smart cities, nanotechnology and quantum computing (Normile, 2017). Through this initiative, the Chinese government aims to establish over 50 large joint laboratories and bid service data platforms on environmental protection and sustainability (Normile, 2017). Currently, the Chinese government has exerted considerable effort towards the effective implementation of B&R. Recently, international summits, conferences and international cooperation forums have been organized to propel and facilitate the rapid implementation of the policy (Normile, 2017). Furthermore, such measures as the establishment of investment funds, including the Silk Road Fund, Asian Infrastructure Investment Fund and Green Silk Road Fund, have been implemented to demonstrate the commitment of the Chinese government and support infrastructure projects in Belat and Road (B&R) countries (Kevin, 2016).

Although several infrastructure projects are funded by the Chinese government or public financial institutions, such as China Development Bank, a major funding gap of infrastructure remains in B&R countries (Finance, 2015). The Asian Development Bank (ADB) has estimated that approximately US$750 billion are required annually up to 2020 to meet the infrastructure demand of Asian B&R countries (Kevin, 2016, Finance, 2015). Meanwhile, ADB and the World Bank can only raise approximately US$30 billion annually, while the Asian Infrastructure

Investment Bank can raise CN¥400 billion (US$ 61 billion) annually (Finance, 2015). Despite the support of international financial institutions, a huge funding gap for infrastructure development remains. Thus, the role of private investments and financing, particularly PPP, in procuring major infrastructure is critical towards the feasibility of development infrastructure in B&R countries (Finance, 2015, Kevin, 2016). Recently, the PPP model has taken roots in many countries along B&R. However, the number of unsuccessful or distressed projects recorded remains high in the majority of developing countries compared with developed countries. Developing countries in the African region, particularly Sub-Saharan Africa (SSA), have recorded many distressed PPP projects and only a few successful projects across different infrastructure sectors. The majority of the reported problems from these projects include lack of experience and skills in handling PPP projects, misallocation of risks, poor institutional structure and legal systems, lack of political commitments and unstable macroeconomic conditions (Osei-Kyei and Chan, 2015). Evidently, a systematic study of TPPP projects should be conducted because TPPP schemes are important for the successful implementation of infrastructure projects in B&R countries (Finance, 2015, Kevin, 2016).

To date, the Chinese government has signed B&R cooperation documents with 123 countries and 29 international organisations (GOV.CN, 2019). Althuough the list of countries has yet to be finalised at the time of writing this paper, the geographic spread of future initiatives is expected to be ambitious.

1.2.2.2 Development context in B&R countries

China and B&R countries are close trading partners. China's economic development and trade growth have provided abundant products and services for

B&R countries, while the large populations and substantial resources of the latter can offer investment opportunities for the former. In 2016, the gross domestic product (GDP) of B&R countries accounted for 16% of the global GDP, whilst the population accounted for 43.4% of the global population. In 2016, the trade volume between China and B&R countries was US$953.59 billion, which accounted for 25.9% of China's total trade and reflected the good momentum of the B&R trade cooperation against the background of the gradual recovery of the global economy (Office, 2017). B&R Russia, which is the largest country in terms of area: China, the most populous country:Qatar, the richest country and the eight least developed countries (GOV.CN, 2019). Therefore, the imbalance in the economic and social development amongst B&R countries is a serious problem that determines the huge infrastructure gap and investment demand in these countries.

1.2.2.3 Transnational investment in B&R countries

In 2017, Chinese companies invested US$14.36 billion in B&R countries, thereby accounting for 12% of the country's total investments (Ministry of Commerce of the People's Republic of China, 2018). The main investment countries are Singapore, Malaysia, Laos, Indonesia, Pakistan, Vietnam, Russia, United Arab Emirates and Cambodia. When considering the industrial distribution, the Chinese companies that directly invest in B&R countries mainly belong to the energy, transportation and information technology industries. In terms of investment enterprises, these companies, the majority of which are state-owned enterprises, mainly come from the four provinces of Beijing, Shanghai, Guangdong and Zhejiang (Ministry of Commerce of the People's Republic of China, 2018). Equal to greenfield investments, cross-border mergers and acquisitions are the main overseas investment models. An increasing trend is observed in transnational

business and companies are seeking different opportunities and new markets to engage in the accumulation of their investments (Hall, 2002).

Along with the signing and implementation of numerous economic cooperation agreements with B&R governments, China's investments in B&R countries will continue to maintain rapid growth. The major trends will be consistent with the needs of the host country's social and economic development and industry demand (China Bond Rating Co., 2017).

1.2.3 Brief introduction of TPPPs

One of the most important goals of the B&R initiative is to build extensive transport and communication networks to connect these countries, thereby promoting cross-country trade, foreign investment and close economic cooperation amongst various regions (Huasheng, 2016). The majority of the countries involved in this initiative are developing countries with relatively insufficient funds in infrastructure. Thus, the demand for PPP infrastructure projects in developing countries is increasing, thereby bringing opportunities for investment, construction, procurement and other business opportunities for investors from other countries (Shen et al., 1996b). For foreign investors, along with the significant development of the economy's globalisation and intergradation, the private sectors participate in local PPP projects and seek investment opportunities in the global market. This background indicates that TPPP is an inevitable concept for global infrastructure and investment in the construction industry. TPPP is a crucial method for developing countries to attract foreign investors to address the huge financing gap and enhance the efficiency of capital allocation.

The current study treats TPPP as a cross-country business strategy and an important

strategy to learn advanced methodologies on implementing PPP projects in countries without relevant experiences. The government uses the PPP experience of other geographical areas, 'translate' these foreign experiences into an 'own' PPP approach and adjusting and adapting to fit their respective region and projects (Hall, 2002).

Infrastructure development is closely related to economic growth in developed and developing countries. Thus, ensuring that infrastructure projects are successfully and efficiently developed should be a top priority in economic development in all countries (Underhill and Zhang, 2008b). However, megaproject infrastructure, such as highways, power plants, dams, bridges, airports and telecommunication networks, require advanced technologies and a huge amount of money. Although the majority of developing countries lack the capability to fund expensive infrastructure projects, TPPP could provide a solution to this problem. The use of TPPP is an innovative means to establish transnational cooperation and global support (Luiz, 2010). TPPP can effectively overcome large budget shortfalls, establish social capital with foreign partners and provide long-term benefits for the life and social environment of many citizens (Trumbull, 2009). Many countries have attempted to explore TPPP in infrastructure developments. For example, rapid economic growth brings heavy demands on infrastructure in China, thereby offering opportunities for foreign investors to explore (Zhang and Kumaraswamy, 2001b). The Indian government has attempted to establish a PPP project framework to attract private investment (including foreign direct investment) into India's highway infrastructure (Thomas et al., 2003b).

1.3 KEY ISSUES FOR TPPP PROJECT EXCELLENCE

1.3.1 TPPP project excellence

Project organisations differ fundamentally from traditional, functionally organised and permanent organisations (Turner, 2014). Projects are specifically aimed at realising a certain project goal (effectiveness) and satisfying key stakeholders' objectives. For PPP projects, focusing on key issues to achieve project excellence is substantially complicated. Many studies have attempted to analyse the success of PPP projects. Key performance indicators (KPIs) have been used to analyse PPP success (Yuan et al., 2009). Other studies have examined PPP success by assessing value for money (VFM) (Burger and Hawkesworth, 2011, Grimsey and Lewis, 2005). Furthermore, early research on measuring PPP project success has provided a universal checklist of success criteria (Kušljić and Marenjak, 2013, Osei-Kyei et al., 2017). Van Aken (1996) defined project success as 'the satisfaction of all stakeholders'. A PPP project is considered successful only if the key interests of all stakeholders are satisfied, whilst the degree of stakeholders' satisfaction should be a considerably reliable measure of PPP success (Ng et al., 2010). To avoid conflicts with critical success factors and explain the project results in a macro level, this study adopts 'project excellence' to define a project that achieves all objectives and the results are satisfied by stakeholders. The starting point in defining excellence in project management must be the definition of project success. The current study defines TPPP project excellence as 'the project may be managed with excellence on a consistent basis and standard, and the project is beneficial for the society and human being'. This research focuses on the key issues and attempts to establish a model for transnational PPP project excellence.

The TPPP project excellence model is derived from the European Foundation for Quality Management (EFQM). The EFQM model is mainly applied on enterprises

to evaluate the management of companies and provide them with a tool for self-evaluation and improvement. This model divided the key issues into enablers and results (Carlos Bou-Llusar et al., 2005). However, EFQM cannot be directly adopted in project management because of the particularity of projects. Westerveld (2003) revised this model on the basis of the characteristics and applied it in project management to establish a project excellence model (see Fig. 1.2).

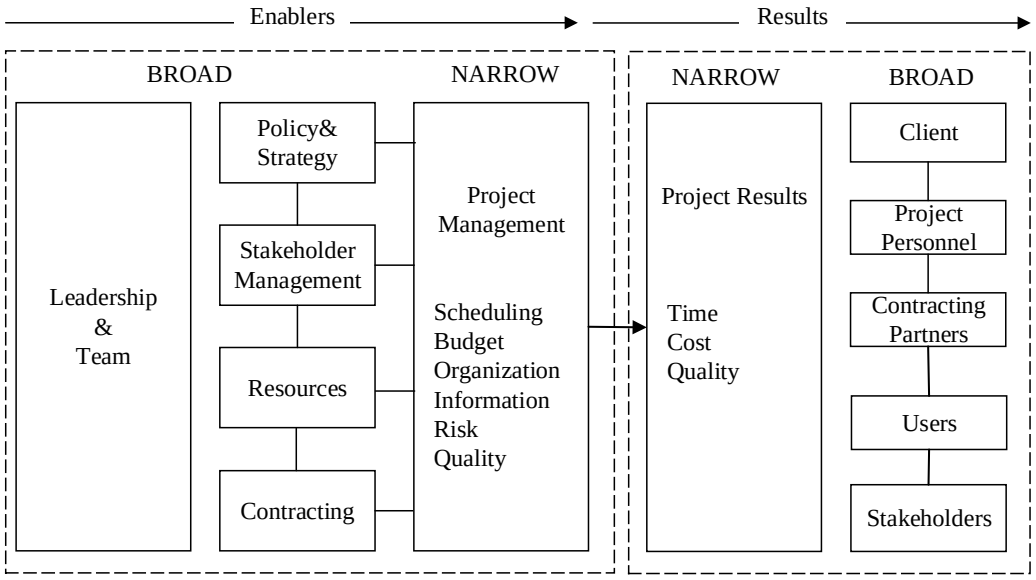


Fig. 1.2 Project excellence model
(Source: Westerveld (2003))

The excellence model shows that the project results – project excellence criteria and enablers – project excellence factors should focus on achieving project excellence. The project results reflect the effectiveness of project management and provide feedback to project management process, thereby contributing in clarifyingthe key issues that have significant impact on project results. The current study uses this conceptual framework as the logical starting point and attempts to identifies the key

issues to achieve TPPP project excellence.

1.3.2 Key issues to achieve TPPP project excellence

Baccarini (1999b) developed a logical framework method (LFM) for defining project success in two main components: (1) product success and (2) project management success. In LFM, product success deals with the effects of a project's final product, whereas project management success focuses on the project process. PPPs are integrated with a comprehensive lifecycle. Therefore, Liu et al. (2014) added process issues in this model, which were subsequently adopted in the PPP project management process. LFM uses a top–down approach to establish a hierarchy of project objectives, including project inputs, process, outputs, purpose and goal. At any level, the lower objective is designed to achieve the succeeding higher level of objectives. This hierarchy has a series of cause-and-effect linkages. The project goal is the overall strategic orientation and shows the contribution to the project, the company, stakeholders, users and society. This orientation should be a macro-level concept and describe the long-term objectives. Hence, the project goal of this study can be defined as project sustainability, which is explained by achieving long-term project implementation and being friendly to the economy, environment, people and society. The successful achievement of project purpose can be realised by critical success factors (CSFs). CSFs are 'the key areas of activity necessary to be focused to ensure competitive performance towards an organization's strategic goals' (Rockart, 1980). The output of TPPP projects explains the project output, namely, infrastructure and public services. Project input requires resources and activities to deliver each output. From input to output, many management issues should be considered, such as construction, stakeholder and risk. To ensure the success of PPP infrastructure projects, all partners should manage the

risks from a project life cycle perspective; that is, risks are identified and assessed in the earliest possible project stage and are allocated to the parties who are in the best position to control them (Zou et al., 2008).

In many cases, stakeholders expect the highest quality from the project. This expectation means that the project team should deliver excellent, outstanding project management (Grau, 2013). Excellence in project management can be defined as a continuous stream of well-managed projects (Kerzner, 1998). The main tasks link to each product success objective or project management success, includingrisk management process, critical success factors and sustainability of TPPP projects, which will be further discussed in the current study (see Fig. 1.3).

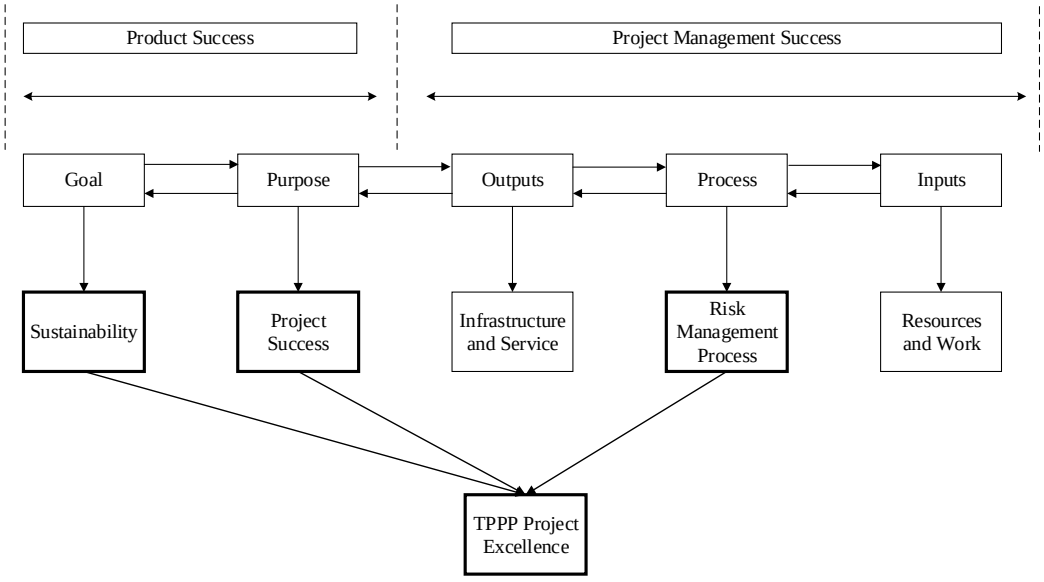


Fig. 1.3 Concept model for TPPP projects
(Adapted from Baccarini (1999b))

1.3.2.1 Risk management in TPPPs

TPPPs have been adopted in many industries. For example, the Laibin B Power Plant, which is the first BOT project in China, was invested by a purely foreign-owned company from France. In this type of project, the host governments play important roles in selecting suitable private sectors, accept the responsibility to

create an attractive investment climate and properly prepare projects to stimulate interest from private companies (Wibowo and Alfen, 2015). However, the complexity of TPPP projects result in challenges and conflicts during the implementation. Typical examples of well-recognised challenges for TPPP include such factors as immediate adaptation to different cultures and environments, establishment of a long-term relationship between foreign participants and local governments and short duration for private consortium to learn and abide by local legislations. Foreign investors remain sensitive to all of these concerns because they could easily result in serious risks. Although TPPP can establish cooperation between a host country's government and foreign investors in an infrastructure project, this partnership could result in difficulties and risks. For these reasons, the risk factors for effective handling or mitigation should be substantially understood to achieve an excellent TPPP.

The number of studies relating to risk management in PPP projects is increasing because risks have been considered crucial and of interest to scholars and practitioners (Ke et al., 2009). The four main stages in risk management in PPP projects are risk identification, assessment, allocation and response (including prevention and treatment) (Ameyaw and Chan, 2015b, Arndt, 2000) (see Fig. 1.4). Risk identification is the initial stage, which has been considered the most important stage in risk management in the entire PPP lifecycle. Hence, the subsequent risk management tasks are all inherently dependent on the input of risk inventory from the first stage (Dey and Ogunlana, 2004). The primary purposes of performing an evaluation of risk factors in PPP projects are to identify the critical risk factors and analyse the extent to which risks may negatively impact the success of projects or objectives of stakeholders. Probability and severity are the two most important

attributes and widely used in measuring risk factors. Thomas et al. (2006) presented a probability-impact assessment framework that involves evaluating the occurrence probability of risk factors and their impact on stakeholders' objectives, such as cost, time, quality and safety. After risk evaluation, the impact of each risk factor can be calculated and ranked. Ameyaw and Chan (2015a) adopted a fuzzy synthetic evaluation approach to measure the probability and severity of risk factors in calculating the risk impact for water supply PPP projects in developing countries. Ke et al. (2011b) used a two-round Delphi survey to identify the key risks in China's PPP projects. The probability of occurrence and severity of the consequence were generally derived from surveys to calculate each risk factor's significance index score.

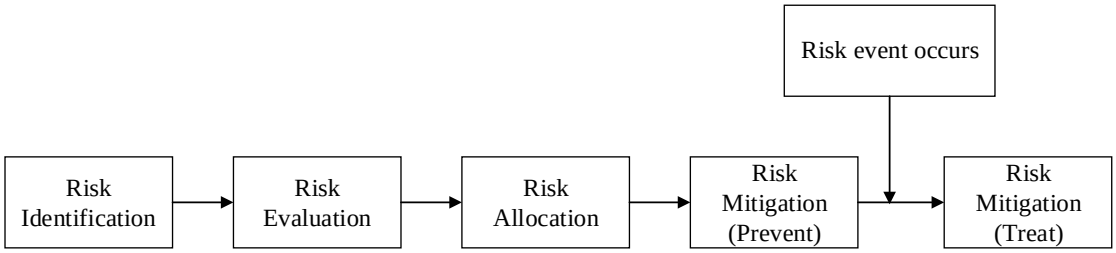


Fig. 1.4 Risk management process for PPP projects (Adapted from Arndt (2000))

For TPPP projects, foreign investors should identify the relevant risks in host countries before making investment decisions to avoid high uncertainties. Wang et al. (2000b) focused on the critical risk factors in TPPP projects and analysed foreign exchange and revenue risks in China's BOT projects. Chou and Pramudawardhani (2015b) conducted a cross-country study that compared drivers, critical success factors and risk allocation strategies in Taiwan, Singapore, China, the UK and Indonesia, and showed the differences in these countries to help foreign investors make informed investment decisions. Although many studies have focused on the identification, evaluation and ranking of risk factors in PPP projects, only minimal

research has focused on risk analysis in TPPP projects. Therefore, a study that specifically focuses on the risk management of TPPP projects should be conducted.

1.3.2.2 CSFs in TPPPs

Several successful PPP cases around the world can serve as model projects for future cases. These projects include the Jamaica North–South Expressway PPP Project, Chengdu No. 6 Water Plant Project, Sri Lanka Colombo Port City Development PPP Project, and Tirana International Airport. The success and advantages of implementing PPP have been substantially documented in these cases. However, not all PPP projects have become successful. Undeniably, the successful progress of PPP implementation is achieved through continuous assessment and exploration of the prevailing CSFs (Osei-Kyei and Chan, 2017b). Countries that are new in adopting PPP or investors who engage in a foreign and unfamiliar market should identify CSFs to maximise the advantages of this project and reduce the risks for all stakeholders (Cheung et al., 2012a). CSFs should be specifically identified and managed for stakeholders to implement TPPP projects. Particularly, stakeholders with sufficient DPPP experience but insufficient TPPP knowledge should focus on the specific success factors in implementing TPPP projects.

1.3.2.3 Project sustainability for TPPPs

The Sustainable Development Goals (SDGs) of the 2030 Agenda presents an immediate objective and challenge for all countries (Nations, 2018). The two important goals of SDGs are ‘to build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation’ and ‘to make cities and human settlements inclusive, safe, resilient and sustainable’. Therefore, infrastructure is considered the main driver for development and comprehensive amplification

(Anwar et al., 2017). Many governments are considerably aware of their responsibility and require that companies implementing projects with a huge impact on society, such as TPPP projects, will develop strategies and be proactive to ensure sustainability and attainment of SDGs (Aarseth et al., 2017). Against this background, considerably research should be conducted on how sustainability could be ensured and promoted in PPPs, particularly in TPPP projects.

Construction projects procured through the TPPP approach have a substantial influence on the environment, sustainability development and wellbeing of people. Therefore, sustainability has become essential in procurement in recent years. Policy makers often expect that sustainability factors would be offered to local residents and highly sustainable public infrastructure projects will be developed through PPP (USAID, 2010). The private sectors provide funding in the infrastructure development and contribute expertise and experience to engender innovation and develop sustainable assets (Cui et al., 2018). TPPP has become the preferred PPP form in recent years because it fosters collaboration amongst countries and enhance technology transfer and innovation. TPPP projects typically have complex stakeholders, whilst the impact of these projects on society and biodiversity is huge. Therefore, sustainability-related issues cannot be underestimated in the delivery of TPPP projects. From a narrow perspective, TPPP sustainability refers to the sustainable existence or operation of a project and the continuous provision of quality services to local residence. From a broad perspective, sustainability means that the project implementation has a positive impact on the sustainable development of society. The current study focuses on the two dimensions of TPPP project sustainability.

1.4 FOCUS OF THIS STUDY

1.4.1 Why TPPP projects

1.4.1.1 Drivers for TPPPs

The popularity of and interest on TPPP have proven its appeal. Except for the financial advantages of adopting PPP, many other drivers move governments and private companies to cooperate in PPP projects. Chan et al. (2009a) identified 15 drivers for implementing PPP: (1) solve the problem of public sector budget restraint, (2) provide an integrated solution (for public infrastructure/services), (3) reduce public money tied up in capital investment, (4) cap the final service costs, (5) facilitate creative and innovative approaches, (6) reduce the total project cost, (7) save time in delivering the project, (8) transfer risk to the private partner, (9) reduce public sector administration costs, (10) benefit the local economic development, (11) improve buildability, (12) improve maintainability, (13) transfer technology to local enterprises (14) nonrecourse or limited resource to public funding and (15) accelerate project development. These factors also drive the adoption of TPPP projects. For host country governments, B&R countries have huge infrastructure demands and financing gap, thereby enhancing these governments' enthusiasm to attract foreign investments. For Chinese investors, some huge companies are attempting to expand their business to international markets to seek additional opportunities and benefits. Given that B&R is an international initiative, some companies are also encouraged by governments to implement TPPP in other countries for political or aid reasons.

1.4.1.2 Emerging trends for TPPPs

The relationship between PPP and B&R is mutually acceptable. On the one hand, B&R requires an efficient infrastructure. TPPP can provide financial support for

public projects. On the other hand, the main aims of B&R are a 'five-pronged approach': promoting policy coordination, infrastructure inter-connectivity, unimpeded trade, currency convertibility and close people-to-people ties (Daily, 2017). For example, policy coordination can provide considerably opportunities and reduce potential barriers for foreign investors. Unimpeded trade can help B&R industries to collaborate with one another to form a complete industrial and supply chain. B&R provides an open environment for TPPP implementation, whilst TPPP projects can promote B&R.

1.4.1.3 Significance of TPPPs

The use of PPP for transnational infrastructure is a complex subject. Particularly, the use of PPPs varies considerably amongst the countries participating in B&R. Governments have their specific administrative and financial systems to develop infrastructure in their respective territory. Evidently, the challenges and characteristics of TPPPs are worthy to be identified and analysed because of the differences amongst countries. TPPP is a market-based, innovative and socialised public service supply management model, whilst its major characteristic is for fair competition, equal cooperation, risk sharing and benefit sharing. By bringing the private sectors from other countries to the host countries, particularly to developing countries, the significant move aims to increase the development of local infrastructure, improve the efficientuse of public resources and eventually enhance the residents' quality of life. However, some problems cannot be disregarded during the infrastructure construction of B&R, such as the huge fiscal pressure and limited participation policy of social capital in some countries. The TPPP model as a major innovation in public service supply mechanism has broad prospects. In applying TPPP to respond to B&R, the key issues in implementing TPPP projects and their

influences on project excellence should be identified and analysed.

1.4.2 Why Chinese investors

In the first international Cooperation Summit Forum, President Xi Jinping of China stated in his keynote speech that the PPP model should be promoted in the B&R construction. The 'Joint Communique of the Leaders Roundtable of the Belt and Road Forum for International Cooperation' also clarified the importance of 'market based operation, recognizing the role of the market and that of business as key players, while ensuring that the government performs its proper role and highlighting the importance of open, transparent, and non-discriminatory procurement procedures', as well as encouraged 'the involvement of governments, international and regional organizations, the private sector, civil society and citizens in fostering and promoting friendship, mutual understanding and trust'(China, 2017). Hence, the PPP model is expected to become an important form of international cooperation in public service projects for providing public goods and infrastructure projects of B&R.

The PPP model is based on market development and guided by the government. The development path aims to provide funds and new development concepts, management models, technologies and talents to the host countries. PPP solves current problems and considers long-term development to achieve mutual benefits for the government, private companies and the public. These goals are highly compatible with B&R.

The international construction market offers numerous opportunities and Chinese contractors are extremely active in overseas construction projects (Liu et al., 2016). However, the emergence of many competitive contractors in recent years has

resulted in difficulty to win bids, whilst the rate of return cannot be guaranteed because of vicious low-price competition. Therefore, many traditionally huge Chinese contractors have considered changing and upgrading their business strategies to match the environment. Accordingly, participation in TPPP projects in overseas markets provides another path for Chinese contractors. The participation of Chinese contractors in project design, investment and financing, construction, operation, maintenance and the entire lifecycle management in different countries and sectors by adopting the PPP model will enable them to create a new profit model with long-term and stable operating cash flow and combine design, construction and operation. China has secured a long history of launching PPP projects in other countries. Most of the private invesotrs from China are state-owned companies. As state-owned companies also have to fairly compete with others in the international market and has no special right in other countries, this study regard the transnational project invested by state-owned company as TPPP. Although many projects experienced immediate success, some minimally successful attempts have also suggested that the TPPP model is not easy to follow. Table 1.1 shows the 10 most popular and important TPPP projects in B&R countries invested by Chinese companies.

Table 1.1 Representative TPPP projects in B&R countries
(Source: China Public Private Partnerships Center, Retrieved 19 June 2018)

Project Name	Sector	Mode	Concession Period
Colombo Port City Project, Sri Lanka	Park development	BOOT	Construction period: 6 years. Operation period: 99 years
Columbia Ma Dao Mar2 Expressway	Transportation-Highway	BOT	Concession period: 29 years (1 year for preparation, 5 years for construction and 23 years for operation)
50 MW Wind Power Project in Sachar, Pakistan	Electric power	EPC+O&M	20 years
Downstream hydropower project in Elassai, Cambodia	Electric power	BOT	Operation period: 30 years
Jamaica H2K Expressway North-South Project	Transportation-Highway	BOT	Construction period: 3 years Operation period: 50 years

East African Yagi Railway Project	Transportation-Railway	EPC+O&M	Operation period: 6 years
Coal fired Power Station in Port Kassem, Pakistan	Electric power	BOO	Construction period: 36 months Operation period: 30 years
Ganzai Hydropower Station in Cambodia	Electric power	BOT	Construction period 4 years Operation period: 40 years
Deep Water Ports and Industrial Parks in the Chiao Pu Special Economic Zone, Myanmar	Transportation-Port Park development	DBFOT	/
PAYRA2*660 MW Coal-fired Power Station in Paala, Bangladesh	Electric power	BOO	Concession period: 25 years

Note: BOOT = Build–Own–Operate–Transfer; EPC+O&M = Engineering Procurement Construction + Operation & Maintenance; BOO = Build–Own–Operate; DBFOT = Design–Build–Finance–Operate–Transfer.

On the basis of the research scope, the data used in this study were collected from overseas TPPP projects, which are invested by Chinese investors. This factor increases the possibility of collecting data because the research was conducted in Mainland China and Hong Kong. Limitations on generalization are expected because this common problem is associated with country-specific, regional, or focused studies. Although the current study focused on the TPPP project invested by Chinese companies in B&R countries, the findings and implications can benefit policy makers, project practitioners and researchers within other contexts.

1.5 RESEARCH AIMS AND OBJECTIVES

To efficiently and effectively promote project management in TPPP projects, the key issues that influence TPPP project excellence should be understood clearly, which is the aim of the current research. By using the logical framework method, the key issues to achieve TPPP project excellence were identified as three different categories: risk management process, project success and sustainability. Specifically, the four objectives were identified to focus on the three key factor categories and TPPP project excellence:

1. To identify the critical risk factors (CRFs) and develop a risk management process model for TPPP projects,

2. To identify the critical success factors (CSFs) and develop a success factor framework for TPPP projects,

3. To identify the critical sustainability factors (CTFs) and develop a sustainability index model for TPPP projects and

4. To develop a TPPP project excellence model and to identify the influences of key issues on TPPP project excellence.

1.6 RESEARCH PROCESS IN BRIEF

The entire research process and flow have been divided into seven phases to achieve the aims and objectives of this study (see Fig. 1.5).

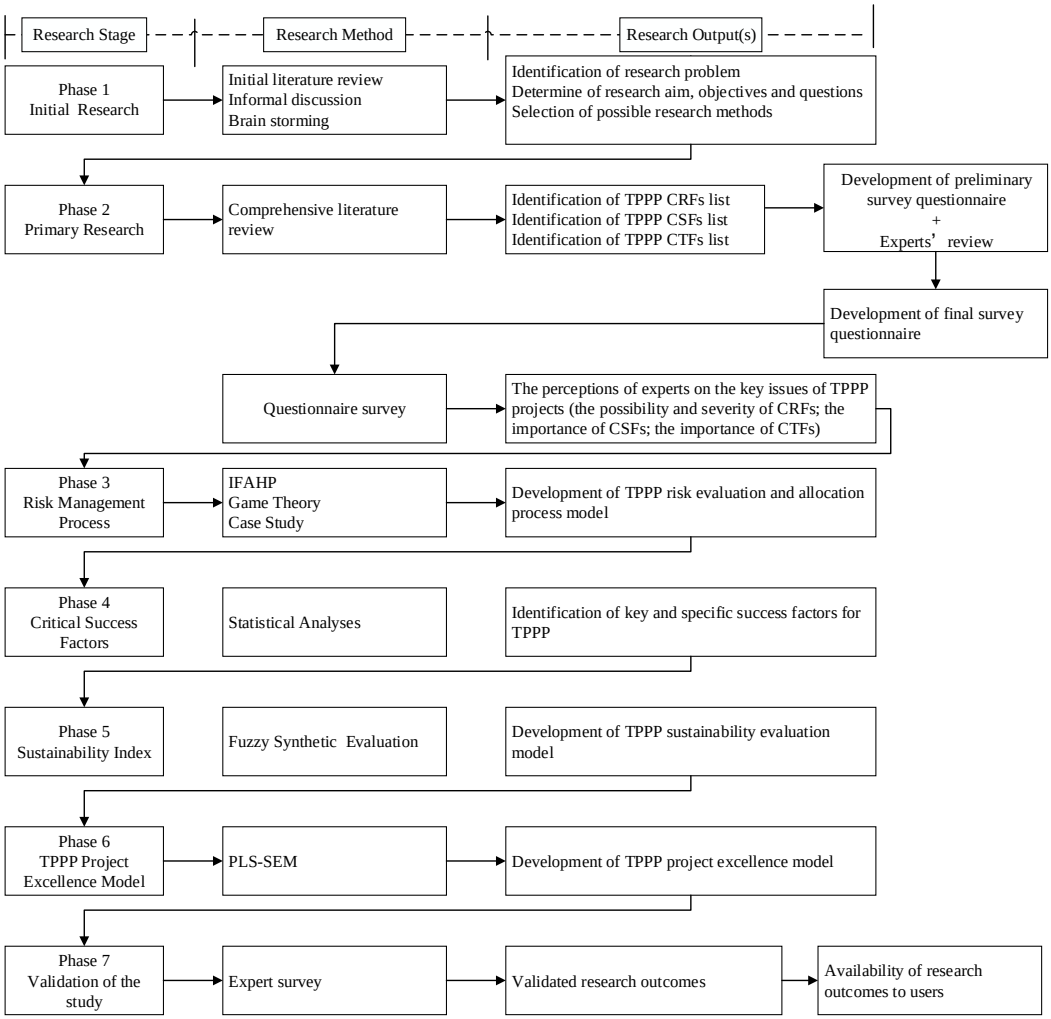


Fig. 1.5 Research process of this study
(modified from Darko (2019))

This section provides a brief overview of the overall research procedure. Chapter 3 presents a detailed description of the research methodology. The overall research process was divided into six systematic and sequential phases to achieve the aims and objectives of this study (see Fig. 1.5). Phase 1 is designed to determine the potential research problem of this area through a review of pertinent literature and discussions with the author's supervisors and some experts in the PPP industry. These initial literature review and discussions facilitated the establishment of the research aims, objectives, and methodology/research methods.

Phase 2 involves a general and detailed review of TPPP in relation to the research objectives. The literature on TPPP and PPP was critically and extensively reviewed to form a strong theoretical base for addressing the research objectives, and, hence, achieving the research aim. Various sources, such as journal and conference papers, Internet data, industrial publications, organisational publications (e.g. World Bank and China PPP Centre), books, seminars and workshops, have been considered useful to this study. The initial CRFs, CSFs and CTFs lists are presented on the basis of the comprehensive literature. Moreover, these identified lists formed the preliminary survey questionnaire. Some experts were invited to revise the list of factors and the final questionnaire was formed on the basis of their perceptions.

Phase 3 aims to achieve objective 1 and mainly comprises risk evaluation and allocation problems. Intuitionistic fuzzy analytic hierarchy process (IFAHP) was used to evaluate the risk possibility and severity, whilst and bargaining game theory (BGT) was used to allocate risks between the public and private sectors. At the end of this stage, a practical case study was adopted to show the process and practicality

of this risk management process model.

Phase 4 focuses on the critical success factors of TPPP projects. Key CSFs and specific CSFs in TPPP projects were identified through a comparative study og CSFs in DPPP projects. The similarity and differences between TPPP and DPPP were discussed to emphasise the particularity of TPPP CSFs. Accordingly, objective 2 was achieved.

Phase 5 uses fuzzy synthetic evaluation (FSE) to develop a TPPP sustainability index. This index can be used to measure the sustainability level of TPPP projects.

Phase 6 comprises the development of a model to value the influences of key issues on the TPPP project excellence, whilst partial least squares-structural equation model (PLS-SEM) was adopted to establish the model and test the influences.

Phase 7 is the final phase and validates the results by interviewing some experts.

1.7 STRUCTURE OF THESIS

This thesis is structured into eight chapters. Chapter 1 introduces the research, defines the key terms, provides the research scope and problem, outlines the research aims and objectives and briefly describes the research methodology. Chapter 2 presents a comprehensive literature review on CRFs, CSFs and CTFs of TPPP projects. This review is crucial to understand the potential issues associated with TPPP implementation and provide theoretical basis for this study. Chapter 3 substantially explains the research methodology and methods. This chapter also presents a comprehensive discussion of the specific data collection and statistical analysis methods employed in this study. Moreover, Chapter 3 discusses the weaknesses and strengths of the methods and the justifications for their selection.

Chapter 4 analyses the risk evaluation and allocation in TPPP projects using the IFAHP and BGT methods. Chapter 5 compares CSFs in TPPP and DPPP to identify the top-ranking CSFs and specific CSFs in TPPP projects. Chapter 6 presents the process and results of establishing the TPPP sustainability index model. Chapter 7 presents and discusses the PLS-SEM results. This chapter also presents the PLS-SEM models that depict the influences of various key issues related to TPPP project excellence, including CRFs, CSFs and CTFs. Chapter 8 validates this research and concludes this study and provides recommendations.

CHAPTER 2 LITERATURE REVIEW[2]

2.1 INTRODUCTION

This chapter comprehensively reviews previous studies to identify the key issues in TPPP projects, including CRFs, CSFs and CTFs. These key issues in TPPP projects should be substantially understood to conduct the following in-depth analyses and build the TPPP project excellence model.

2.2 CRFs FOR TPPP PROJECTS: LITERATURE REVIEW

2.2.1 Introduction of CRFs for TPPPs

Risk events have been of interest to researchers working on PPP projects (Tang et al., 2010). In TPPP, risk is bound to increase with foreign involvement because of unfamiliarity in geography, supply chain, local legislation and business practices (Rebeiz, 2012).Although numerous studies over the past decade have discussed risk factors in TPPP, only minimal focus was provided to t review the published TPPP CRFs. Therefore, a systematic review of previous TPPP CRF-related studies should be conducted. Moreover, the current literature review will facilitate the understanding of risk management in TPPP projects and identifying the risk list of TPPP CRFs.

2.2.2 Literature review process

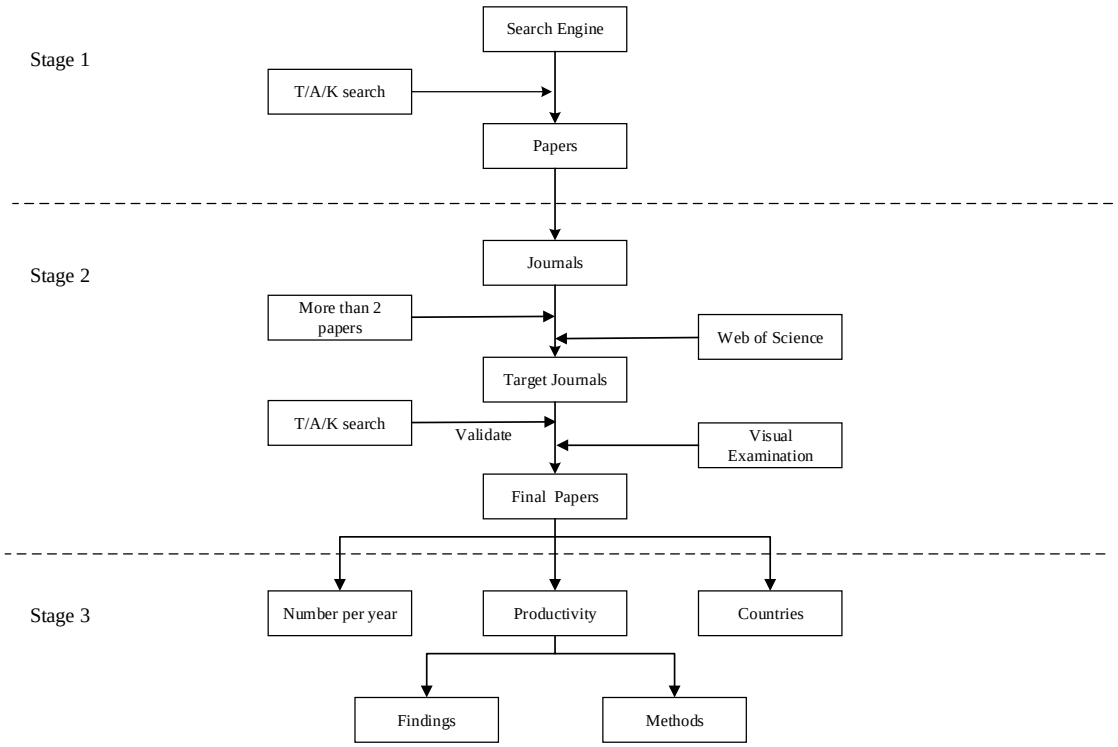
Literature review is a useful method to gain insights into a particular research topic and appreciate the existing body of knowledge on such a topic (Mok et al., 2015).

[2] This chapter is largely based upon:

Yu, Y., Chan, A. P., Chen, C. & Darko, A. 2017. Critical Risk Factors of Transnational Public–Private Partnership Projects: Literature Review. *Journal of Infrastructure Systems,* 24, 04017042.

Yu, Y., Osei-Kyei, R., Chan, A. P. C., Chen, C., & Martek, I. (2018). Review of social responsibility factors for sustainable development in public–private partnerships. *Sustainable Development,* 26(6), 515-524.

Thus, this section reviews the literature on TPPP to identify CRFs in this type of projects. The review methodology utilized in the present study has been extensively used to conduct similar review studies in the construction management domain (Hong et al., 2012, Yi and Chan, 2013, Ke et al., 2009, Osei-Kyei and Chan, 2015). This method comprises three main stages (see Fig. 2.1): selection of target journals, selection of relevant papers, and contribution assessment (as discussed in the following sections).



Note: T/A/K-title/abstract/keywords
Fig. 2.1 Research framework of the current study
Source: Ke et al. (2009)

2.2.2.1 Selection of target journals

In Stage 1 of the review process, a comprehensive desktop search was conducted under the 'title/abstract/keyword' field of the Scopus search engine. Scopus was selected for this study because of four reasons, (1) extensively used in similar review studies on construction management (Osei-Kyei and Chan, 2015, Yi and

Chan, 2013); (2) archives the majority of research papers in engineering, management, business, accounting, and construction (Hong and Chan, 2014); (3) considered the best and most effective search engine for literature review (Tober, 2011) and (4) has accurate and precise performance compared with other search engines (e.g. Web of Science, PubMed, and Google Scholar) (Falagas et al., 2008). The search keywords included 'Public–Private Partnership', 'PPP', 'Private Finance Initiative', 'PFI', 'Build–Operate–Transfer', 'BOT', 'Build–Own–Operate–Transfer', 'BOOT', 'Design–Build–Finance–Operate' and 'DBFO'. However, these keywords were limited to TPPP by adopting such keywords as 'transnational', 'oversea', 'offshore', 'abroad', 'foreign', 'multinational', 'cross national' and 'international'. Papers with these specific terms in the title, abstract or keywords were considered to have met the initial requirement for further analysis. Moreover, the search was restricted to papers published from 1991 to 2015 (inclusive years). The full search code is listed as follows:

TITLE-ABS-KEY("PPP" OR "PFI" OR "public private partnership" OR "private finance initiative" OR " Build-Operate-Transfer" OR "BOT" OR " Build-Own-Operate-Transfer" OR "BOOT" OR " Design-Build-Finance-Operate" OR "DBFO" OR "private infrastructure" OR "public infrastructure") AND TITLE-ABS-KEY("oversea" or "offshore" or "abroad" or "foreign" OR "transnational" OR "multinational" OR "cross national" OR "international")) AND DOCTYPE(ar OR re) AND PUBYEAR > 1990 AND PUBYEAR < 2016 AND (LIMIT-TO(SUBJAREA,"ECON") OR LIMIT-TO(SUBJAREA,"SOCI") OR LIMIT-TO(SUBJAREA,"BUSI") OR LIMIT-TO(SUBJAREA,"ENGI") OR LIMIT-TO(SUBJAREA,"ENVI") OR LIMIT-TO(SUBJAREA,"ENER") OR LIMIT-TO(SUBJAREA,"DECI")) AND (LIMIT-TO(LANGUAGE, "English"))

The search initially retrieved 1,084 papers. Despite the search restrictions, several unrelated papers still appeared. The search results indicated that these papers appeared in over 150 different journals. The selection of the target journals for this study was based on the following criteria:

(1) Journals that published at least two papers during the period covered by the study (according to the search results) (Darko and Chan, 2016, Osei-Kyei and Chan, 2015)and

(2) Journals listed in the Web of Science database and well-known journals from the Scopus database, with relatively high effect and important position in the construction management research area.

On the basis of these selection criteria, 102 journals that publish TPPP studies were identified for the selection of the relevant papers for this study.

2.2.2.2 Selection of relevant papers

The 102 selected journals provided 404 of the initially identified papers (i.e. 1,084 papers). However, not all of the 404 papers presented research arguments on the issue of CRFs for TPPP. Therefore, the papers were briefly examined through a reading of their abstracts and contents to filter out the unrelated papers. A total of 37 papers were eventually selected for further validaion and analysis. The sample size of 37 papers was adequate and could provide a good overview of TPPP CRFs when compared with Osei-Kyei and Chan (2015), who reviewed 27 papers on CSFs of PPP. The 37 papers were published in 22 peer-reviewed journals. Table 2.1 summarises the number of relevant papers identified from each journal. A total of 6 papers were published by the *International Journal of Project Management* (*IJPM*), whilst 4 papers were published by ASCE's *Journal of Construction Engineering*

and Management (*JCEM*). The remainder of the papers are distributed across the other journals.

Table 2. 1 Search Results of Papers on CRFs for TPPP in Selected Journals

Journal name	**Number of papers retrieved from search engine**	**Number of papers relevant to study**
International Journal of Project Management	14	6
Journal of Construction Engineering and Management	20	4
Antipode	2	2
Built Environment Project and Asset Management	4	2
Construction Management and Economics	5	2
International Journal of Water Resources Development	4	2
Journal of Infrastructure Systems	4	2
Journal of International Development	2	2
Journal of Management in Engineering	7	2
Engineering, Construction and Architectural Management	6	1
Environment and Planning C: Government and Policy	2	1
Global Governance	3	1
International Affairs	4	1
International Journal for Housing Science and Its Applications	2	1
International Journal of Social Economics	2	1
International Studies Perspectives	2	1
International Studies Review	2	1
Journal of Business Ethics	3	1
Journal of Contemporary Asia	2	1
Journal of Transport Geography	4	1
Natural Resources Forum	2	1
Transportation Research Record	6	1
Total	102	37

2.2.2.3 Contribution assessment

A formula proposed by Howard et al. (1987) was utilized to assess the contributions of countries and researchers to CRFs for the TPPP research. This formula has been extensively used in previous review studies (Ke et al., 2009, Osei-Kyei and Chan, 2015, Hong and Chan, 2014, Darko and Chan, 2016, Yi and Chan, 2013, Hong et al., 2012), thereby guaranteeing reliability and suitability for the present study. The formula is given as follows:

$$\text{score} = \frac{1.5^{n-i}}{\sum_{i=1}^{n} 1.5^{n-i}}, \tag{2.1}$$

where *n* refers to the number of authors and *i* denotes the order of a specific author.

In applying this formula, each paper is assigned a score of 1.00. This formula assigns the corresponding scores for authors on the basis of their position in a multi-authored paper. This formula is based on the assumption that a first author has provided more contributions than a second author, a second author more than a third author and so on. Table 2.2 shows the detailed score matrix for multi-authored papers. In adopting this methodology, the scores of each country and author were calculated, ranked, and discussed in the next section.

Table 2. 2 Score Matrix for Multi-authored Papers

	Order of specific author				
Number of authors	1	2	3	4	5
1	1.00				
2	0.60	0.40			
3	0.47	0.32	0.21		
4	0.42	0.28	0.18	0.12	
5	0.38	0.26	0.17	0.11	0.08

2.2.3 Analysis of findings from studies on CRFs for TPPP projects

This section presents and discusses the results of this study. Despite the comprehensive literature search, the total number of relevant papers retrieved may not be exhaustive and inclusive of all papers in the TPPP area under this study. Therefore, the analyses performed are exclusively based on the data obtained through the specific literature search and selection approaches adopted in this research. Moreover, this study did not intend to examine the complete population of papers on the issue of TPPP CRFs but to review the literature on TPPP CRFs on the basis of a sample and identify the most reported risk factors for future activities related to TPPP project risk management. Thus, the findings must be interpreted carefully.

2.2.3.1 Annual publications on CRFs for TPPP projects

The number of papers on TPPP CRFs published annually in the current study period

is presented in Fig. 2.2. None of the identified papers was published from 1991 to 1995. Since 1996, no stable output of TPPP CRFs publications have been made. Several declines and increases at certain times are also shown in Fig. 2.2. However, the peak within the study period is 2010 with seven papers, followed by four papers each in 2003 and 2015. The highest number of publications during the period before 2003 has been found to be 2 papers each in 1998, 2000 and 2001. Evidently, the past decade is presumed to have witnessed an enhancing research interest in CRFs for TPPP projects. Since the 2008 economic crisis, international PPP has been adopted extensively to enhance investments in global infrastructure development. This condition may explain the reason behind the increasing trend in the interest of researchers and practitioners toward TPPP CRFs in recent years. The research trend on CRFs for TPPP is projected to continue increasing as numerous PPP projects are being developed worldwide (Osei-Kyei and Chan, 2015).

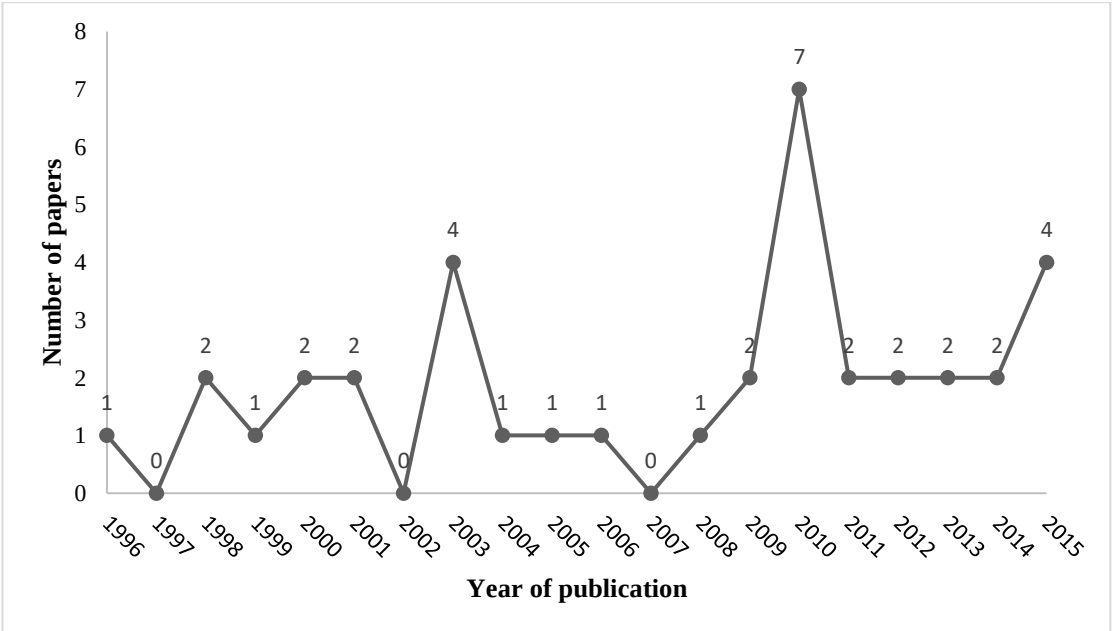


Fig. 2.2 Annual number of publications on TPPP CRFs from 1991 to 2015

2.2.3.2 Author's origin/country and active contributors of CRFs for TPPP research

The contribution score of each country to TPPP CRF research was calculated by employing the score matrix in Table 2.2. Table 2.3 summarises the results. The countries that contributed to TPPP CRFs in the study period are identified together with the number of institutions/universities, researchers and papers (see Table 2.3). The contributions of different countries in investigating CRFs of TPPP projects should be assessed because the geographical distribution of research outputs on a particular topic may reflect the extent of industrial practice and development on the topic in specific locations (Hong and Chan, 2014). Therefore, knowing the extent of research effort on CRFs of TPPP in certain locations may provide useful insights into the extent of risk management initiatives on TPPP projects in such locations. To determine the contribution score of each country, the score for each author either in a multi-authored or single-authored paper was added for each country on the basis of the score matrix. For example, if an author is the first author of paper A, second author of paper B, and third author of paper C (assuming each paper has three authors), then the score of this author is 1 (0.47+0.32+0.21), which could also be used to score his or her country.

Table 2. 3 Research Origin of the TPPP CRF-related Papers

Country	Institutions/universities	Researchers	Papers	Score
UK	7	12	6	4.47
Germany	6	10	5	4.40
Singapore	2	5	5	4.15
India	2	6	3	3.00
South Africa	3	3	3	3.00
Hong Kong	2	6	4	2.21
Korea	5	6	2	2.00
Canada	3	3	2	2.00
The Netherlands	2	2	2	1.60
US	3	3	3	1.44
Taiwan	1	2	1	1.00
Sweden	3	3	1	1.00
Australia	1	3	1	1.00
Morocco	1	2	1	1.00
Turkey	1	1	1	1.00

Lebanon	1	1	1	1.00
China	3	3	3	0.85
Indonesia	1	1	1	0.60
Italy	2	2	1	0.60
Philippines	1	1	1	0.40
Belgium	2	1	1	0.28

Table 2.3 shows that developed and developing countries have studied CRFs of TPPP projects, thereby suggesting that this topic is of global interest. The UK, Germany and Singapore are the top three countries with scores of 4.47, 4.40 and 4.15, respectively. In the UK, 12 researchers from 7 institutions published 6 papers on TPPP that discussed CRFs. In Germany, 10 scholars in 6 organisations contributed 5 publications in the study period. These results are reasonable. For example, the UK is internationally known as a forerunner of the implementation of PPP projects. Germany has also made good progress in PPP projects, which could be attributed to this country's establishment of a well-organised central PPP unit (Fischer et al., 2006). In Singapore, 5 researchers from 2 research centres published 5 papers. Additionally, some developing countries, such as India and South Africa, published papers in this research area with the same score (i.e. 3.00). Meanwhile, attracting foreign investors in infrastructure through the TPPP model is an effective method for economic development in developing countries. Although the number of studies on CRFs for TPPP that emanate from developing countries is relatively low, this condition is understandable because PPP originated from and has been a long-standing issue in developed countries.

2.3.3.3 Keyword co-occurrence network

In this section, the research method was structured following the workflow provided by Brner (2010). CiteSpace5 software, which was used to collect data, is the fifth generation of the CiteSpace technique for scientometric research and

modelling. The primary source of data is Wos and Scupos. Information on 22 papers is directly from Wos, whilst that on the other 15 is from Scopus. The data from Scopus should be converted to the Wos format. Thereafter, the data of the 37 papers can be processed together.

Several options, such as time slicing, node type and link selection, and pruning, were predetermined before the keyword co-occurrence network was visualised. Node attributes are the frequency with which a keyword has been used.

After all options were set, CiteSpace was used to visualise the keyword co-occurrence network. All keywords were retained because of the limited number of input papers. This process generated 211 nodes. Fig. 2.3 presents the visualisation picture drawn by CiteSpace, which shows the entire keyword co-occurrence network. Node size represents the frequency with which a keyword occurs in the data set. Edge weight denotes the frequency with which two keywords have been used in combination. Table 2.5 shows the top 10 key words with at least 4 times frequency.

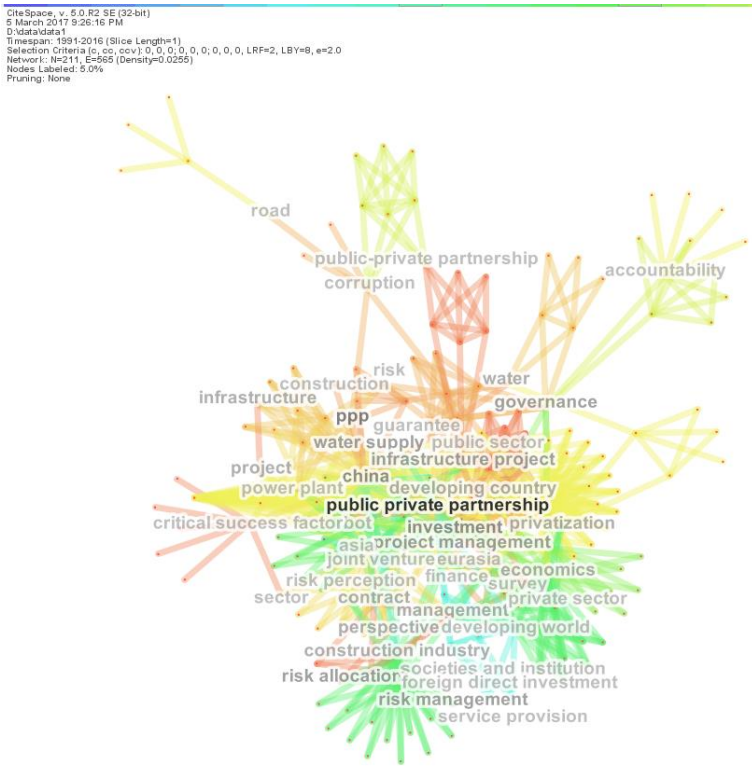


Fig. 2.3 Keyword co-occurrence network

Table 2. 4 Frequency of keywords

Frequency	Keywords
11	public private partnership
6	PPP
5	investment
5	China
4	project management
4	infrastructure project
4	water supply
4	risk allocation
4	risk management
4	governance

This scientometric method visually and quantitatively reflects research hotspots in the last 20 years. This method is similar to the global sensitivity and uncertainty analyses method adopted in Convertino et al. (2016). On the basis of the outcome of the CiteSpace analysis, 10 topics were identified for the research interests of TPPP paper: (1) Public Private Partnership; (2) PPP, (3) investment, (4) China, (5) project management, (6) infrastructure project, (7) water supply, (8) risk allocation,

(9) risk management, and (10) Governance.

Although some papers focused on 'BOT' (Thomas et al., 2003b) or 'TOT' (Jang et al., 2014b) to discuss a specific type of PPP, PPP remains the first to elicit attention. Choi et al. (2010b) identified the risk perfection of participants in China's water sector. Tijhuis (2015a) discussed how to deal with business–culture influences in managing PPP projects. 'Investment' is the direct objective for private sectors participating in PPP projects in other countries, thereby making this topic the second top keyword. Babatunde et al. (2015a) analysed the major barriers in the implementation of PPP projects in Nigeria to help foreign private investors develop strategies for investing in this country and other developing countries. China is the third keyword with five times. Along with the rapid economic growth in China is the high demand for basic infrastructure, such as roads, ports and power generation facilities. Hence, numerous investment opportunities in PPP projects in China are available for foreign investors (Wang et al., 1998b). Many Chinese scholars have conducted research on the basis of China's background. Project management is a macroscopic concept with four frequencies. All PPP studies can be considered a type of project management research. The majority of TPPP projects are infrastructure with four frequencies. The delivery of infrastructure requires substantial amount of money. Innovative PPP, global cooperation and the support of international institutions are provided to solve this problem (Luiz, 2010). World Bank reports encourage the development of public water systems in developing countries through PPP (Ameyaw and Chan, 2015a). Thus, private sector participation in the water sector has become one of the most controversial policy developments in the last two decades (Cocq and McDonald, 2010a). Risk management is one of the most popular research topics in PPP and has four

frequencies in this analysis. Risk management includes risk identification, risk evaluation and many types of specific risk factors (Ke et al., 2009). This definition is similar with that in selected TPPP studies. TPPP is a new form of governance that has attracted the interest of researchers and practitioners in recent years. Hence, TPPP is considered a soft mode of governance in global finance (Ritter, 2010) and has four frequencies in the current study.

2.2.4 CRFs for TPPP projects

2.2.4.1 Identification of CRF list

Risk management is an important topic in PPP research (Ke et al., 2009). For TPPP, when foreign investors expand their services internationally in other countries, uncertainties often increase the risk of becoming unsuccessful. Therefore, foreign investors should identify the risk factors in host countries and completely understand the characteristics of PPP projects overseas before making investment decisions. The 37 papers analysed in this study examined and discussed CRFs for TPPP from various perspectives. A review of these papers identified 42 risk factors (see summary in Table 2.6). Table 2.6 shows the factor list with references.

Table 2. 5 TPPP Risk Factors Identified from the Literature

No.	Risk factors	References	Total
1	Legal risk	Wibowo and Alfen (2015), Wang et al. (2000a), Babatunde et al. (2015b), Choi et al. (2010a), Chou and Pramudawardhani (2015a), Jang et al. (2014a), Smith et al. (2004), Wang and Tiong (2000a), Khalifa and Essaouabi (2003), Ritter (2010)； Schäferhoff et al. (2009), Wang et al. (1999), Appuhami et al. (2011), Ke et al. (2010a), Zhang and Kumaraswamy (2001a), Muller (2003b), Rebeiz (2011)； Bennett (1998), Ramakrishnan (2014a)	19
2	Cooperation risk between public and private sectors	Cocq and McDonald (2010b), Tijhuis (2015b), Wibowo and Alfen (2015), Thomas et al. (2003a), Babatunde et al. (2015b), Beisheim and Campe (2012), Bexell et al. (2010), Underhill and Zhang (2008a), Akcay (2010), Chou and Pramudawardhani (2015a), Luiz (2010), Khalifa and Essaouabi (2003), Abramov (2009a), Ke et al. (2010a), Zhang and Kumaraswamy (2001a), Muller (2003b), Meng et al. (2011), Bennett (1998)	18
3	Tariff risk	Cocq and McDonald (2010b), Wibowo and Alfen (2015), Wang et al. (2000a), Babatunde et al. (2015b), Akcay (2010), Choi et al. (2010a), Chou and Pramudawardhani (2015a), Jang et al. (2014a), Wang et al. (1999), Lobina (2005), Wang et al. (1999), Wang et al. (1998a), Zhang and Kumaraswamy (2001a), Franceys and Weitz (2003), Muller (2003b), Rebeiz (2011), Ramakrishnan (2014a)	17
4	Financing risk	Cocq and McDonald (2010b), Thomas et al. (2003a), Wang et al. (2000a), Babatunde et al. (2015b), Underhill and Zhang (2008a), Choi et al. (2010a), Chou and Pramudawardhani (2015a), Lobina (2005), Wang et al. (1998a), Appuhami et al. (2011), Ke et al. (2010a), Zhang and Kumaraswamy (2001a), Muller (2003b), Meng et al. (2011), Rebeiz (2011), Parola et al. (2013a)	16
5	Political risk	Thomas et al. (2003a), Wang et al. (2000a), Babatunde et al. (2015b), Choi et al. (2010a), Chou and Pramudawardhani (2015a), Smith et al. (2004), Wang and Tiong (2000a), Lobina (2005), Schäferhoff et al. (2009), Wang et al. (1999), Wang et al. (1998a), Appuhami et al. (2011), Ke et al. (2010a), Franceys and Weitz (2003), Rebeiz (2011), Parola et al. (2013a)	16
6	Technology risk	Cocq and McDonald (2010b), Tijhuis (2015b), Thomas et al. (2003a), Babatunde et al. (2015b), Beisheim and Campe (2012), Smith et al. (2004), Wang and Tiong (2000a), Khalifa and Essaouabi (2003), Wang et al. (1998a), Ke et al. (2010a), Franceys and Weitz (2003), Rebeiz (2011), Parola et al. (2013a), Ramakrishnan (2014a)	14
7	Corruption risk	Tijhuis (2015b), Wibowo and Alfen (2015), Wang et al. (2000a), Babatunde et	14

		al. (2015b), Beisheim and Campe (2012), Chou and Pramudawardhani (2015a), Fischer et al. (2006), Lobina (2005), Ritter (2010), Abramov (2009a), Meduri and Annamalai (2012), Wang et al. (1999), Wang et al. (1999), Rebeiz (2011), Bennett (1998)	
8	Administrative procedure risk	Wibowo and Alfen (2015), Thomas et al. (2003a), Wang et al. (2000a), Babatunde et al. (2015b), Choi et al. (2010a), Chou and Pramudawardhani (2015a), Wang et al. (1999), Wang et al. (1998a), Ke et al. (2010a), Franceys and Weitz (2003), Parola et al. (2013a), Bennett (1998)	12
9	Currency risk	Cocq and McDonald (2010b), Wang et al. (2000a), Babatunde et al. (2015b), Chou and Pramudawardhani (2015a), Wang and Tiong (2000a), Lobina (2005), Shen et al. (1996a), Appuhami et al. (2011), Zhang and Kumaraswamy (2001a), Ramakrishnan (2014a)	10
10	Demand and revenue risk	Thomas et al. (2003a), Wang et al. (2000a), Akcay (2010), Chou and Pramudawardhani (2015a), Smith et al. (2004), Wang and Tiong (2000a), Lobina (2005), Ke et al. (2010a), Meng et al. (2011), Ramakrishnan (2014a)	10
11	Credit risk	Tijhuis (2015b), Thomas et al. (2003a), Wang et al. (2000a), Underhill and Zhang (2008a), Choi et al. (2010a), Chou and Pramudawardhani (2015a), Appuhami et al. (2011), Ke et al. (2010a), Bennett (1998)	9
12	Worker risk	Barchiesi (2001), Cocq and McDonald (2010b), Chou and Pramudawardhani (2015a), Jang et al. (2014a), Wang and Tiong (2000a), Ritter (2010), Ke et al. (2010a), Rebeiz (2011), Bennett (1998)	9
13	Construction risk	Thomas et al. (2003a), Wang et al. (2000a), Chou and Pramudawardhani (2015a), Wang and Tiong (2000a), Meduri and Annamalai (2012), Ke et al. (2010a), Zhang and Kumaraswamy (2001a), Rebeiz (2011)	8
14	Operation risk	Thomas et al. (2003a), Wang et al. (2000a), Chou and Pramudawardhani (2015a), Lobina (2005), Shen et al. (1996a), Ke et al. (2010a), Zhang and Kumaraswamy (2001a), Rebeiz (2011)	8
15	Force majeure	Thomas et al. (2003a), Wang et al. (2000a), Chou and Pramudawardhani (2015a), Wang and Tiong (2000a), Wang et al. (1999), Ke et al. (2010a), Zhang and Kumaraswamy (2001a), Rebeiz (2011)	8
16	Lack of government support	Wibowo and Alfen (2015), Thomas et al. (2003a), Babatunde et al. (2015b), Choi et al. (2010a), Chou and Pramudawardhani (2015a), Wang et al. (1999), Parola et al. (2013a)	7
17	Public opposition/resistance	Babatunde et al. (2015b), Beisheim and Campe (2012), Chou and Pramudawardhani (2015a), Appuhami et al. (2011), Ke et al. (2010a), Muller (2003b)	6

18	Natural condition	Chou and Pramudawardhani (2015a), Ke et al. (2010a), Muller (2003b), Rebeiz (2011), Bennett (1998)	5
19	Risk in land acquisition	Thomas et al. (2003a), Babatunde et al. (2015b), Chou and Pramudawardhani (2015a), Wang et al. (1999), Ke et al. (2010a)	5
20	Competitiveness risk	Tijhuis (2015b), Choi et al. (2010a), Wang et al. (1999), Khalifa and Essaouabi (2003), Meng et al. (2011)	5
21	Inability of government to manage PPP	Babatunde et al. (2015b), Chou and Pramudawardhani (2015a), Ke et al. (2010a), Muller (2003b)	4
22	Long-term management risk	Barchiesi (2001), Tijhuis (2015b), Rebeiz (2011)	3
23	Tax risk	Chou and Pramudawardhani (2015a), Wang et al. (1999), Ke et al. (2010a)	3
24	Payment risk	Chou and Pramudawardhani (2015a), Wang et al. (1999), Lobina (2005)	3
25	Cultural impediments	Babatunde et al. (2015b), Rebeiz (2011), Parola et al. (2013a)	3
26	Excessive contract variation	Choi et al. (2010a), Chou and Pramudawardhani (2015a)	2
27	Bidding method	Jang et al. (2014a), Muller (2003b)	2
28	Restriction on import and supporting facilities	Chou and Pramudawardhani (2015a), Wang et al. (1999)	2
29	Performance risk	Lobina (2005)； Muller (2003b)	2
30	Conflict of national essence (capitalism/socialism)	Cocq and McDonald (2010b)	1
31	Risk of business-cultural clashes	Tijhuis (2015b)	1
32	Restriction policy on foreign investor	Wibowo and Alfen (2015)	1
33	Lack of consistent dispute resolution scheme	Wibowo and Alfen (2015)	1
34	Perceptions of a country or nation as high-risk economy by foreign investors	Babatunde et al. (2015b)	1
35	Environment risk	Ritter (2010)	1
36	Limited decision power for private sector	Underhill and Zhang (2008a)	1
37	Prohibition of cross-border design and construction services	Choi et al. (2010a)	1
38	High transaction cost	Lobina (2005)	1
39	Reliability of cooperation with local entities	Wang et al. (1999)	1
40	Commercial risk	Franceys and Weitz (2003)	1
41	Language differences	Parola et al. (2013a)	1
42	Environmental transformations	Ramakrishnan (2014a)	1

2.2.4.2 Groups of different project sectors

The papers discussed in the previous section cover the different sectors of TPPP projects. The categorisation of sectors is shown in Fig. 2.4. The distribution of this chart indicates that the majority of these papers did not focus on a specific sector. A total of 21 papers discussed general TPPP projects. Fischer et al. (2006) conducted a survey that viewed the PPP framework in the international context. Schäferhoff et al. (2009) analysed TPPP based on the basis of the international relations perspective. Ke et al. (2010c) compared the risk allocation in Grace, Hong Kong and China in general PPP projects to provide international investors an improved understanding of the risk preferences in different countries or jurisdictions. However, some papers selected a specific sector and focused on the problems existing in this type of projects. Eight papers focused on the water sector. Jang et al. (2014b) identified the strengths, weaknesses, opportunities and threats of the water PPP market in China to provide useful information for foreign investors who aim to expand their share in this market. Lobina (2005) reviewed the problems of the private sectors in water concessions and the interactions between multinational companies and other stakeholders. Additionally, power plant is an important sector discussed by several papers. Five papers limited their scope in the power plant sector. Wang et al. (2000b) evaluated the foreign exchange and revenue risks in China's BOT projects. Laibin B Power Plant was applied in this study to emphasise the importance of exchange rate and risks in convertibility, financial closing, dispatch constraint and tariff adjustment. Rebeiz (2012) used an illustrative case study of a BOOT thermal power plant project to analyse the risk factors of PPP projects in emerging countries. Several scholars are also interested in other sectors. Meduri and Annamalai (2013) found that states that are substantially developed and

had low levels of corruption could be successful in attracting private sector investment for road projects. Parola et al. (2013b) analysed the factors underlying the foreign entry strategies of terminal operators in container ports.

Many risk factors (e.g. politics, corruption, force majeure) are similar no matter which project sector is involved. However, some special risk factors exist in a specific sector. For example, low-level water price, difficulty in price adjustment and competitiveness of local water companies are particular potential risks in the water sector (Choi et al., 2010b, Lobina, 2005, Rebeiz, 2012); In the power plant sector, the fluctuating demand of power generated, cost of fuel or coal and transmission failure are special risks (Wang et al., 2000b, Wang and Tiong, 2000b). Traffic revenue is one of the most serious risks in road TPPP projects (Thomas et al., 2003b). Meanwhile, private international investors are limited in the port sector (Parola et al., 2013b).

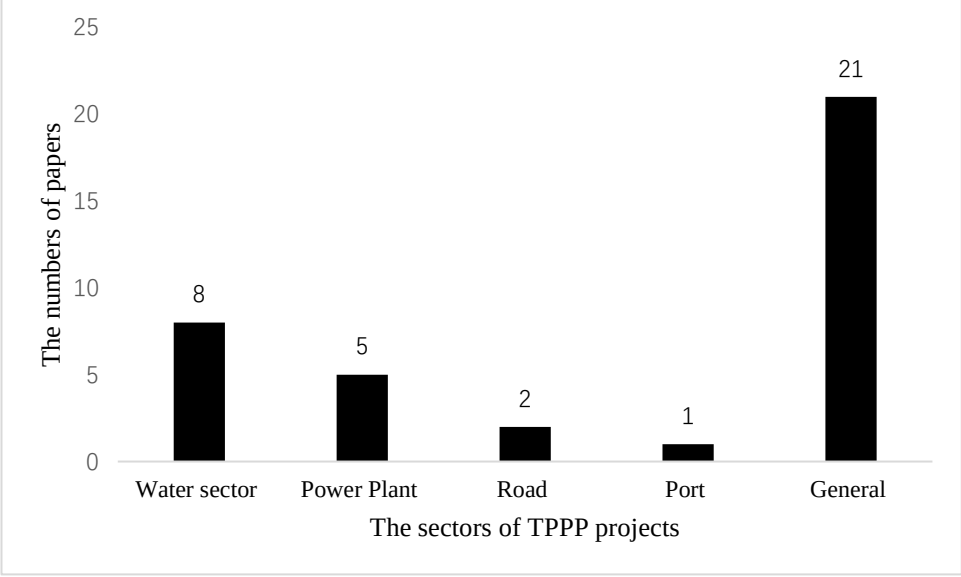


Fig. 2.4 Sector distribution of TPPP studies

2.2.4.3 Methodologies adopted for studies on TPPP CRFs

The papers reviewed were further analysed to clarify the research methodologies

that they adopted to explore CRFs for TPPP projects. The distribution of methods adopted to explore CRFS of TPPP projects is shown in Fig. 2.5.

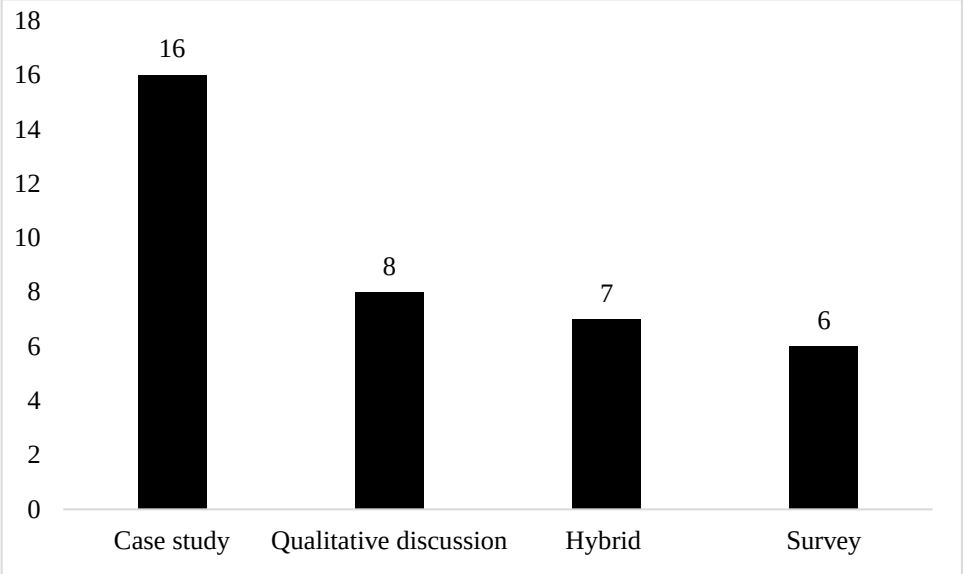


Fig. 2.5 Research methods adopted in TPPP studies

The results presented in Fig. 2.5 indicate that four types of methods have been used in TPPP CRF-related studies: case study, qualitative descriptive, hybrid method and survey. The case study is the most preferred method and 43.2% (16 papers) of the studies used this approach. This result is understandable because the case study method can provide detailed information on the phenomenon under investigation (Cavaye, 1996). Eight papers used qualitative discussion to analyse some phenomena discussed in previous studies and related reports. The hybrid method refers to at least two methods combined; this method was used in seven studies. Moreover, some scholars used opinion survey to measure the level of factors and in-depth case study to explain these factors (Jang et al., 2014b). Survey, through interviews and questionnaires, was used by six of the papers analysed. Survey has long been a preferred method in construction management research because this technique presents a direct and relatively easier means to simultaneously collect data from various experts and practitioners (Holt, 2010). Moreover, this method is

useful for sensitive issues, such as TPPP.

The current study identified the research methods adopted by TPPP studies to discuss CRFs from 1991 to 2015. Each method has advantages and disadvantages. Moreover, the use of a particular method is dependent upon certain issues, such as time, scope and specific research background.

2.3 CSFs FOR TPPP PROJECTS: LITERATURE REVIEW

2.3.1 Introduction of CSFs for TPPPs

PPP has been extensively practiced in the majority of developed countries (Osei-Kyei and Chan, 2017b). Currently, this strategy is also popular in many developing countries. A World Bank report indicated that in the first half of 2017, the top five countries (i.e. Indonesia, Brazil, Pakistan, China, and Jordan) by investment commitments in infrastructure projects with private participation are developing countries (Group, 2017). A few of these countries have attempted to attract foreign investors to implement PPP projects to help local infrastructure development. The situation of implementing PPP projects in other countries and in the domestic country of the investor is different owing to unfamiliarity in geography, supply chain, local legislation and business practices (Rebeiz, 2011).

Rockart (1980) defined CSF as the 'few key areas of activity where favourable results are absolutely necessary for a manager to reach his/her goals'. CSFs are necessary to ensure success in management (Boynton and Zmud, 1984). CSFs have been employed in TPPP projects for management measures and practices that can contribute to the success of the entire life cycle of projects or increase the possibility of project success. Particularly, when the objectives of a project are completely achieved, this project can be deemed successful (Ika, 2009). For a TPPP project,

'success' should be a lifecycle definition, including the construction and operation stages. LFM for defining project success (Baccarini, 1999a) was used as basis to define the success of TPPP projects in terms of three components, namely, (1) meeting time, cost and quality; (2) quality of project management process and (3) satisfying the needs of project stakeholders. The CSF approach provides an important area to ensure success in management (Boynton and Zmud, 1984).

Previous studies have highlighted appropriate risk allocation and sharing as extremely critical in achieving success in TPPP project implementation (Jin and Doloi, 2008). Risk allocation means identifying and sharing risks to the appropriate parties (i.e. public or private sector) (Ke et al., 2010a). Foreign investors in TPPP projects remain particularly sensitive to culture, environment, legislation and partnership (Yu et al., 2017). Therefore, risk management strategy should be the focus of the public and private sectors to share the risk in a substantially reasonable manner, thereby achieving project success. Other studies have emphasised that a successful TPPP project requires transparent procurement (Osei-Kyei and Chan, 2015). TPPP is a procurement process and is politically sensitive. Particularly, transparency should apply in the bidding process and throughout the entire lifecycle. Regardless whether TPPP projects are implemented in the domestic country or other countries, stakeholders should abide by local legislation and provide the necessary information to external stakeholders or users. Other important CSFs for TPPP projects identified by previous studies include political support, favourable legal framework and available and mature economic market (Abdul-Aziz and Kassim (2011) Hwang et al. (2013)).

2.3.2 Identification of CSF list

Osei-Kyei and Chan (2015) performed a comprehensive literature review and developed a thorough CSF list for general PPP projects. To further ascertain the appropriateness of the generated list with respect to its applicability in TPPP, the list was updated by reviewing other papers focusing on CSFs for TPPP projects. Table 2.7 shows the revised set of CSFs for PPP projects with their relevant literature sources.

Table 2. 6 CSFs for PPP projects
(Adapted from Osei-Kyei and Chan (2015))

	CSF	Sources	Total
S01	Appropriate risk allocation and sharing	Mladenovic et al. (2013), Jacobson and Ok Choi (2008), Meng et al. (2011), Hwang et al. (2013), Li et al. (2005), Nisar (2013), Dulaimi et al. (2010), Zhang (2005a), Tiong (1996), Jefferies et al. (2002), Jefferies (2006), Olusola Babatunde et al. (2012), Cheung et al. (2012a)	13
S02	Strong private consortium	Liu and Wilkinson (2013), Ng et al. (2012), Hwang et al. (2013), Tang and Shen (2013), Li et al. (2005), Nisar (2013), Dulaimi et al. (2010), Zhang (2005a), Tiong et al. (1992), Tiong (1996), Jefferies et al. (2002), Cheung et al. (2012a)	12
S03	Political support	Abdul-Aziz and Kassim (2011), Jacobson and Ok Choi (2008), Li et al. (2005), Gannon and Smith (2011), Ozdoganm and Talat Birgonul (2000), Dulaimi et al. (2010), Zhang (2005a), Olusola Babatunde et al. (2012), Chan et al. (2010a)	9
S04	Transparent procurement	Mladenovic et al. (2013), Jamali (2004), Tang et al. (2012), Hwang et al. (2013), Tang and Shen (2013), Li et al. (2005), Gannon and Smith (2011), Chan et al. (2010a)	8
S05	Public/community support	Jacobson and Ok Choi (2008), Li et al. (2005), Gannon and Smith (2011), Zhang (2005a), Jefferies et al. (2002), Jefferies (2006), Chan et al. (2010a), Kumaraswamy and Morris (2002)	8
S06	Favourable legal framework	Mladenovic et al. (2013), Jamali (2004), Hwang et al. (2013), Li et al. (2005), Dulaimi et al. (2010), Olusola Babatunde et al. (2012), Cheung et al. (2012a)	7
S07	Stable macroeconomic condition	Mladenovic et al. (2013), Liu and Wilkinson (2013), Dulaimi et al. (2010), Zhang (2005a), Olusola Babatunde et al. (2012), Cheung et al. (2012a), Chan et al. (2010a)	7
S08	Clarity of roles and responsibilities among parties	Abdul-Aziz and Kassim (2011), Jacobson and Ok Choi (2008), Tang et al. (2012), Hwang et al. (2013), Tang and Shen (2013), Chan et al. (2010a)	6
S09	Competitive procurement	Mladenovic et al. (2013), Abdul-Aziz and Kassim (2011), Meng et al. (2011), Jefferies (2006), Olusola Babatunde et al. (2012), Chan et al. (2010a)	6
S10	Strong commitment by both parties	Jacobson and Ok Choi (2008), Tang et al. (2012), Tang and Shen (2013), Li et al. (2005), Gannon and Smith (2011)	5
S11	Detailed project planning	Mladenovic et al. (2013), Abdul-Aziz and Kassim (2011), Jacobson and Ok Choi (2008), Zhang (2005a), Olusola Babatunde et al. (2012)	5

S12	Open and constant communication	Abdul-Aziz and Kassim (2011), Jacobson and Ok Choi (2008), Meng et al. (2011), Tang et al. (2012), Tang and Shen (2013)	5
S13	Technology innovation	Liu and Wilkinson (2013), Dulaimi et al. (2010), Tiong et al. (1992), Tiong (1996), Jefferies et al. (2002)	5
S14	Government providing guarantees	Liu and Wilkinson (2013), Tang et al. (2012), Ozdoganm and Talat Birgonul (2000) Chan et al. (2010a),	4
S15	Long term demand for the project	Mladenovic et al. (2013), Ng et al. (2012), Meng et al. (2011), Ozdoganm and Talat Birgonul (2000)	4
S16	Selecting the right project	Askar and Gab-Allah (2002), Tiong et al. (1992), Tiong (1996), Jefferies et al. (2002)	4
S17	Clear project brief and design development	Jamali (2004), Tang et al. (2012), Raisbeck and Tang (2013), Jefferies (2006)	4
S18	Political stability	Mladenovic et al. (2013), Zhang (2005a), Jefferies (2006)	3
S19	Streamline approval process	Liu and Wilkinson (2013), Jefferies et al. (2002), Jefferies (2006)	3
S20	Acceptable level of tariff	Tang et al. (2012), Tiong (1996), Zhang (2005a)	3
S21	Mature and available financial market	Li et al. (2005), Ozdoganm and Talat Birgonul (2000), Jefferies (2006)	3
S22	Suitable environment	Tiong et al. (1992), Jefferies et al. (2002)	2
S23	Reliable service delivery	Tang et al. (2012), Meng et al. (2011)	2
S24	Choosing the right partner	Zhang (2005a), Zhang (2005a)	2
S25	Well organized and committed public agency	Hwang et al. (2013), Li et al. (2005)	2
S26	Sound economic policy	Raisbeck and Tang (2013), Ozdoganm and Talat Birgonul (2000)	2
S27	Clear goals and objectives	Tang et al. (2012), Tang et al. (2012)	2

2.3.3 Discussion of CSFs for TPPPs

Various studies have explored several CSFs crucial to the success of PPP projects. The current study adopted a comprehensive literature review from Osei-Kyei and Chan (2015) and identified 27 CSFs from the relevant articles. These CSFs are crucial for the success of TPPP and DPPP projects. To understand the TPPP characteristics, the success factor list was categorised and discussed by different groups. Following the categorisation of CSFs in PPP projects from Ozdoganm and Talat Birgonul (2000) and Ng et al. (2012), CSFs can be divided into four main groups, namely, financial and commercial, political and legal, technical and social factors. Given the factor meaning used in the current study (see Table 2.7) and comments from experts in the pilot study, the 27 CSFs s were updated and subsequently categorised into five groups (see Figure 2.6): (1) political and legal, (2) technical, (3) financial and economic, (4) stakeholder relationship and (5) social. Two new success factors, namely, state relationship and consistent performance standard, were also added for transnational projects on the basis of experts' suggestion.

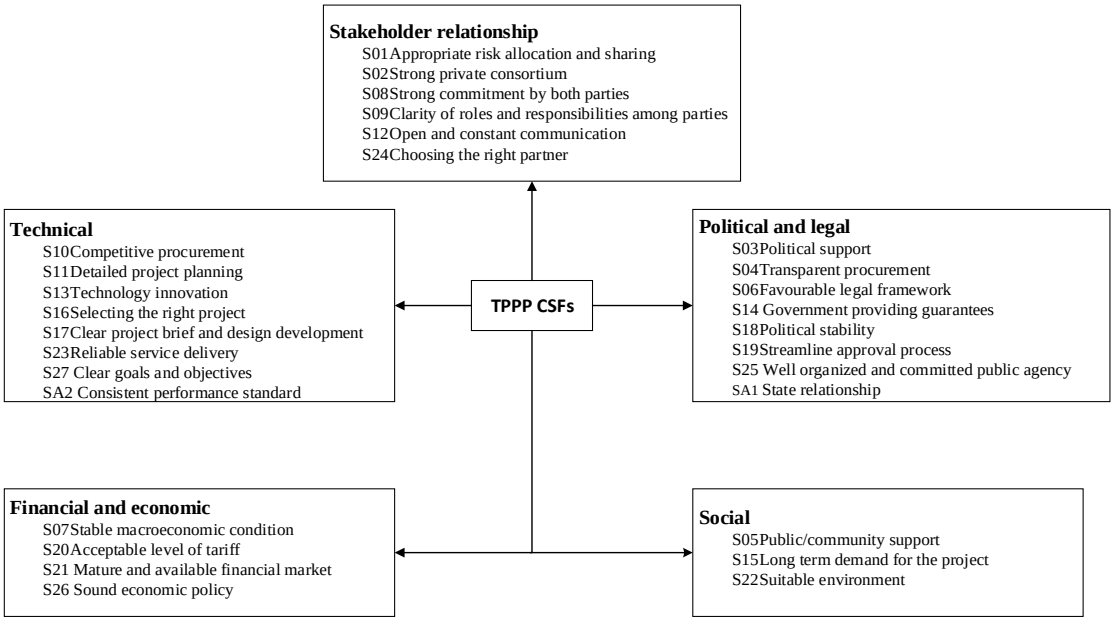


Fig. 2.6 Groups of CSFs in TPPP projects
Ng et al. (2012) and Ozdoganm and Talat Birgonul (2000)

2.3.3.1 Political and legal factors

A legal and political environment is an enabling regulatory and the cornerstone of private sector participation in urban infrastructure services (Bennet et al., 1999). A government will have difficulty in starting a project without political support, whilst the private sector will be concerned with the risk of a project being overturned (Ng et al., 2012). TPPP projects have a close relationship with the political context of the host country (Li et al., 2005). The approval of a TPPP project would not be granted without the necessary political support (Jacobson and Ok Choi, 2008). In transnational cooperation, a positive attitude towards the private sector involved in an infrastructure project would support the growth of PPP, whilst inadequate political support would pose a serious risk (Li et al., 2005). Government guarantee is important in the PPP project implementation, particularly in the early stage of project evolution (Hardcastle et al., 2005). In TPPP projects, investment requires government participation in the form of project guarantees to reduce the risk to

private investors (Brandao and Saraiva, 2008). In a TPPP project, the host country's political stability plays a key role in attracting foreign investors. The success of PPPs depends on stable legal and political environments (Sachs et al., 2007). GIven that the political environment is changeable, Chinese investors should also consider the relationship between the governments of China and the host country. A good state relationship will facilitate the reduction of local market barriers and provide support in the project implementation.

A favourable legal system is a fundamental issue in establishing TPPP projects (Li et al., 2005). The legal system is a basic guarantee for foreign investors to implement TPPP projects safely and efficiently. Transparency limits the bidding process and is observed throughout the entire life cycle of PPP projects (Osei-Kyei and Chan, 2015). The public and private sectors involved in the same TPPP project should be open and transparent in communicating and sharing information with each other. Meanwhile, projects should publicise the necessary information to users and the media for external supervision. The implementation of an infrastructure project is a significant plan for a government and involves many official departments for approval and support. Thereafter, the project constantly takes a long time to obtain the approval certificate. A supportive government can play a facilitating role by accelerating the approval process (Agus, 1989). Except for these CSFs, a well-organised and committed public agency can negotiate on behalf of the public body and manage the project by adopting the essential technical and management ability (Chan et al., 2010a).

2.3.3.2 Financial and economic factors

A stable macroeconomic condition is important for the successful TPPP project

implementation. Governments should adopt economic policies to maintain a stable and growing economic environment (Hardcastle et al., 2005). Given sound economic policies, foreign investors may develop the confidence to operate in a particular market (Li et al., 2005). The ability of an efficient and mature financial market with the benefits of low financing and diversified range of financial products would be an incentive for the private sector to pursue TPPP projects (Cheung et al., 2012b). In the operation stage of a TPPP project, tariff helps to decide whether the main stakeholders can obtain satisfactory benefits. Acceptable tariff and reasonable payment strategies should be explored and finalised in the project plan stage and clearly written in the concession contract. To avoid unexpected issues that could affect tariff and income, renegotiation strategies should also be indicated in the contract.

2.3.3.3 Technical factors

Government and foreign investors should be aware that not all projects are suitable for the PPP model. Government and private sectors agreement over the advantages of PPP should be finalised (Jefferies et al., 2002). Project feasibility must show evidence of viability, whilst VFM is constantly used to test whether a project should adopt the PPP or traditional model. Given the investor's perspective, the most suitable projects should be selected amongst a wide range of countries, markets and potential projects. In TPPP projects, the long-term concession period and complex project stages require a detailed and appropriate project plan and a clear project brief and design development. The project owner should conduct a proper and detailed feasibility study, which would provide sufficiently detailed information to produce an accurate project estimate and proper planning (Abednego and Ogunlana, 2006). The interests and objectives for the different stakeholders involved in TPPP

projects may be different. Each stakeholder should clearly define goals and priorities and negotiate to maximise goals (Ogunlana, 2008).

Fair competition in procurement is critical for the public sector (which is constantly the sponsor) to select the best or most appropriate private sector to b involved in a partnership. Moreover, the procurement process should be competitive, transparent, well organized and effective (Olusola Babatunde et al., 2012). The main output products of the majority of TPPP projects is public service. The service delivered to users should be qualified and reliable. The service standards contain the extent and levels of service required, weightings of service delivery depending on priority, performance assessment criteria, rectification period if service fails and ratchet mechanisms for repeated or widespread failures (Oyedele, 2012). Although international organisations have attempted to improve the consistency in applying infrastructure in different countries or areas, the differences in output performance standards remain a source of potential conflicts in transnational projects. Therefore, a consistent performance standard can decrease the negotiation cost and contribute to success. One important driver in adopting PPP is to maximise the private sectors' advanced technology and management skills. Technology innovation improves the success rate of a project and facilitates industry development.

2.3.3.4 Stakeholder relationship factors

Among the fundamental components of PPP projects are allocating and sharing risks (Jin and Doloi, 2008). Accordingly, risk should be allocated effectively and efficiently. One of the main objectives of the current study is to develop a risk management process, including a risk allocation process. Chapter 4 details the importance of risk allocation in implementing TPPP projects.

When PPPs are created, the partners enter into an agreement with their respective objectives and resources (Forrer et al., 2010). Hence, choosing the correct partner means that the stakeholders agree with their respective project plans and management skills, thereby enabling the public and private sectors to build a good relationship. In the majority of cases, a strong private consortium is more important than seeking a private sector with the lowest cost. Accordingly, the government should take a long-term view in seeking the correct partner for a successful project (Cheung et al., 2012a). Strong commitment from the top is needed to build the capacity for effective contracting because of the complexity and challenges of public contract management (Savas and Savas, 2000). A contract is the best means to appoint these commitments and clarify the rights and responsibilities of both sectors. Cooperation between the public and private sectors is not one-time but lasts for the entire project lifecycle. Therefore, open and constant communication is critical for stakeholders' relationship.

2.3.3.5 Social factors

The long-term demand for the products/services offered by a project decides the real need and potential long-term revenue of such an undertaking. If a project can satisfy the real needs of local residents and provide their favourite products/services, the TPPP projects can easily receive public and community support. Environment and natural resources are also important for TPPP projects. A suitable environment helps control a project's overall cost, safety and quality. If the natural environment is unsuitable, then investors would incur additional costs and technologies to construct the project, thereby increasing the possibility of project failure.

2.4 CTFs FOR TPPP PROJECTS: LITERATURE REVIEW

2.4.1 Introduction of CTFs for TPPPs

Construction projects procured through the PPP approach have a substantial influence on the environment, sustainability development and wellbeing of people. Therefore, sustainability has become essential in project procurement in recent years. Policymakers often expect that sustainability would be offered to local residents, whilst highly sustainable public infrastructure projects will be developed through PPP (USAID, 2010). Sustainability simply implies the duties and obligations of an organisation or an individual for the benefit of society (ISO, 2006). The sustainability concept has become important in PPP projects because many previous projects have failed to offer sufficient social benefits, such as job opportunities, reliable service delivery, environmental health and safety, and affordability; such a failure has resulted in public agitations, political oppositions and frustrations (Tam, 1999; Osei and Chan, 2015a). The majority of previous PPP projects that demonstrated minimal social benefits have either failed or are in distressed states (World Bank, 2015). For TPPP projects, the host country needs long-term sustainable projects that is beneficial to the country's economy, environment and citizens. In this regard, CTFs should be thoroughly reviewed to inform practitioners of the key measures that should be considered when developing an effective sustainability policy/framework.

Sustainability is described as the willingness of an organisation to consider the social and environmental effects of its decisions and activities (ISO, 2006). Moreover, sustainability is a means for an organisation to offer intervention initiatives and programs to society. Sustainability promotes local development and enhances cooperation and relationship between societies and organisations (USAID, 2010). TPPP projects have a substantial impact on the environment, citizens, and

wide scope in society throughout their long life cycle, thereby resulting in the critical role of CTFs in their development. Moreover, an increasing number of project companies have developed enthusiasm to generate sufficient profits (Osei-Kyei et al., 2014). Hence these companies have to exert considerable effort to offer social interventions and promote sustainability measures. In recent years, various types of CTFs have been employed in PPPs and often focused on such areas as health, poverty reduction, education, sanitation and charity work (USAID, 2010).

Furthermore, project companies adopt practical measures, such as sign posts and public awareness programs, to ensure the safety of occupants or users of facilities. Ensuring transparency and ethical behaviours in the TPPP project life cycle is adopted as an SR measure in PPPs (Zeng et al., 2015). Transparency enhances the public's confidence in government officials and improves the positive perception of PPP project arrangements (Osei-Kyei and Chan, 2017). When the conducts of contracting authorities and private partners are consistent with international standards, national laws and industrial policies, the perception of the public on TPPP will be highly affirmative. Such positive perceptions mitigate agitations and demonstrations often observed in PPP arrangements, particularly in developing countries where TPPP projects are implemented (Osei-Kyei and Chan, 2015a).

Generally, project sustainability is fundamentally crucial for sustainable development (Lin et al, 2017), whilst the adoption of the appropriate CTFs is important to the results of TPPP projects. Therefore, in-depth review and analysis of the effective methods should be conducted to enhance sustainability management in TPPPs.

2.4.2 Identification of a CTF list

The process of identifying a CTF list is similar to the methodology of identifying CRFs in TPPPs. However, the detailed review stages will not be provided in this thesis.

Table 2.8 presents CTFs identified from the selected publications. These CTFs are mainly strategies that ensure or improve sustainable development in TPPP projects. The details of the 26 publications with their corresponding numbers are provided in Appendix B. The number of times each factor was mentioned in the literature is also presented (i.e. Table 2.8, last column). A total of 38 CTFs in TPPP projects were identified.

Table 2. 7 Findings from studies on CTFs for TPPP projects

No.	CTFs for TPPP projects	Publications	Total
1	Establish an environment management system	Bossink (2002a), Koppenjan (2015), Pardo-Bosch and Aguado (2016), Patil et al. (2016), Wang et al. (2013), Dohrman and Aiello (1999), Martins et al. (2011), Forsyth (2005), Owen (2013), Takahasi (2004), Salman et al. (2007), Massoud et al. (2003), Couth and Trois (2012)	13
2	Ensure accountability, legitimacy, and transparency	Abramov (2009a), Brereton and Temple (1999), Haughton and McManus (2012), Koppenjan (2015), Lund-Thomsen (2009b), Patil et al. (2016), Dohrman and Aiello (1999), Forsyth (2005), Salman et al. (2007), Wuisan et al. (2012), Zegras and Grillo (2014)	11
3	Innovation	Haughton and McManus (2012), Koppenjan (2015), Lenferink et al. (2013), Patil et al. (2016), Regan et al. (2011b), Wang et al. (2013), Dohrman and Aiello (1999), Martins et al. (2011), Clark II (2007), Salman et al. (2007), Zegras and Grillo (2014)	11
4	Cost reduction	Kyvelou et al. (2011), ,Lenferink et al. (2013), Pardo-Bosch and Aguado (2016), Regan et al. (2011b), Wang et al. (2013), Martins et al. (2011), Owen (2013), Salman et al. (2007), Massoud et al. (2003), Zegras and Grillo (2014)	10
5	Improve resource performance and efficiency	Horsley et al. (2003), Koppenjan (2015), Kyvelou et al. (2011), Lund-Thomsen (2009b), Patil et al. (2016), Regan et al. (2011b), Wang et al. (2013), Massoud et al. (2003), Wuisan et al. (2012), Zegras and Grillo (2014)	10
6	Profitability	Bennett (1998), Haughton and McManus (2012), Koppenjan (2015), Lenferink et al. (2013), Patil et al. (2016), Smyth (2008), Dohrman and Aiello (1999), Martins et al. (2011), Salman et al. (2007), Couth and Trois (2012)	10
7	Establish a waste emission management system	Bossink (2002a), Kyvelou et al. (2011), Lund-Thomsen (2009b), Patil et al. (2016), Regan et al. (2011b), Wang et al. (2013), Forsyth (2005), Massoud et al. (2003), Couth and Trois (2012)	10
8	Keep close partnership between stakeholders	Brereton and Temple (1999), Koppenjan (2015), Kyvelou et al. (2011), Regan et al. (2011b), Smyth (2008), Dohrman and Aiello (1999), Forsyth (2005), Takahasi (2004), Wuisan et al. (2012)	9
9	Improve project quality	Horsley et al. (2003), Kyvelou et al. (2011), Pardo-Bosch and Aguado (2016), Patil et al. (2016), Regan et al. (2011b), Wang et al. (2013), Martins et al. (2011), Massoud et al. (2003), Wuisan et al. (2012)	9
10	Proper contract	Koppenjan (2015), Lenferink et al. (2013), Pardo-Bosch and Aguado (2016), Regan et al. (2011b), Dohrman and Aiello (1999), Martins et al. (2011), Wuisan et al. (2012), Zegras and Grillo (2014)	8
11	Water protection	Bennett (1998), Kyvelou et al. (2011), Lund-Thomsen (2009b), Patil et al. (2016), Regan et al. (2011b), Owen (2013), Clark II (2007)	7
12	Serve community and benefit residents	Abramov (2009a), Brereton and Temple (1999), Haughton and McManus (2012), Lund-Thomsen	6

		(2009b), Regan et al. (2011b), Wang et al. (2013)	
13	Efficient maintenance	Lenferink et al. (2013), Lund-Thomsen (2009b), Patil et al. (2016), Smyth (2008), Massoud et al. (2003)	5
14	Provide jobs	Lund-Thomsen (2009b), Pardo-Bosch and Aguado (2016), Patil et al. (2016), Martins et al. (2011), Couth and Trois (2012)	5
15	Use sustainable design and materials	Bossink (2002a), Wang et al. (2013), Martins et al. (2011), Clark II (2007), Couth and Trois (2012)	5
16	Proper payment	Patil et al. (2016), Dohrman and Aiello (1999), Owen (2013), Salman et al. (2007), Wuisan et al. (2012)	5
17	Improve service standard	Bossink (2002a), Lenferink et al. (2013), Regan et al. (2011b), Wang et al. (2013)	4
18	Ensure projects running on time and budgets	Haughton and McManus (2012), Lenferink et al. (2013), Regan et al. (2011b), Massoud et al. (2003)	4
19	Meet demands and provide great service	Kyvelou et al. (2011), Smyth (2008), Martins et al. (2011), Zegras and Grillo (2014)	4
20	Reduce users cost	Patil et al. (2016), Regan et al. (2011b), Lund-Thomsen (2009b), Patil et al. (2016), Wang et al. (2013), Owen (2013)， Zegras and Grillo (2014)	4
21	Improve climate resilient and air quality	Koppenjan (2015), Patil et al. (2016), Wang et al. (2013)	3
23	Ensure worker health and safety	Lund-Thomsen (2009b), Patil et al. (2016), Wang et al. (2013)	3
24	Improve environmental policy	Bossink (2002a), Koppenjan (2015), Kyvelou et al. (2011)	3
25	Soil protection	Lund-Thomsen (2009b), Patil et al. (2016), Dohrman and Aiello (1999)	3
26	Landfill protection	Dohrman and Aiello (1999), Clark II (2007), Couth and Trois (2012)	3
27	Reduce carbon emissions	Horsley et al. (2003), Koppenjan (2015)	2
28	Protect human rights	Lund-Thomsen (2009b), Patil et al. (2016)	2
29	Effective communication with users	Bossink (2002a), Takahasi (2004)	2
30	Support local business	Brereton and Temple (1999)	1
32	Influence wider market	Horsley et al. (2003)	1
34	Noise prevention	Patil et al. (2016)	1
35	Biodiversity protection	Patil et al. (2016)	1
37	Working altruistically for the public good	Brereton and Temple (1999)	1
38	Promote integrity, honesty, and	Brereton and Temple (1999)	1

	impartiality		
39	Improve local policy	Kyvelou et al. (2011)	1
42	Protect cultural heritage	Patil et al. (2016)	1
43	Appropriate resettling, rehabilitation, and compensation	Patil et al. (2016)	1
45	Forest protection	Clark II (2007)	1

'Establishing an environment management system' is the most reported factor in the literature (i.e. 12 papers, 31.58%), thereby clearly suggesting that environmental sustainability is a crucial component of sustainability management in TPPP projects. 'Ensuring accountability, legitimacy, and transparency' is identified in 11 papers. This finding is expected because transparency and accountability in TPPP arrangements can reduce the negative perception of the public on private sector participation in public service delivery and foster trust and confidence amongst the public and project participants (Osei-Kyei and Chan, 2015a). 'Innovation' is identified in 11 papers. The objectives of PPP are to attract private sector finance and benefit from the advanced technology and innovative initiatives provided by private companies (Osei-Kyei et al, 2014). Innovation is a meaningful strategy for local economic and industrial developments. Through innovative design and construction, private developers and investors can minimise operational costs, thereby ensuring affordability and reducing environmental pollution.

'Cost reduction', 'improving resource performance and efficiency', 'profitability' and 'establishing a waste emission management' are identified in 10 publications. When the costs of PPP projects are reduced, users are likely to pay low tariffs, thereby enhancing the standard of living of people, particularly the low-income earners in society. Additionally, improving resource performance and efficiency is important to ensure the efficient use of limited resources to achieve multifaceted objectives of the PPP project arrangements. However, an appropriate evaluation system is required to ensure the efficient use and performance of resources. Profitability is the basic goal of private investors and achieving such a goal requires a reliable and efficient service delivery. When service providers/investors ensure uninterrupted service delivery, the demand for public facilities/services will

increase, whilst the revenue generation from public facilities/services will also increase. Evidently, the wastes of TPPP projects should be properly managed to avoid pollution and the depletion of the natural environment, thereby resulting in environmental sustainability.

2.4.3 Discussion of CTFs for TPPPs

The identified 38 CTFs are further analysed and categorised into different responsibility dimensions. Three unrelated dimensions are identified on the basis of the general principles of sustainable development. These categories are economic, environmental and community development (see Fig. 2.7) (Shen et al., 2002, Kyvelou et al., 2011, Mostafa and El-Gohary, 2014a, Zhang et al., 2014, Yao et al., 2011, Edum-Fotwe and Price, 2009, Wang et al., 2014, Shen et al., 2011).

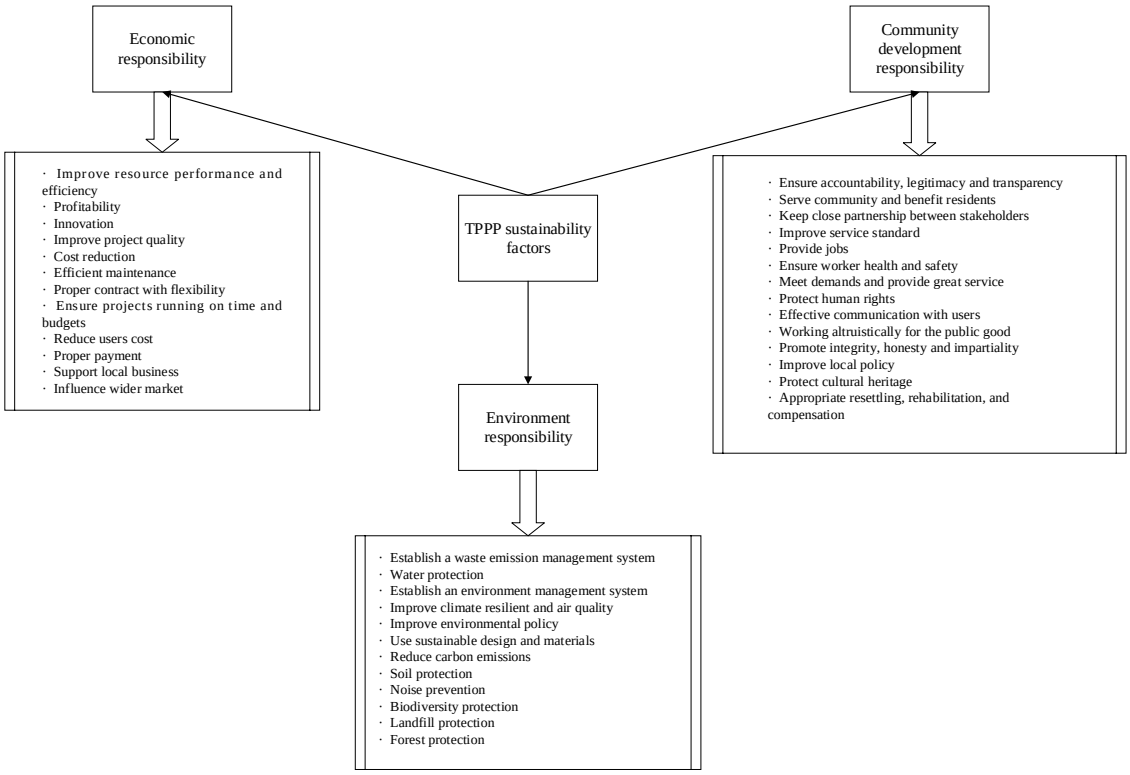


Fig. 2.7 Three categories of TPPP CTFs

As presented in Fig. 2.7, 12 SR factors are grouped under the economic category,

12 factors under the environment category and 14 factors under the community development dimension.

2.4.3.1 Economic category

Although the ultimate goal of PPP projects is to provide additional social benefits, the economic objective of PPPs remains important (Koppenjan, 2014). Unlike traditionally procured projects, TPPP projects should offer significant reduction in government budgetary constraints and provide essential benefits to private investors (Osei-Kyei et al, 2014). Undoubtedly, innovation is crucial to improve resource efficiency and ensure economic performance (Haughton and McManus, 2012, Wang et al., 2014). Koppenjan (2014) and Regan et al. (2011a) contended that innovative designs and creativity can enable project participants to optimise the economic efficiency of TPPP projects. The use of innovative technology in TPPP projects can also completely improve high performance in terms of time, cost and quality (Lenferink et al., 2013).

Project quality affects profitability and sustainability, thereby subsequently influencing the satisfaction of occupants/users (Horsley et al., 2003, Patil et al., 2016, Regan et al., 2011a). In this regard, such measures as quality control and total quality management should be considered to satisfy the required output standards and reduce operation and maintenance costs. Evidently, this condition will increase the benefits for stakeholders and users/occupants toward project service delivery. Resource maintenance and efficiency are critical to maintain long-term integrity and sustainable socio-ecological systems in TPPP arrangements (Patil et al., 2016). High resource efficiency could reduce the cost of maintenance facilitates and enable project parties to earn a reasonable amount of interests. Resource efficiency, such

as using high-quality materials, strict quality control in construction period and timely and efficient maintenance, should be carefully considered throughout a project's life cycle (Wang et al., 2014). These aspect s will facilitate the improvement of the economic efficiency and sustainability of TPPP projects (Lund-Thomsen, 2009a).

Reduction of user fees is an essential CTF in TPPP that benefits local residents. Although construction projects are generally capital intensive, the use of TPPP is expected to minimise the overall cost owing to the sharing of risks and high efficiency of the private sector. In TPPPs, risks are generally allocated to the party with effective mitigation measures (Ke et al, 2010). This allocation facilitates the reduction of costs and user fees and contributes to the affordability of the project service (Kyvelou et al., 2011, Lenferink et al., 2013). Profitability is also a relevant CTF and has direct influence on the economic sustainability of TPPP projects. To achieve profitability, the government should offer some financial incentives, such as tax holidays and tax rebates on imported machinery and equipment. Given these financial policy initiatives, private investors are able to reduce their operational costs and eventually improve profits (Patil et al., 2016). Proper contracting also contributes in ensuring economic performance and sustainability. Particularly, proper contracting entails awarding an appreciable length of concession periods for projects (Osei-Kyei and Chan, 2015a). Concession period should neither be considerably short nor substantially long; this period should be relatively reasonable to enable investors to generate sufficient revenue for paying debts and development costs (Patil et al., 2016). In this regard, a win-win benefit can be achieved through TPPP project arrangements.

Influence on the wide market is a macro-level important CTF. TPPP implementation should exert a considerable positive effect on the investment environment of the project location. Through TPPP project arrangements, local enterprises should expand and actively create additional job opportunities for local residents (Horsley et al., 2003). TPPP projects can influence the business market when additional local participation is employed in their development (Osei-Kyei and Chan, 2015a). This influence will expand local markets (i.e. in terms of materials, skills and equipment) and promote economic sustainability.

Generally, the economic aspect is the baseline for sustainability in TPPP projects. A TPPP project with effective economic CTF strategies can offer high-quality services through innovative design and technology and efficient use of resources at reasonable costs. This strategy will also ensure the effective economic performance of TPPP projects and overall economic development.

2.4.3.2 Environmental category

The environmental category comprises 12 CTFs. These factors seek to enhance the environmental performance of TPPP projects and inform project participants to consider measures that can ensure the health and safety of occupants and the environment when developing TPPPs, thereby improving the sustainable development of the host country.

ISO emphasises the need for construction organisations to develop environmental management systems/policies. These systems and policies will help organisations to adopt the appropriate environmental management measures for projects (Pardo-Bosch and Aguado, 2016), thereby facilitating environment-friendly projects. PPP projects often exert profound negative effects on the ecosystem because of the

large-scale and complex construction involved. Thus, many governments require private investors to provide a comprehensive environmental management system when submitting their bids or proposals (Wang et al., 2014). Although private investors are responsible for developing a comprehensive environmental management system, many local investors in developing countries consistently fail to provide such a plan. This failure occasionally jeopardises the environmental sustainability and performance of projects. Therefore, an efficient method is to integrate environmental management policies into the quality assurance systems of organisations (Bossink, 2002b). Moreover, environmental management systems/policies for TPPP projects have to be open, democratic and fair to harness and incorporate diverse feedback from other project stakeholders (Patil et al., 2016).

Effective waste management initiatives, such as separating wastes into different variants, reusing wastes, preventing waste in the design stage, installing durable waste assortment and creating recycling facilities (Wang et al., 2014), can enhance the environmental performance of TPPP projects (Regan et al., 2011a). Consequently, employing these waste management measures can reduce construction wastes and help preserve the environment for future generations. Solid wastes require careful attention because of the existence of corrosive wastes (Kyvelou et al., 2011). Moreover, toxic materials should be appropriately recycled and disposed of in accordance with internationally accepted practices. In summary, adopting innovative construction practices and internationally accepted standards are appropriate means to ensure effective waste management in TPPPs (Patil et al., 2016).

Water protection is an important aspect of projects' environmental performance.

Prior to the implementation of a TPPP project, the contracting authority should completely assess the impact of the proposed project on any existing or nearby water sources. The private company should present a comprehensive plan to protect existing water pipelines and water sources. Simultaneously, water protection plans must be appropriately communicated to local residents to avoid any public opposition in the future. In recent years, climate quality has become a key objective in many project arrangements owing to the heightened public awareness on climate change (Wang et al., 2014). Private investors should employ advanced design schemes and technologies to improve air quality. For example, CO_2 emission has received considerable attention globally, whilst the reduction of greenhouse gases emission can enhance climate quality (Koppenjan, 2014). Hence, project participants should exert considerable effort to adopt strategies that can minimise the CO_2 emission during the construction and operation of facilities.

The improvement of the local environmental policy is another important environmental CTF that has immense influence on environmental sustainability. The experience related to the environmental performance of previous TPPP projects should be incorporated in the environmental policy development of the area and country of the project location. Such incorporation will enhance the usefulness and comprehensiveness of the local environmental policy and be studied for future project implementation. Although specific TPPP projects need particular environmental management plans, a detailed overall environmental policy could demonstrate the positive attitude of the government towards environmental sustainability and offer the best sustainable practice experience for investors.

2.4.3.3 Social category

CTFs in this category are generally related to justice, staff welfare, industry development and public welfare. This group includes many responsibility factors, which are further classified into four different levels on the basis of their influence and scope. The four levels are (from the microscopic to the macroscopic level) project, industry, community and ethical levels (see Figure 2.8).

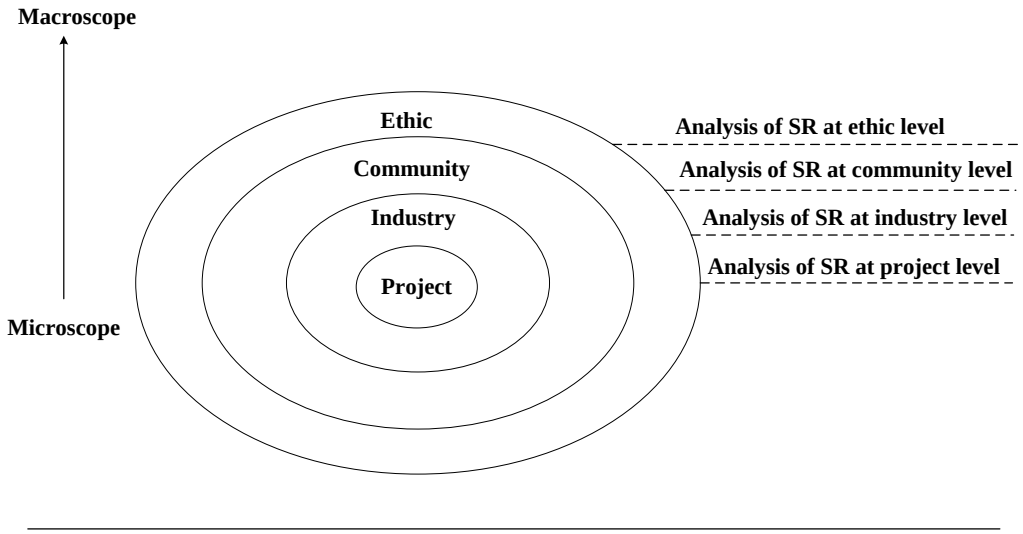


Fig. 2.8 Framework for analysing community development factors (modified from Yi and Chan (2013))

Project Level

Maintaining close partnership amongst stakeholders

Stakeholders in TPPP projects generally include the contracting authority, private investors, suppliers, customers, employees, civil society groups and the local community (Osei-Kyei and Chan, 2015a). A stable and long-lasting relationship is essential to achieve a win-win situation amongst stakeholders. If stakeholders can fairly and sufficiently benefit from TPPP arrangements, then a stable and cordial relationship is easily maintained. Specifically, enduring stakeholder bond, constant communication, balanced needs, trust and openness should be achieved (Brereton and Temple, 1999, Kyvelou et al., 2011). If stakeholders can adequately bond in TPPPs, then the PPP business market can expand because numerous investors will

gain confidence in the investment environment of this project market. Moreover, the confidence of the public in the TPPP concept will be enhanced and strengthened.

Ensuring transparency, anti-corruption and fair competition

Transparency is critical in strengthening the confidence of the public in TPPP arrangements (Haughton and McManus, 2012). For example, when information on contract negotiations and awards is made publicly available, the media can be used as a catalyst to promote transparency in TPPPs. Additionally, press conferences are organised to disseminate the progress of TPPP projects to the public. This action will minimise public agitations and foster confidence in the TPPP system of the project location country (Brereton and Temple, 1999). Fair and open competition in the tendering process is equally critical to achieve VFM (Koppenjan, 2014). Corruption has been identified as a key obstacle to the success of TPPP projects because it causes mistrust between local residents and key project parties (Abramov, 2009b). Therefore, project participants should exert considerable effort to avoid fraudulent acts and practices, particularly at the tendering stage of the TPPP process (Lund-Thomsen, 2009a).

Protecting the wellbeing, health and safety of workers

Job opportunities can be created during the construction and operation periods of TPPP projects (Pardo-Bosch and Aguado, 2016). As such, workers should be provided with good and safe working conditions. The wellbeing of workers should also be a priority for key project stakeholders (Lund-Thomsen, 2009a). Ideally, the key project parties should ensure the availability of a comprehensive wellbeing plan for workers. This plan should cover the benefits and insurance policies for the long-term (e.g. occupational disease) and short-term health (e.g. accidental injury) of

workers. Additionally, the plan should include provisions for health and safety training and allow workers to regularly provide a report on their health issues and status. Project managers should formulate policies to protect the human rights of workers. These policies should make provisions for workers to report any intimidation or racial abuse at the workplace (Patil et al., 2016, Lund-Thomsen, 2009a).

Industry level

Meeting demands and providing quality services

The reduction of government budgetary constraints is not the only prime reason for adopting TPPPs but also for benefiting from the innovative ideas of private investors in developing 'VFM' infrastructure and good quality services for users (Osei-Kyei et al, 2014). Unlike the traditional method, the TPPP concept enables the public to receive reliable and quality public services. TPPP projects should meet the demands and needs of society. Project services should match the expectations of users and improve the livelihood of local residents (Smyth, 2008). Therefore, a thorough and in-depth analysis of needs for the society should be conducted at the inception stage. Moreover, the contracting authority should employ individual private consultants to conduct such feasibility studies.

Improving service standards

Generally, the service standards of TPPP projects can be improved if the contracting authorities provide clear and unambiguous outcomes (Lam and Javed, 2013). Unlike the traditional approach, TPPP arrangements offer output-based standards instead of input specifications. This approach enables private investors to adopt innovative techniques to deliver project objectives. In this regard, public authorities should provide clear outcomes at the negotiation and award stages to enable

investors identify the expected project outcome, thereby improving the service standards of TPPP projects. In situations where outcomes are met, some special incentives, such as bonus points or extension of service delivery, could be provided to investors (Lenferink et al., 2013, Regan et al., 2011a). These incentives will motivate other investors to achieve and even go beyond the expected output requirements of other projects.

Community level

Improving public initiatives

Although TPPPs can minimise the pressure of public sector budget and offer quality infrastructure service delivery, other public intervention initiatives, such as scholarships, staff volunteerism, public awareness programs and charity works, cannot be disregarded (USAID, 2010). Private companies should attempt to provide intervention initiatives. At the inception stage of any project, the project stakeholders should examine the social needs of local residents and attempt to fulfil such needs through a reasonable design stage. Evidently, quality service delivery is not the only societal benefit of TPPP because enhancing other public initiatives and programs can maximise the societal benefits of TPPP arrangements.

Serving the community and benefiting local residents

The meaning of serving the community is loyalty to the community (Brereton and Temple, 1999). However, balancing between making profits and addressing community demands is occasionally difficult. In TPPP arrangements, serving the community can be achieved in a diverse manner. Apart from job creation, social intervention programs and provision of good quality services, local residents and the community should feel part of the project development (Osei-Kyei and Chan, 2015a; Nordensvard et al. 2015). Project stakeholders should ensure continuous

openness, coordination and transparency in their activities to provide the community with a sense of belongingness to the project. This human value is important and crucial in sensitive TPPP projects (Osei-Kyei and Chan, 2015a). Furthermore, conducting a survey on public user satisfaction is an important approach and shows loyalty and commitment to societal needs.

Ethical level

TPPP arrangements should be a win-win outcome, in which all stakeholders, including the community, private investors and public departments, can gain mutual benefits. To achieve this goal, a high level of integrity and concern for others should be considered. For example, when people have to be displaced caused by the construction of a project, they should be adequately compensated or relocated to an appropriate place. Evidently, forcing people to leave their legally acquired properties for the sake of a TPPP project development is certainly unethical. Moreover, at the early stages of TPPP project development, the key project parties should adequately compensate any person who will be negatively affected by the project construction.

2.5 RESEARCH STATUS AND GAP IN KNOWLEDGE

After a comprehensive literature review, the risk, success, and sustainability factors of TPPP projects have been identified. The literature review results show that most PPP related research covers many aspects, such as risk management, key success factors, stakeholder relationship management and performance evaluation. Some scholars have focused on PPP projects and conducted related research, but have not yet formed systematic research results, and most of the scholars who pay attention to this field are from public management and governance perspective. Few studies in project management are specifically targeted at TPPP projects and scholars used

different terms. Some scholars use “transnational” to represent transnational attributes, and some scholars used “International PPP”. “Cross-border PPP” is widely adopted by some international agencies or banks.

From the perspective of the research object: the economic form, legal system, government organization, and social environment are different among countries, the private sector needs to pay special attention to the difference in implementing DPPP projects and TPPP projects. The management of key issues in TPPP project management (eg. risk management, critical success factors, sustainability) requires a more comprehensive and scientific system based on the characteristics of the TPPP project. From the research content: the current PPP research mainly focuses on the fields of risk management and performance management, and the research on the sustainability of PPP projects is still not comprehensive. Most scholars regard “success” or “compliance with performance appraisal standards” as the PPP project results, but ignore the macro social significance and impact of the project. Although scholars have proposed the concept of “project excellence” or “PPP project excellence”, there has not been a systematic study on the “TPPP Project Excellence”.

The current study aims to address this gap by examining CRF, CSF and CTF for TPPP projects. Moreover, this research will use these lists as bases to conduct an empirical study and identify the key issues; build models for risk management, success issues and sustainability index and develop the TPPP project excellence model. The findings may help industry practitioners and policymakers promote the results in TPPP projects.

2.6 CHAPTER SUMMARY

This chapter provides an understanding of the context within this research by

presenting a brief overview of the current situation of TPPP project implementation in B&R countries. Through comprehensive literature reviews, this chapter has revealed many categories of key issues that influence TPPP projects. This chapter reviewed previous studies that have identified critical risk, success and sustainability factors in the implementation of TPPP projects. Accordingly, this chapter identified the gaps in the body of knowledge that the present research aims to address. Chapter 3 presents a detailed introduction of the research methodology adopted to achieve each research objective of this study.

CHAPTER 3 RESEARCH METHODOLOGY[3]

3.1 INTRODUCTION

The impact of methodology on the possible outcomes and contributions of any research cannot be overemphasised. After introducing the background, aim and objectives of this study in Chapter 1 and the comprehensive literature review in Chapter 2, this chapter discusses the methods applied in this research and how they will be combined to ideally serve the purpose of this research. Particularly, the research methods, their strengths and weaknesses and the reasons for their selection are discussed in this chapter. Moreover, this chapter explains in detail the methodology adopted for the current research, which is sectioned into data collection and analysis techniques. The appropriate research methodology should be chosen to ensure that the research objectives are achieved and the research findings are validated (Steele, 2000). Accordingly, selecting and applying rigorous and appropriate research methods enable the construction management (CM) research to achieve meaningful outcomes and contribute significantly to industrial practice and knowledge (Walker, 1997).

Previous studies have applied a wide range of research methods to explore risk management process, critical success factors and sustainability. The popular

[3] This chapter is partially based upon:

Yu, Y., Chan, A. P., Chen, C. & Darko, A. 2017. Critical Risk Factors of Transnational Public–Private Partnership Projects: Literature Review. *Journal of Infrastructure Systems,* 24, 04017042.

Yu, Y., Osei-Kyei, R., Chan, A. P. C., Chen, C., & Martek, I. (2018). Review of social responsibility factors for sustainable development in public–private partnerships. *Sustainable Development,* 26(6), 515-524.

Yu, Y., Darko, A., Chan, A.P., Chen, C. and Bao, F., 2018. Evaluation and Ranking of Risk Factors in Transnational Public–Private Partnerships Projects: Case Study Based on the Intuitionistic Fuzzy Analytic Hierarchy Process. *Journal of Infrastructure Systems,* 24(4), p.04018028.

Chen, C., Yu, Y., Osei-Kyei, R., Chan, A. P. C., & Xu, J. 2019. Developing a Project Sustainability Index for Sustainable Development in Transnational Public Private Partnership Projects. *Sustainable Development.* sd 1954. (Accepted)

research methods include comprehensive literature review, interviews, case studies and questionnaire survey.

The current study used a variety of methods to support different objectives. A structured questionnaire survey was adopted as the main data collection tool to investigate the key issues and their relative weights and the societal attributes (i.e. CRFs, CSFs, CTFs). Data analysis will be performed using the Statistical Package for Social Science (SPSS 21.0 for windows) and other modelling methods (e.g. IFAHP, bargaining theory, FSE). The results are descriptively expressed in mean values, Mann-Whitney U test and other descriptive analyses. IFAHP was used to model and optimise the evaluation process of risk factors through a case study. Bargaining theory was adopted to build an efficient model to allocate risks between the public and private sectors. FSE was used to build the TPPP sustainability index. In the final stage, the PLS-SEM method was used to build the TPPP Project Excellence model to identify the relationship between these issues and project excellence. Details of each method and reasons for adopting these methods are discussed in the succeeding sections.

3.2 RESEARCH METHODS

The choice and application of a particular research methodology are generally dependent on the form of research objectives, questions and settings. Fast rules for selecting research methods do not exist, neither is one best research method that is applicable to all situations (Yin, 2009). Thus, the current study chooses different methods to achieve each objective. Although no fast and hard rules are used for choosing the methods that should be used for a particular research, the adoption of well-known and widely used methods ensures meaningful results; these methods

can also be replicated, reproduced and compared with other studies that have used similar methodologies (Alwaer and Clements-Croome, 2010). However, innovative methods should also be considered to optimise the current process and build a substantially efficient theoretical model. To achieve the research objectives of the current study, Table 3.1 highlights the research methods used to achieve each objective and shows the output of each objective.

Table 3.1 Research objectives and methods for achieving them

Research objectives	Research methods								
	Data collection methods			Data analysis methods					
	Extensive literature	Questionnaire survey	Case study	Mean score ranking	Mean Whitney U test	IFAHP	Bargaining game theory	FSE	PLS-SEM
To identify the critical risk factors (CRFs) and to develop a risk management process model for TPPP projects	√	√	√	√		√	√		
To identify the critical success factors (CSFs) and specific success factors for TPPP projects	√	√		√	√				
To identify the critical sustainability factors (CTFs) and to develop the sustainability index model for TPPP projects	√	√		√				√	
To develop a TPPP project excellence model and to identify the influences of key issues on TPPP project excellence	√								√

3.3 DATA COLLECTION METHODS

3.3.1 Comprehensive literature review

Literature review is a method used to consolidate previous studies and build the foundation of any research (Chow, 2005). A comprehensive review of academic journals, text books, organisation reports, conference papers and doctoral theses was conducted to establish the theoretical background of the current study.

The objectives of the literature review are as follows: (1) understand BRI and the infrastructure situations in B&R countries, (2) review PPP-related studies and define the research gap and research problem, (3) identify a risk factor list for TPPP projects, (4) identify a CSF list for TPPP projects, (4) identify a sustainability factor list for TPPP projects, (5) identify case studies for analyses, (6) develop an instrument for interviews and questionnaire survey and (7) identify a suitable methodology to achieve each objective.

Chapter 3 reviews CRFs, CSFs, and CTFs for TPPP projects. The main aim of this chapter is to provide an understanding of key issues in implementing TPPP projects. These factor lists set the foundation of the questionnaire and builds the factors used in the survey.

3.3.2 Questionnaire survey

In social science research, survey is one of the most popular methods to obtain a representative sample of a study area and serves as one of the most useful strategies to obtain data (Czaja and Blair, 1996). Questionnaire survey and interviews are the two most important methods used to collect data and opinions. A questionnaire is an efficient and cost-effective means to sample many respondents from a wide

range of geographical locations, thereby achievng good outcomes (McQueen and Knussen, 2002). Along with the development of technology, numerous researchers may be found from the Internet and a survey can also be conducted online (Wright, 2005). Questionnaire survey is one of the widely used methods in PPP studies to measure and evaluate the relationship existing in practitioners' perceptions and opinions (Spector, 1994, Osei-Kyei and Chan, 2015). The current study adopted the questionnaire survey approach as the main data collection tool to provide a quantitative description of opinions, attitudes or trends of the entire population through an analysis of a population sample (Creswell and Creswell, 2017). Despite some disadvantages of this method, such as the risk of bias and low response rate, the questionnaire survey offers substantial opportunity for researchers to examine a wide range of issues from several experts (Akadiri, 2011). A quantitative questionnaire has been designed on the bases of lists of factors identified from literature review, case study and pilot study. A questionnaire was used to gather first-hand information to ascertain an overall view of stakeholders on the implementation of TPPP projects in B&R countries. A questionnaire survey was used in this study for the following purposes:

1. evaluate the possibility and severity of CRFs for TPPP projects,
2. examine the importance of CSFs for TPPP projects and compare with DPPP projects,
3. evaluate the importance of CTFs for TPPP projects and
4. Evaluate the influences of key issues on TPPP project excellence.

The results obtained from the questionnaire will be analysed in the following

chapters.

3.3.2.1 Questionnaire structure

For ease of presentation and analysis, the main questionnaire has been divided into five main sections.

Section A: Requests individual and organisational background information of respondents, including the type of organisation, position, years of TPPP working or research experience and number of involved TPPP projects

Section B: Requests the impact of risk factors. This section comprises two dimensions: asking respondents to express their views on the relative probability of risk occurrence and risk severity based on a 5-point Likert scale

Section C: Requests respondents to indicate their level of importance of CSFs when implementing TPPP projects by using a 5-point Likert scales

Section D: Requests respondents to express their opinions on the importance of CTFs when implementing TPPP projects based on a 5-point Likert scale

Section E: Requests respondents to express their agreements on the statements of TPPP project excellence

Blank spaces are provided for the respondents to add any new factors that are not listed in the original questionnaire. This step ensures that all relevant issues are captured by the questionnaire survey.

3.3.2.2 Rating scales

In construction management research, researchers have used different types of rating/ranking scales, such as 5-, 7-, 9- and 11-point rating scales, to solicit the

opinions of respondents in assessing various variables and issues. In the current study, a 5-point Likert scale was adopted on the basis of similar studies (Osei-Kyei, 2017, Cheung et al., 2012b, Ke et al., 2010b). Table 3.2 shows the rating scales for variables in the survey questionnaire.

Table 3.2 Definition of rating scores (modified from Ameyaw (2014))

Rating core	**CRFs**		**CSFs**	**CTFs**	**Excellence**
	Occurrence possibility	Severity	Importance	Importance	Opinion
1	Extremely low	Extremely low	Least important	Least important	Extremely disagree
2	Low	Low	Unimportant	Unimportant	Disagree
3	Medium	Medium	Medium	Medium	Neutral
4	High	High	Important	Important	Agree
5	Extremely high	Extremely high	Extremely important	Extremely important	Extremely agree

3.3.2.3 Pilot study

After developing the initial questionnaire, the output should be tested (i.e. pre-test or pilot study) to show whether the research or methodology is rigorous for a survey (Munn and Drever, 1990).

A pilot study was conducted to examine the comprehensiveness and reliance of the questionnaire for the study before delivering to experts. The questionnaire was emailed to six experts, who were selected because of their knowledge and experience in the PPP research area. They were invited to evaluate the appropriateness of the questionnaire, including the clarity of description, wording, technical terms, structure, length and complexity (Oyedele, 2010). Given the availability of the experts, willingness to respond to the survey and difficulties involved in eliciting global feedbacks, four returned pilot questionnaires were

considered sufficient to vet the coherence, relevance and comprehensiveness of the questionnaire. The four experts are two professors, one senior lecturer and an industry expert who has experience in PPP area. All experts are from China and have TPPP knowledge, thereby ensuring that the questionnaire fit into the B&R TPPP context as well.

The questionnaire was revised on the basis of the four experts' feedback to improve the suitability for the main survey. For example, the experts' feedback seemed to suggest reducing the length of the questionnaire. The final form of the questionnaire was the result of implementing the suggested changes.

3.2.2.4 Sampling

Samling is necessary for any research because of cost and time constraints (Babbie, 1990). The current study considered projects managers, engineers, officials and researchers from three main sectors (i.e. government, private sector and academe) with knowledge of and experience in the implementation of TPPP projects in B&R countries. However, only a few cases are available because the B&R PPP market is in the infancy stage. Thus, selecting experts from specific TPPP projects by using a random sampling approach is impossible. Therefore, non-probability sampling is the ideal approach to obtain a representative sample (Patton, 2001). By using this sampling method, respondents cannot be selected randomly but are invited on the basis of their experience and willingness to participate in the current study (Wilkins, 2011). To select suitable experts who have adequate knowledge and expertise to respond to this survey, two main non-probability sampling approaches, namely, purposive and snowball, were adopted (Zhang et al., 2011, Cao et al., 2014).

A variety of methods were used by adopting purposive sampling, such as requesting

information from relative organisations or association. (i.e. China Public Private Partnership Centre, China International Contractors Association) and searching through the Internet and related publications. After identifying a list of targeted respondents, official invitation letters to participate in the survey were sent via numerous channels, such as email, social media (i.e. WhatsApp, WeChat) and the CNBR Yahoo group. The questionnaires were sent by attachment in email and online questionnaire link (English version by Survey Monkey and Chinese version by Questionnaire Star) for respondents to choose their preferred format. Each approach has its own advantages. Email-based survey facilitates easy access to numerous expert respondents and saves money and time but personal visits addresses potential problems, such as clarity of questions (Cooper et al., 2006). Another efficient method to deliver the questionnaire is snowball sampling. The initially identified experts were asked to share the questionnaire to other potential respondents (Moglia et al., 2009). Thereafter, the potential respondents recommended by their fellow practitioners were invited to participate in the research. The two important criteria for the selection of respondents are as follows:

1. Have in-depth knowledge of the general practice of PPP and should have followed closely the development of PPP in B&R counties and

2. Have extensive direct hands-on or research experience in TPPP projects.

The selection of participants also considered their accessibility and willingness to respond to the survey. To guarantee the credibility and reliability of the respondents, only practitioners fulfilling the aforementioned criteria will be invited to participate in the survey.

3.2.2.5 Questionnaire delivery process

The general perceptions of the expert respondents were gathered to identify the perceived important or critical issues concerning TPPP implementation in B&R countries. These factor lists originally identified from the literature review were revised and finalised on the basis of comments from the pilot study. The questionnaire survey was scheduled between December 2016 and August 2017. Expert respondents were invited to complete the questionnaire by expressing their views to provide a reflection of how they perceive the possibility and severity of CRFs and importance of CSFs and CTFs to implement TPPP, as well as provide their statement of agreement to assess TPPP project excellence. In the questionnaire, the experts were invited to add any new factors. To handle the difficulties of carrying out surveys, a variety of methods were used to collect the responses (e.g. email, online survey system, self-administration or personal visits), depending on the preference and location of a respondent.

During the questionnaire survey, the following steps were taken as incentives to encourage participation or good response and minimise the attrition rate.

The questionnaire is accompanied by a signed cover letter with the letterhead of the institution sponsoring this research.

1. Written communications with the selected experts will be kept clear, free from any ambiguity and simple. This style potentially ensures low attrition rates and good response (Somerville, 2007).

2. The questionnaire has been designed to be straightforward and simple to achieve a high response rate (Hallowell and Gambatese, 2009).

3. Experts who show considerable interest in this research will be kept as

regular contacts and updated on the study's progress. Their views on other important areas will also be sought through informal means.

4. Given the busy schedules of the experts, a four-week period deadline was given to them to complete the questionnaire (Delbecq et al., 1975).

5. A pilot study was conducted with experts to assess the appropriateness of the questionnaire before the form was distributed.

6. The questionnaire indicated that a summary of the findings can be shared with the expert who has interest in the study (Li and Zou, 2011).

3.3.3 Case study

Case study is a method that can provide an in-depth understanding of a phenomenon using a variety of data sources (Baxter and Jack, 2008). In evaluative situations, case studies are commonly used to document and analyse implementation processes (Yin, 2011). Moreover, using a case study is appropriate in a unique situation or has not earlier been the subject of detailed scientific investigation (Jefferies, 2006). Case study analyses were adopted in the current research for the following objectives:

1. understand IFAHP in evaluating the risk factors of TPPP projects and

2. Comprehend the process of adopting bargaining game theory (BGT) in risk allocation for TPPP projects.

3.4 DATA ANALYSIS METHODS

3.4.1 Kendall's coefficient of concordance (W)

Given that different participants have contributed to the current study, the degree of

consensus on the survey in each respondent group should be determined. Accordingly, Kendall's W will be used to determine the presence of consensus amongst the within-group ratings and the relative strength of the consensus (Schmidt, 1997). This method has been applied in many similar studies because of the simplicity of interpretation and application (Cheung and Chan, 2010, Ke et al., 2011b). Kendall's W ranges from 0 to 1, where 0 indicates no agreement and 1 indicates perfect concordance or agreement. With the respondents' ratings, W can be computed using the following formula (Siegel and Castellan):

$$\mathrm{w} = 12\sum \frac{R_i^2 - 3k^2N(N+1)^2}{k^2N(N^2-1) - k\sum T_j}, \qquad (3.1)$$

where $\sum R_i^2$ is the summation of the squared sum of the ranks for the individual ranked N factors; k is the total number of respondents or rankings; T_j is the factor for correction needed for the *j*th set of ranks for the tied ranks, which is defined as $T_j = \sum_{i=1}^{gj}(t_i^3 - t_i)$, where *gj*= number of groups of ties in the *j*th set of ranks and t_i is the number of tied ranks in the *i*th grouping of ties.

3.4.2 Mean score ranking

Mean score ranking has gained grounds in similar studies as a typical methodology used to investigate the relative significance of individual factors, thereby enabling the easy identification of the key factors. Tang et al. (2012) used the mean score to rank the critical factors in PPP briefings, including procurement-, stakeholder-, risk-, and finance-related factors. Shrestha et al. (2017) also used the mean score to test the risk significance of PPP water projects in China. The mean scores are calculated using the following formula:

$$\text{Mean Score} = \frac{1n_1+2n_2+3n_3+4n_4+5n_5}{N}, \quad (3.2)$$

where n is the respondents' scores based on a 5-point scale (i.e. from 1 to 5) and N is the total number of expert respondents. The mean score ranking was used to perform the preliminary test for evaluating the significance of each factor list. This simple and direct method shows the perspectives of respondents.

3.4.3 Mann Whitney U statistics

An interesting aspect is comparing key issues for TPPP and DPPP because of the differing environments where they belong. The Mann–Whitney U test was conducted to determine the significant differences in the rankings of success factors by the respondents for the TPPP and DPPP projects. The results would be helpful to identify the specific CSFs in TPPP projects. The Mann–Whitney U test is a non-parametric test used to study the association of ordinal (rank order) data with two independent samples. This test tool is considered appropriate for the current study because of the unequal sample sizes of the two independent groups. To use this method, the data set does not need to follow any distribution pattern. The predefined significance level is 0.05. A factor with significant test value below 0.05 means a significant difference in the perception of the TPPP and DPPP projects (Sheskin, 2003).

3.4.4 Intuitionistic Fuzzy Analytic Hierarchy Process

IFAHP is an extended method developed by the classic and fuzzy AHP to solve comprehensive multi-criteria decision-making problems (Xu and Liao, 2014). This method shows definite advantages in handling vagueness and uncertainty over a fuzzy set. By using this method to evaluate risk, the participating experts used intuitionistic fuzzy sets to evaluate the occurrence possibility and severity of each

risk factor in the AHP matrix. To show the process of this method, a case study adopting this method will be discussed in Chapter 4. The ranking of the risk factor list is produced on the basis of this method, thereby enabling practitioners gain an improved understanding of the key risks and prepare for the possible risks in TPPP projects.

AHP is a useful theory of relative measurement in the form of pairwise comparisons by decomposing a complex problem into simple and multilevel hierarchical structures. AHP can incorporate tangible and intangible judgement criteria in a decision problem and analyse/model them on the basis of the formalisation of experts' knowledge and experience (Saaty, 1988). Traditional AHP is unable to handle the inherent uncertainty and vagueness in human judgements (Xu and Liao, 2014). To overcome this limitation of the traditional AHP, fuzzy set theory (FST) has been proposed as a viable method that could allow decision makers to use unquantifiable and non-obtainable information and partially ignorant facts to make sound decisions (Kulak et al., 2005). The approach of combining FST and AHP is known as FAHP. Van Laarhoven and Pedrycz (1983) first studied FAHP and used triangular membership to describe fuzzy weights and fuzzy performance scores to rank alternatives. Buckley (1985) complemented the traditional AHP with fuzzy utilities by using fuzzy numbers in the comparison process. Chang (1996) introduced a new method to derive priorities for comparison ratios by triangular fuzzy numbers, which was adopted in many areas, such as transportation management (Kulak and Kahraman, 2005) and safety management (Dağdeviren and Yüksel, 2008).

Intuitionistic fuzzy set (IFS) is extended by the fuzzy set and characterised by

membership, non-membership and hesitancy functions (Atnassov, 1999, Atanassov and Gargov, 1989). When decision makers make decisions, they may not clearly indicate the extent to which one alternative is better than others (Herrera-Viedma et al., 2007). Alternatively, they are unable to express their preferences accurately because of the lack of sufficient knowledge of the alternatives (Mitchell, 2004). Decision makers may be uncertain in providing preferences between the alternatives and providing an accurate certain preference degree (Deschrijver and Kerre, 2003). IFS is a useful method to solve this problem and has become popular in a broad range of areas, such as decision-making (Bing et al., 2005, Herrera-Viedma et al., 2007, Xu, 2007, Atanassov et al., 2005), medical diagnosis (De et al., 2001), fuzzy cognitive maps (Papageorgiou and Iakovidis, 2013) and fuzzy hardware (Zavala and Nieto, 2012).

IFAHP is an extended form of FAHP that combines the advantages of AHP and IFS. IFAHP can be used to solve complex problems, in which decision makers may be uncertain in providing preference values of the alternatives (Xu and Liao, 2014). Table 3.3 summarises some applications of the IFAHP method in different fields. Moreover, Table 3.3 shows the extensive application of the IFAHP method and its versatility in modelling and decision-making processes in practical and complex multicriteria problems. Sadiq and Tesfamariam (2009) adopted the IFAHP method in environmental decision-making under uncertainty. Kaur (2014) applied IFAHP in solving the vendor selection problem.

In the PPP industry, risk evaluation is confronted with challenges, such as a shortage of data. In such cases, subjective estimations were made by experts with practical knowledge in their respective fields of interest. In some situations, decision makers

may be reluctant or unable to assign the crisp evaluation values to the comparative judgements because of their limited knowledge. IFAHP is a useful method to handle the subjective preferences of experts in assigning the evaluation values to the risk evaluation (Nguyen, 2016). Therefore, IFAHP was applied in the current study to handle the vagueness and ambiguity related to uncertainties in the risk factor evaluation and ranking in TPPP projects.

Table 3.3 Selected previous studies on the application of the IFAHP method

Study	Specific area of application	Summary of application
Sadiq and Tesfamariam (2009)	Environmental decision making	The IFAHP method was applied to an illustrative example to select best drilling fluid (mud) for drilling operations under multiple environmental criteria.
Kaur (2014)	Selection of Vendor	A triangular intuitionistic fuzzy number-based approach was proposed for the vendor selection problem using analytical hierarchy process.
Rajaprakash and Ponnusamy (2015)	Ranking business scorecard factor	The IFAHP method was used with Fuzzy Delphi to analyze the uncertainty factors in business scorecard and explore the importance ranking of various factors.
Rajaprakash and Ponnusamy (2016)	Determining the balance scorecard sheet metal industry	The IFAHP method was applied with Fuzzy Delphi to rank the factors in the balance scorecard and identify which area has to be given higher priority in the Balance Scorecard.
Nguyen (2016)	Ship system risk estimation	The IFAHP was used to estimate the propulsion risk of container carriers operating on the North Atlantic Line.

3.4.5 Bargaining Game Theory

BGT has a long history of research (Muthoo, 1999, Nash Jr, 1950, Peters, 1986). Bargaining theory deals with situations in which people interact rationally with one another and assume that an individual's action depends on what other individuals may do.

Bargaining theory provides a systematic, conceptual and analytical framework in the construction field. Kang et al. (2013) presented a transformed first-price sealed bid auction with independent private values to determine equilibrium royalties and subsidies in PPP. Shen et al. (2007) established a new method called BOT bargaining concession model to enable the identification of a specific concession period, which considers the bargaining behaviour of the two parties concerned in a BOT contract (i.e. investor and government concerned).

Bargaining theory was used in the current study in the risk allocation procedure for TPPP projects. The two players' (i.e. public and foreign private sectors) trade-off was between risk and revenue and bargain for the ratio of risk allocation. Each player expects a reasonable share of risk allocation. When one player makes an offer in each bargaining round, their counterpart will accept or reject the offer. An equilibrium result exists when two players reach an agreement in the bargaining process. The detailed process is discussed in Chapter 4.

3.4.6 Fuzzy synthetic evaluation

Fuzzy synthetic evaluation (FSE) is a branch of FST. FST is designed to supplement the interpretation of linguistic or measured uncertainties for random phenomena. The main method involved in a large-scale complex decision-making process could be properly described by fuzzy membership functions (Chang et al., 2001). Assessment of project sustainability is a task shrouded with imprecision and uncertainty because some measurement factors depend on subjective perception. FSE can be used to represent experiential knowledge of practitioners from a non-normal distribution (Lam et al., 2007). By using FSE, the uncertainty and the participants' perceived influence on the criticality of KSPI could be reduced (Gan

et al., 2017). In the current study, FSE will be used to build the TPPP sustainability index. The detailed process will be discussed in Chapter 6.

3.4.7 Modelling: PLS-SEM method

SEM is a versatile multivariate statistical analysis method capable of simultaneously examining the relationships amongst variables in a theoretical model (Eybpoosh et al., 2011). To test the complete concepts and theories, SEM has become a popular and indispensable statistical analysis technique in CM research (Xiong et al., 2015). SEM has been successfully used because of its ability to examine cause–effect relationships amongst latent variables and assess the measurement of the latent variables (Babin et al., 2008). The two main types of SEM are PLS-SEM and covariance-based SEM (CB-SEM). This study adopts the PLS-SEM because of the following reasons.

PLS-SEM was originally introduced by Wold (1974) and has some advantages over CB-SEM. Hence, PLS-SEM has become considerably successful and frequently used in a variety of disciplines. F. Hair Jr et al. (2014) found that the most prominent justifications by researchers applying PLS-SEM are small sample sizes, data distribution (i.e. non-normally distributed data) and use of formative indicators (Ringle et al., 2012). In the current study, the anticipated small sample size had a major influence on the decision to use PLS-SEM. The method is better suited for small sample sizes that may be problematic for CB-SEM to handle (Henseler, 2010), even when highly complicated models are involved. In recent years, PLS-SEM has been widely accepted in CM research (Cao et al., 2014, Mohamed, 2002, Zhao et al., 2014). PLS-SEM analysis is also adopted because of the ease of identifying key driving variables. This technique amalgamates regression and path and principal

component analyses to simultaneously evaluate data and theory. The two types of variables involved in PLS-SEM are the latent and observed variables. Observed variables can be directly measured, whereas latent variables are theoretical or hypothetical constructs inferred from the former. PLS-SEM is a multi-stage process that involve three salient steps: (1) model specification, (2) evaluation of the inner model and (3) evaluation of the outer model. F. Hair Jr et al. (2014) (Hair Jr et al., 2016) provided detailed insights into these PLS-SEM steps.

The current study applied PLS-SEM to model the influences of various types of risk, success and sustainability factors on TPPP project excellence. The research hypotheses and models are developed and presented in Chapter 7.

3.5 CHAPTER SUMMARY

This chapter discussed the research methodology of the current study. The specific methods were described and reasons why these methods are suitable for that research objective were explained. This chapter first discussed the research process of the entire study and the data analysis methods. Particularly, this chapter described how these methods will be combined to achieve the aims and objectives of this study.

CHAPTER 4 RISK MANAGEMENT PROCESS FOR TPPP PROJECTS[4]

4.1 INTRODUCTION

The previous chapters introduced this study, reviewed the relevant literature and described the research methodology. The present chapter uses two different methods to solve the risk evaluation and allocation problems in TPPP projects. This chapter's objectives are to provide clear and efficient risk evaluation and allocation process. After introducing the risk process step by step, a case study is adopted to show how to use the method.

4.2 RISK EVALUATION FOR TPPP PROJECTS

4.2.1 Risk evaluation problem for TPPP projects

Risk management in PPPs has attracted considerable attention from scholars and practitioners because of the long period and complex stakeholder relationships involved in PPP contracts. However, the lack of systematic risk assessment and management frameworks has been one of the critical reasons for the failure of PPP projects (Li and Zou, 2011).

TPPP has been adopted in various industries, such as transportation, water and power plants. For example, a foreign-owned company from France invested in the Laibin B Power Plant, which is the first BOT project in China. Another project in

[4] This chapter is largely based upon:
Yu, Y., Chan, A. P., Chen, C. & Darko, A. 2017. Critical Risk Factors of Transnational Public–Private Partnership Projects: Literature Review. *Journal of Infrastructure Systems,* 24, 04017042.
Yu, Y., Darko, A., Chan, A.P., Chen, C. and Bao, F., 2018. Evaluation and Ranking of Risk Factors in Transnational Public–Private Partnerships Projects: Case Study Based on the Intuitionistic Fuzzy Analytic Hierarchy Process. *Journal of Infrastructure Systems,* 24(4), p.04018028.

the Caribbean Island of Aruba called 'The Green Corridor' has its main goals to include creating interests and promoting networks and consortiums for local and international parties (Aruba, 2011). In such projects, the host governments play important roles in selecting suitable private sectors, accepting the responsibility to create an attractive investment climate and properly preparing projects to stimulate interest from private companies (Wibowo and Alfen, 2015).

Over the years, studies have been conducted to understand and highlight the risk factors in domestic PPP projects. However, only limited scholarly attention has been directed toward the need to analyse the risk factors in TPPP projects (Schäferhoff 2009). The successful management of TPPP projects entails an evaluation of the impact of their potential risks. The objective of this section is to propose IFAHP as a risk assessment framework to stimulate the vagueness of expert judgement and improve the assessment accuracy. By using this method, participating experts used IFS to evaluate the occurrence possibility and severity of each risk factor in the AHP matrix. The findings of this section facilitate an improved understanding of the key risks in TPPP projects. Consequently, practitioners, stakeholders and policymakers could adequately prepare for the possible risks to be encountered in their TPPP projects.

4.2.2 IFAHP adopted in risk evaluation

4.2.2.1 IFAHP framework used in risk evaluation

This research was conducted systematically by using IFAHP (see Fig. 4.1 for the process). In stage 1, literature review was used to identify the risk factors. In stage 2, the risk factor list was revised and categorised. In stage 3, a questionnaire was used to collect data from experts who have experiences in and knowledge in TPPP

projects. The experts were asked to assess each factor on the basis of the two dimensions of probability and severity and use IFS to provide their preferences for the alternatives. In stage 4, an evaluation index system was set up for the risk factor probability and severity. In stage 5, the consistency index was checked and adjusted. In stage 6, the weighting functions were calculated and integrated. The risk factor impact could be calculated using the multiplication formula based on the grade of possibility and severity.

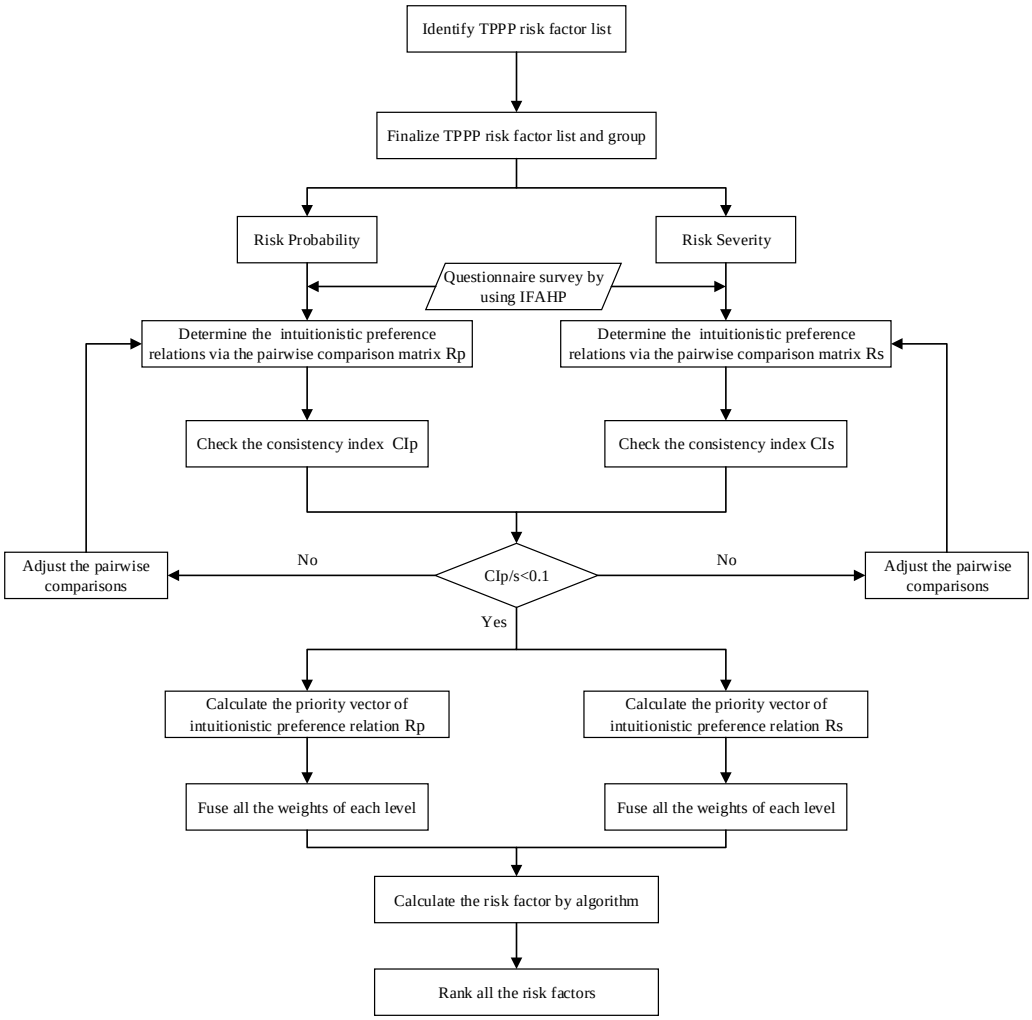


Fig. 4.1 Process of adopting IFAHP in ranking risk factors in TPPP projects (Adapted from Xu and Liao (2014))

4.2.2.2 IFAHP framework used in risk evaluation

Before conducting the IFAHP process used in the risk evaluation process, the risk factor list was formed on the basis of comprehensive literature review (see Chapter

2).

Step 1: Set up the evaluation index system

To develop the IFAHP method, the risk factor evaluation is provided. The four first grade indexes $(A_j, j = 1,2,3,4)$ are financial/commercial (A_1), legal and socio-political (A_2), technical and natural (A_3) and partnership risk categories (A_4). Two performance criteria, namely, possibility (C_1) and severity (C_2), were used to evaluate all alternatives and rank these risk factors.

Step 2: Build the intuitionistic fuzzy judgment matrix

Intuitionistic fuzzy judge matrix is generated using pairwise comparisons. All pairwise comparison judgements are represented by intuitionistic fuzzy values (IFVs). The intuitionistic preference relation can be obtained naturally. Xu (2007) defined the intuitionistic preference relation R on the set $X = \{x_1, x_2, \dots, x_n\}$, which is presented by matrix $R = (r_{ij})_{n\times n}$, where, $r_{ij} = (\mu_{ij}, \upsilon_{ij})$. In this definition, μ_{ij} is the degree that the alternative x_i is preferred to the alternative x_j and υ_{ij} denotes the degree to which the object x_i is not preferred to x_j. $\pi_{ij} = 1 - \mu_{ij} - \upsilon_{ij}$, which is interpreted as a hesitancy degree, with the following condition:

$$\mu_{ij}, \upsilon_{ij} \in [0,1],\ \mu_{ij} + \upsilon_{ij} \leq 1, \mu_{ij} = \upsilon_{ji}, \mu_{ji} = \upsilon_{ij}$$

$$\mu_{ii} = \upsilon_{jj} = 0.5, \pi_{ij} = 1 - \mu_{ij} - \upsilon_{ij}$$

for all $i, j = 1,2,\cdots, n$.

The current study used two dimensions, namely, occurrence possibility and severity, to evaluate the risk impact. The comparison matrix was adopted twice to measure

the possibility and severity. In this round of occurrence possibility survey, each expert has to provide the evaluation of possibility in five comparative matrixes for the first level of risk categories, financial/commercial (A_1), legal and socio-political (A_2), technical and natural (A_3) and partnership (A_4). Evidently, measuring severity follows a similar method.

After all the experts have provided their evaluation matrixes, each matrix was adopted into the consistency checking. Thereafter, the arithmetic average of each participants' score is the final matrix.

Step 3: Consistency checking

In the pairwise comparisons, consistency checking cannot be disregarded because the inconsistency of preference relations may result in misleading solutions. Each original matrix provided by the participants in the questionnaire survey has to be checked for consistency. Saaty (1988) provided a methodology to check the consistency for the conventional AHP. However, if the preference relation lacks consistency, evaluators have to re-evaluate the preferences. The reason is that this method cannot repair or improve the inconsistent preferences by calculating the original data. Kwong and Bai (2003) and Chan and Kumar (2007) used a similar method to check the consistency in the fuzzy AHP. The current study used another method to check the consistency of the preference relations in IFAHP, which originated from Xu and Liao (2014). This approach has the advantage of checking the consistency of an intuitionistic preference relation and repairing and improving the output until consistency is achieved. The consistency checking formula is as follows:

$$d(\overline{R}, R) = \frac{1}{2(n-1)(n-2)} \sum_{i=1}^{n} \sum_{j=1}^{n} \left(\left| \overline{\mu}_{ij} - u_{ij} \right| + \left| \overline{\nu}_{ij} - \nu_{ij} \right| + \left| \overline{\pi}_{ij} - \pi_{ij} \right| \right) \quad , \tag{4.1}$$

where $d(\overline{R}, R)$ is the distance between the given intuitionistic preference relation R and its corresponding perfect multiplicative consistent intuitionistic preference relation $\overline{R}$.

For $j > i + 1$, let $\bar{R} = (\bar{\mu}_{ij}, \bar{\nu}_{ij})$, where

$$\overline{\mu}_{ij} = \frac{\sqrt[j-i-1]{\prod_{t=i+1}^{j-1} \mu_{it}\mu_{tj}}}{\sqrt[j-i-1]{\prod_{t=i+1}^{j-1} \mu_{it}\mu_{tj}} + \sqrt[j-i-1]{\prod_{t=i+1}^{j-1} (1-\mu_{it})(1-\mu_{tj})}}, \quad j > i + 1 \tag{4.2}$$

$$\bar{\nu}_{ij} = \frac{\sqrt[j-i-1]{\prod_{t=i+1}^{j-1} \nu_{it}\nu_{tj}}}{\sqrt[j-i-1]{\prod_{t=i+1}^{j-1} \nu_{it}\nu_{tj}} + \sqrt[j-i-1]{\prod_{t=i+1}^{j-1} (1-\nu_{it})(1-\nu_{tj})}}, \quad j > i + 1 \tag{4.3}$$

R is an acceptable multiplicative consistent intuitionistic preference relation if $d(\overline{R}, R) < \tau$, where

τ is the consistency threshold and generally $\tau = 0.1$.

If $d(\overline{R}, R)$ is considerably high, then the transformed intuitionistic preference relation $\overline{R}$ cannot represent the initial preferences of the decision maker. The two requirements of the modified intuitionistic preference relation R are passing acceptable multiplicative consistency and maintaining original preference information from the survey participants.

$$\tilde{\mu}_{ij} = \frac{(\mu_{ij})^{1-\sigma} (\overline{\mu}_{ij})^{\sigma}}{(\mu_{ij})^{1-\sigma} (\overline{\mu}_{ij})^{\sigma} + (1-\mu_{ij})^{1-\sigma} (1-\overline{\mu}_{ij})^{\sigma}}, i, j = 1,2, \cdots, n \tag{4.4}$$

$$\tilde{v}_{ij} = \frac{(v_{ij})^{1-\sigma}(\overline{v}_{ij})^{\sigma}}{(v_{ij})^{1-\sigma}(\overline{v}_{ij})^{\sigma}+(1-v_{ij})^{1-\sigma}(1-\overline{v}_{ij})^{\sigma}}, i,j = 1,2,\cdots,n \quad (4.5)$$

where σ is a controlling parameter, which means that the relation between $\tilde{R}$ and R are decided by the participants who provided the original preference relation matrixes. The lower the σ value, the closer the distance between $\tilde{R}$ are R. Particularly, when $\sigma = 0$, $\tilde{R} = R$; when $\sigma = 1$, $\bar{R} = R$.

The preceding analysis indicates that an automatic algorithm to repair the inconsistent intuitionistic preference relation can be developed.

$$d\left(\overline{R}, R^{(p)}\right) = \frac{1}{2(n-1)(n-2)}\sum_{i=1}^{n}\sum_{j=1}^{n}\left(\left|\overline{\mu}_{ij} - u_{ij}{}^{(p)}\right| + \left|\overline{v}_{ij} - v_{ij}{}^{(p)}\right| + \left|\overline{\pi}_{ij} - \pi_{ij}{}^{(p)}\right|\right), \quad (4.6)$$

where p is the number of iterations. Let $p = 1$. Construct the perfect multiplicative consistent intuitionistic preference $\overline{R}$ and $R^{(p)}$. Thereafter, calculate the distance $d\left(\overline{R}, R^{(p)}\right)$ between $\overline{R}$ and $R^{(p)}$ using formula (6).

$$\tilde{\mu}_{ij}^{(p)} = \frac{\left(\tilde{\mu}_{ij}^{(p)}\right)^{1-\sigma}(\overline{\mu}_{ij})^{\sigma}}{\left(\tilde{\mu}_{ij}^{(p)}\right)^{1-\sigma}(\overline{\mu}_{ij})^{\sigma}+\left(1-\tilde{\mu}_{ij}^{(p)}\right)^{1-\sigma}(1-\overline{\mu}_{ij})^{\sigma}}, i,j = 1,2,\cdots,n \quad (4.7)$$

$$\tilde{v}_{ij}^{(p)} = \frac{\left(\tilde{v}_{ij}^{(p)}\right)^{1-\sigma}(\overline{v}_{ij})^{\sigma}}{\left(\tilde{v}_{ij}^{(p)}\right)^{1-\sigma}(\overline{v}_{ij})^{\sigma}+\left(1-\tilde{v}_{ij}^{(p)}\right)^{1-\sigma}(1-\overline{v}_{ij})^{\sigma}}, i,j = 1,2,\cdots,n \quad (4.8)$$

Let $R^{(p+1)} = \tilde{R}^{(p)}$, $(\mu_{ij}^{(p+1)} = \tilde{\mu}_{ij}^{(p)}, v_{ij}^{(p+1)} = \tilde{v}_{ij}^{(p)})$. Let $p = p + 1$. Thereafter, use formula (6). Through an iteration step, the consistency level of the intuitionistic preference relation will be improved without losing substantial original information.

Step 4: Calculate the weighting functions

The n-dimensional vector $\omega = (\omega_1, \omega_2, \cdots, \omega_n)$ obtained from the multiplicative preference relation, where ω_i is the weight that accurately represents the relative dominance of the alternative A_i amongst the alternatives in A.

$$\omega_i = \left(\frac{\sum_{j=1}^{n} \mu_{ij}}{\sum_{i=1}^{n}\sum_{j=1}^{n}(1-\upsilon_{ij})}, 1 - \frac{\sum_{j=1}^{n}(1-\upsilon_{ij})}{\sum_{i=1}^{n}\sum_{j=1}^{n}\mu_{ij}}\right) i = 1,2,\cdots,n \quad (4.9)$$

This method is relatively different from the methods used in AHP and FAHP and does not influence the extension of the original AHP method (Xu and Liao, 2014).

Step 5: Integrating the information

The fifth step of IFAHP is integrating the information calculated from the previous steps. All weights from the lowest level should be fused to the highest level on the basis of the following operational rules of IFVs (Xu, 2007):

$$r_{ij} \oplus r_{tl} = (\mu_{ij} + \mu_{tl} - \mu_{ij}\mu_{tl}, \upsilon_{ij}\upsilon_{tl}) \quad (4.10)$$

$$r_{ij} \otimes r_{tl} = (\mu_{ij}\mu_{tl}, \nu_{ij} + \nu_{tl} - \upsilon_{ij}\upsilon_{tl}). \quad (4.11)$$

Step 6: Rank the impact grade of each risk factor

The previous steps should be implemented twice for possibility and severity. After computing the two aspects, the impact of each risk factor can be derived by obtaining the square root of the product of possibility and severity using the following formula (Chan et al., 2014):

$$impact = (possibility \times severity)^{0.5}.$$

Similarly, the IFV operational rules (formulas (11) and (12)) should be used to calculate the risk factor impact:

$$r_{ij}{}^{\lambda} = \left(\mu_{ij}^{\lambda}, 1 - \left(1 - \upsilon_{ij}\right)^{\lambda}\right), \lambda > 0 \quad .$$

(4.12)

Each risk factor can obtain its evaluation IFV score after this step. Lastly, Szmidt and Kacprzyk (2009) proposed a function to calculate the overall weights of IFVs:

$$\rho(\alpha) = 0.5(1 + \pi_{\alpha})(1 - \mu_{\alpha}). \quad (4.13)$$

The low value of $\rho(\alpha)$ means a high value of IFV. After calculating the $\rho(\alpha)$, all the risk factors can be ranked in this study on the basis of the impact value of each factor.

4.3 RISK ALLOCATION FOR TPPP PROJECTS

4.3.1 Risk allocation problem in TPPP

Although many infrastructure projects have adopted the PPP approach, these projects are not equally successful because some are exposed to extremely high risks (Thomas et al., 2003a). The need to adapt to different cultures and environments within a short period, establishment of a long-term relationship between foreign participants and local governments and short period for the private consortium to learn and comply with local regulations represent typical examples of well-recognised challenges in implementing TPPP. Foreign investors remain sensitive to all of these challenges because they could easily result in serious risks. Although TPPP can help establish cooperation between a host country's government and foreign investors participating in an infrastructure project, the project continues to face difficulties and risks. Therefore, to successfully implement TPPP projects, the risk allocation process for effective handling or mitigation of risks in TPPP projects should be substantially understood.

In TPPP projects, the public and private sectors have different levels of power or authority. The government of the host country assumes the dual roles of participant and regulator. Accordingly, an unfair risk allocation scheme may arise or the public sector may force the private sector to assume additional risks. An appropriate risk allocation strategy can facilitate project success and provide high-quality infrastructure services (Jin and Zhang, 2011). In recent decades, several studies have analysed the risk allocation in DPPP projects. However, no research has been performed to develop risk allocation models, particularly for TPPP projects. Therefore, the objective of this section is to examine the risk allocation process between the public and private sectors from different countries in TPPP projects. BGT was employed to analyse the bargaining process of risk allocation. The process provided in this study will help build an effective risk management model for scientific and reasonable risk allocation in TPPP projects. A practical hydropower project was used as a case study in developing the process model. The results of this study could help the public and private sectors involved in TPPP projects gain an improved understanding of the risk allocation process and conduct proper and effective risk allocations.

4.3.2 BGT used in the risk allocation process

4.3.2.1 Game behaviour or risks undertaken in TPPP projects

Risks should be allocated efficiently and fairly between key project stakeholders to better manage risks and achieve project success. Several systematic studies have been conducted on risk allocation in DPPP projects (Abednego and Ogunlana, 2006, Bing et al., 2005, Jin and Doloi, 2008). Before providing the process and result of risk allocation, the principles on allocating risks between the public and private sectors should be demonstrated. Table 4.1 shows five important risk allocation

principles identified from a comprehensive literature review on various risk allocation principles.

Table 4.1 Principles for equitable risk allocation in PPP projects

Code	Risk allocation principles	References
1	Each risk should be allocated to the party that can best manage it (i.e., the party that can best influence and control the risky outcome)	Cooper (2005); Ke et al. (2010b); Li et al. (2016); Medda (2007); Abednego and Ogunlana (2006); Chan et al. (2010b); Hwang et al. (2013); Ibrahim et al. (2006); Roumboutsos and Anagnostopoulos (2008); Xu et al. (2010a); Loosemore and McCarthy (2008)
2	The risk should be borne by the agent that can bear it at the lowest cost	Cooper (2005); Ke et al. (2010b); Medda (2007); Chan et al. (2010b); (Hwang et al., 2013); Xu et al. (2010a); Loosemore and McCarthy (2008)
3	A party must be willing to accept the risk or be least able to refuse risks	Abednego and Ogunlana (2006); Jin and Doloi (2008); Jin and Zhang (2011)
4	Appropriate risk allocation would significantly reduce transaction cost	Jin and Zhang (2011); Zaghloul and Hartman (2003)
5	Proper risk allocation can cultivate rational and cautious participant behaviours	Li et al. (2016); Liu and Wang (2006)

Table 4.1 shows that the most widely accepted risk allocation principle is to allocate risks to the party that can best manage these issues at the least cost. However, the power of the government is stronger than that of the private investor in real PPP projects, particularly TPPP projects. As such, risks would inevitably be allocated to the party that is least able to refuse them rather than the party that can best manage them (Jin and Zhang, 2011). Moreover, allocating heavy risks to the private sector may not be an optimal risk allocation strategy and this situation may cause considerable problems to the project (Ke et al., 2010b). Therefore, optimal risk allocation should immensely contribute to maximising project efficiency and minimising total cost (Irwin, 2007, Quiggin, 2004). Risk transfer should incentivise and benefit all parties (Medda, 2007). In addition to these fundamental principles, the negotiation skills of all parties are also important to the risk allocation results.

Given the technical, legal, political and economic complexities of PPP projects, risk

allocation in these projects have been found highly variable, intuitive, subjective and unsophisticated (Ng and Loosemore, 2007). Several studies have attempted to provide an optimal risk allocation model. Risk allocation schemes provided by previous studies were based on a specific country. For example, Ke et al. (2010b) adopted a two-round Delphi survey to analyse the risks and their allocations in PPP projects in China. Bing et al. (2005) used a questionnaire survey to explore the preferences in risk allocation in PPP projects in the UK. Hwang et al. (2013) focused on the perspective of contractors to provide a preferred risk allocation model for Singapore. Ibrahim et al. (2006) investigated the perception of Nigerian construction professionals on the relative importance of their risk allocation preferences. These studies have suggested that risk allocation in PPP projects is not the same across different countries and that the context-specific nature should be understood when conducting TPPP. Compared with DPPP, some specific risks may occur in TPPP projects, such as currency risk (Appuhami et al., 2011, Babatunde et al., 2015b), cultural impediments (Chou and Pramudawardhani, 2015a), conflict of national essence (capitalism/ socialism) (Cocq and McDonald, 2010b), restriction policy on foreign investor (Wibowo and Alfen, 2015), prohibition of cross-border design and construction services (Choi et al., 2010a). However, research relating to the risk allocation considering these TPPP-specific risk factors has been inadequate.

For TPPP projects, foreign investors need to identify the relevant risks in host countries and require a fair and proper risk allocation scheme with the local government. Generally, PPP projects have been featured in many risk allocation studies. However, no study has yet to specifically focus on risk allocation in TPPP projects, which are different from domestic PPP projects. Therefore, a study that specifically focuses on the risk allocation for TPPP project should be conducted.

BGT has a long history (Nash, 1950, Nash Jr, 1950, Harsanyi, 1956). This theory deals with situations in which partners interact rationally with each other and assumes that an individual's action depends on what other individuals may do. BGT aims to solve the situation in which players have a common and conflicting interests to cooperate. Each player attempts to reach an agreement that is as favourable as possible. However, the bargaining process is time consuming and involves the players making offers and counteroffers (Muthoo, 1999).

Bargaining theory has been used in PPP-related research to analyse participants' bargaining behaviour, such as price negotiation, revenue and risk allocation and concession period negotiation (Li et al., 2016). Medda (2007) applied bargaining theory to analyse the process of risk allocation between the public and private sectors in transport infrastructure agreements. Shen et al. (2007) considered the bargaining behaviour of the two parties (investor and government) into the BOT project concession model to enable the identification of a specific concession period. Kang et al. (2013) used royalty bargaining to present a transformed first-price sealed-bid auction with independent private values to determine the equilibrium royalties and subsidies in PPP. Li et al. (2016) proposed a risk allocation tool on the basis of bargaining theory by using different alternating offer sequences of participants for PPP projects. The behaviours in risk allocation process of two main stakeholders in PPP project (e.g. public and private sectors) are well suited to adopt the BGT model. The reason is that two stakeholders attempt to achieve a risk allocation scheme whilst simultaneously attempting to ensure their respective optimal benefits. Given that no previous research has been conducted on risk allocation in TPPP projects, the current study attempts to fill in this gap. The present research examines risk allocation in TPPP as a bargaining process between the

public and private sectors confronted with the decision on risk allocation offers (Medda, 2007).

In the real practice of TPPP projects, the private sector's estimation of relevant risks in the participation process is directly related to the public sector. Moreover, some risks are directly caused by public sector policy adjustment. The asymmetrical status of the public and private sectors in TPPP projects may have an impact on the risk allocation process. The goal of the public sector in conducting TPPP projects is to provide qualified infrastructure and services to satisfy public needs, whereas the private sector intends to acquire additional profits. The risk retained by any sector means substantial direct costs to prevent risk and potential costs to retreat risk. Therefore, participants spend substantial time on the opponent's information acquisition and risk allocation negotiation. This negotiation process of risk allocation can be described by using the bargaining model in game theory, whilst the optimal risk allocation proportion can be determined by using the optimal calculation. The result of the optimal calculation can improve the rationality of risk allocation, thereby resulting in project success.

4.3.2.2 Hypotheses of bargaining theory

Rational behaviour

The assumption is that the public and private sectors are rational participants. They do not deviate from the best strategy because of such factors as forgetting, mistakes or wilfulness. The decision-making and behaviour of both parties are based on maximising an individual's interests, rather than maximising collective interests. Both sectors likewise optimistic that the final negotiation would be successful. Players consider their interests and makes a trade-off between risk and revenue by

pursuing the optimal strategy for achieving maximum profit amongst all possible results (Li et al., 2016).

Incomplete information sharing

In any bargaining process, information is an important factor for participants' negotiations. In TPPP projects, the public sector has substantial information as the sponsor of the majority of projects. The public sector may not disclose certain information for its benefits or to attract additional private sectors to compete for a project. This different position in achieving information leads to information asymmetry.

Bargaining risk allocation

Risk allocation represents the responsibility of participants. Players expect a reasonable share of risk allocation based on their prospective revenue. When one player makes an offer in each bargaining round, the counterpart would accept or reject the offer. An equilibrium results when two players reach an agreement in the bargaining process. The current study assumes that each risk factor is independent (Li et al., 2016). For risk factor i, if the risk allocation ratio for the public sector is r_i, then the ratio for the private sector is 1- $r_{i,}$ and participants are bargaining for the magnitude of r_i.

Negotiation loss factor

In the actual operation of a TPPP project, negotiations may last a long period and the benefits lost during the negotiations cannot be disregarded. Time costs should be considered in the bargaining process. The negotiation costs and interests lost during the negotiation process substantially reduce the interests of both parties. In

the long negotiation process, the final agreement is accompanied by an increase in costs and a loss of income. Therefore, both parties would bear additional risks and minimal income. Thus, participants are more inclined to reach an agreement earlier than expected. Negotiation loss factor means both sectors that in the bargaining process would incur a certain negotiation cost, including the time paid by both parties, the various expenses made on information acquisition and opportunity cost benefits. Therefore, the longer the bargaining process, the higher the risk loss that both parties have to bear. Negotiation loss factor ξ is related to patience N_1, participants' negotiation skills N_2, negotiation costs N_3 and opportunity cost N_4. These factors are determined by the participants' mental tolerance and economic endurance. The relationship between ξ and these four factors is $\xi = f\left(N_1^{-1}, N_2^{-1}, N_3, N_4\right)$ (Yan, 2017). The higher the patience and negotiation skills and the lower the negotiation cost and opportunity cost, the lower the negotiation loss factor. In TPPP projects, the private sectors are more sensitive to time than the government. The longer negotiation period would delay the start of the project and impact on the benefits to the private sector. Thus, this study assumes $\xi_p > \xi_g$, which means that if the negotiation turns to the next round, then the private sector would face additional risks.

4.3.3 BGT model

4.3.3.1 Bargaining game model for risk allocation

Project lifecycle is defined as the series of sequential stages through which a project is developed from its origin to closure (PMI, 2013b). Given the complexity of the PPP arrangement, the lifecycle of PPP projects can be divided into several stages: project identification, project preparation, bidding, contract organising, financing

and construction, operation and transfer stages (Bank, 2008, Bao et al., 2018, Bank, 2014). The process of TPPP projects is similar to that of PPP projects. The risk management in PPP projects should be conducted from a lifecycle perspective that starts at the identification stage and carried out through the operation and transfer stages with continuous monitoring (Zou et al., 2008). Figure 4.2 shows the main milestone events and risk management tasks in each TPPP project stage.

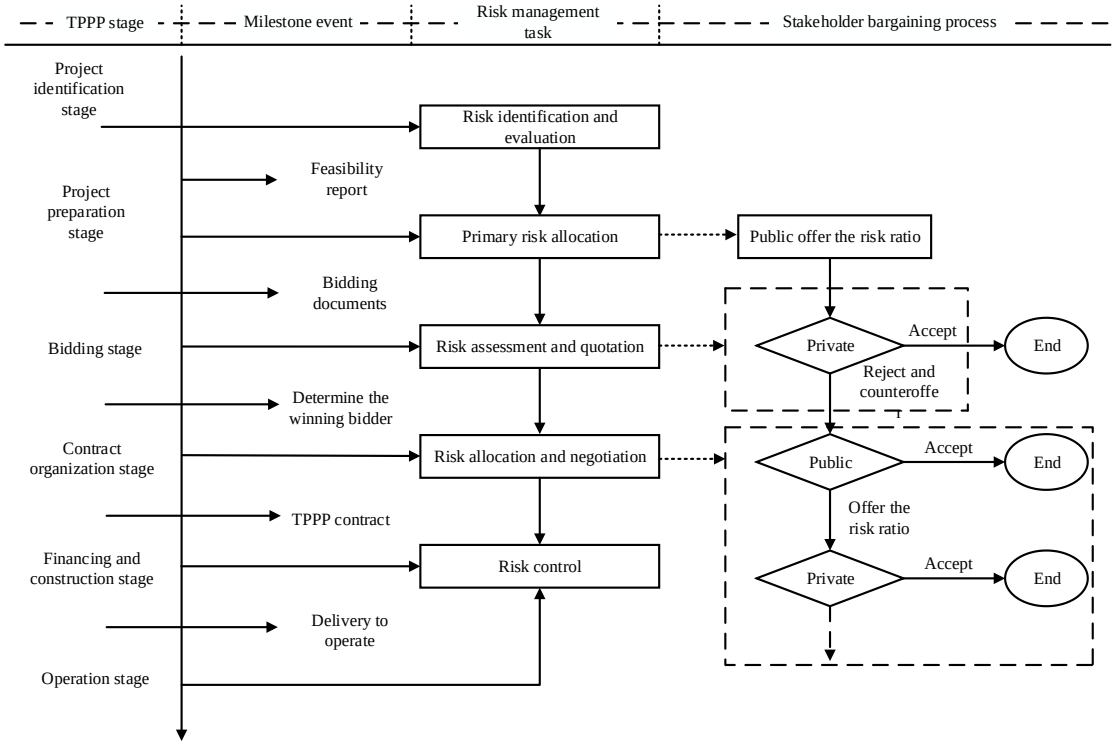


Fig. 4.2 Risk management process in the lifecycle of TPPP projects (modified from Li et al. (2016))

For the majority of TPPP projects, the government as the sponsor is responsible for project identification. After identifying the project, the public sector should identify and evaluate risks and prepare a primary risk allocation plan to include these details in the bidding documents. In the bidding stage, the potential private sector would assess the risk impact and benefits on the basis of the offered risk allocation plan and their technologies, resources and experiences. Eventually, the private sector would provide their quotation. Thereafter, the project goes into the contract organisation stage, in which the public and private sectors negotiate to obtain the

final risk allocation scheme. In the financing and construction and operation stages, risk control is the important task for the public and private participants.

BGT can describe the process of how two players negotiate the risk allocation scheme. The public sector offers the risk ratio after the primary risk allocation $r_1(0 \leq r_1 \leq 1)$, whilst the private sector assesses the risks and determines whether to accept or reject it and provides counteroffer r_2. Thereafter, the negotiation process circulates in the risk allocation and negotiation stages. The offers of both parties are at discontinuous points of time (0, t_1, t_2…). When t is an odd number, the public sector makes an offer; when t is an even number, the private sector makes an offer. The negotiations are not over until the two players reach an agreement.

4.3.3.2 Calculation of the risk allocation ratio

This study adopted the bargaining game model introduced by Li et al. (2013a) and Li et al. (2016). Given the practical risk negotiation process for TPPP projects, the bargaining process should be initiated in the first round by the public sector. The public and private sectors are not familiar with each other's characteristics because information sharing is incomplete. Given the unequal status of both stakeholders in a TPPP project, the public sector has p_1 possibility to transfer risks to the private sector and (1- p_1) possibility not to transfer risks to the private sector.

Round 1

In the first bargaining round, the public sector makes a risk ratio offer r_1, with the corresponding private sector risk 1- r_1. Under the situation that the powerful government may transfer risk ratio α_1 to the private sector, the expected risks allocated to the public and private sectors are shown in equations 4.14 and 4.15, respectively:

$$G_1 = p_1(r_1 - \alpha_1) + (1 - p_1)r_1 \quad (4.14)$$

$$P_1 = p_1(1 - r_1 + \alpha_1) + (1 - p_1)(1 - r_1), \quad (4.15)$$

where G_1 and P_1 indicate the public and private sectors' expectations, respectively, of taking risks in the first round. The private player can consider whether to accept or reject the offer and makes the bargaining game move to the second round.

Round 2

If the private sector rejects the offer in the first round, then the bargaining process moves into the second round. In such a case, both sectors would suffer from negotiation loss factor. In the second round, the private sector makes a counteroffer that the public sector should take r_2 risk ratio. Similar to round 1, the public player has p_1 possibility to transfer risk ratio α_2 to the private sector. The expected risks allocated to the public and private sectors are shown in equations 4.16 and 4.17, respectively:

$$G_2 = \xi_g p_1(r_2 - \alpha_2) + \xi_g(1 - p_1)r_2 \quad (4.16)$$

$$P_2 = \xi_p p_1(1 - r_2 + \alpha_2) + \xi_p(1 - p_1)(1 - r_2). \quad (4.17)$$

What should be emphasised is that the negotiation loss factor ξ_g and ξ_p should be considered from the second round. If the public player accepts the counteroffer, then the negotiation is terminated. Otherwise, the negotiation process moves into the third round.

Round 3

In the third round, the expected risks allocated to the public and private sectors are shown in equations 4.18 and 4.19, respectively:

$$G_3 = {\xi_g}^2 p_1(r_3 - \alpha_3) + {\xi_g}^2(1 - p_1)r_3 \quad (4.18)$$

$$P_3 = {\xi_p}^2 p_1(1 - r_3 + \alpha_3) + {\xi_p}^2(1 - p_1)(1 - r_3). \quad (4.19)$$

The bargaining process only terminates when the public and private sectors reach a risk allocation agreement. Table 4.2 summarises the risk expectations of the public and private sectors in three rounds.

Table 4.2 Risk expectations of the public and private sectors in each bargaining round

Round	Public sector	Private sector
1	$G_1 = p_1(r_1 - \alpha_1) + (1 - p_1)r_1$	$P_1 = p_1(1 - r_1 + \alpha_1) + (1 - p_1)(1 - r_1)$
2	$G_2 = \xi_g p_1(r_2 - \alpha_2) + \xi_g(1 - p_1)r_2$	$P_2 = \xi_p p_1(1 - r_2 + \alpha_2) + \xi_p(1 - p_1)(1 - r_2)$
3	$G_3 = {\xi_g}^2 p_1(r_3 - \alpha_3) + {\xi_g}^2(1 - p_1)r_3$	$P_3 = {\xi_p}^2 p_1(1 - r_3 + \alpha_3) + {\xi_p}^2(1 - p_1)(1 - r_3)$

This model is an infinite bargaining game model under incomplete information conditions. Therefore, the inverse inductive method cannot be applied to the solution of this model. From the infinite bargaining model of Shaked and Sutton (1984), the reverse point is set in the third round. If the risk allocation plan offered by the private sector makes the risk ratio expectation of the public sector $G_2 > G_3$ in the third round, then the public sector would reject the second round to make the game move into the third round. Entering the third round would generate unnecessary costs for the two participants. Therefore, the proposed risk allocation should simultaneously satisfy the following aspects: the risk ratio allocated to the private sector should minimise P_2, whilst the risk ratio allocated to public sector G_2 should not exceed G_3. Thus, the optimal strategy for the private sector in the second round is $G_2 = G_3$.

$$\xi_g p_1(r_2 - \alpha_2) + \xi_g(1 - p_1)r_2 = {\xi_g}^2 p_1(r_3 - \alpha_3) + {\xi_g}^2(1 - p_1)r_3$$

then,

$$r_2 = \xi_g r_3 - \xi_g p_1 \alpha_3 + p_1 \alpha_2.$$

Therefore, the risk ratios of the private sector in the second and third rounds are shown in equations 4.20 and 4.21, respectively:

$$P_2 = \xi_p\left(1 - \xi_g r_3 + \xi_g p_1 \alpha_3\right) \tag{4.20}$$

$$P_3 = {\xi_p}^2(1 - r_3) + {\xi_p}^2 p_1 \alpha_3. \tag{4.21}$$

To compare P_2 and P_3,

$$P_2 - P_3 = \xi_p\left[\left(1 - \xi_p\right) - (\xi_g - \xi_p)(p_1 \alpha_3 - r_3)\right]$$

Given that $1 < \xi_g < \xi_p,\ 0 \le p_1 \le 1,\ 0 \le \alpha_3 \le r_3 \le 1,\ P_2 - P_3 < 0,\ P_2 < P_3$. This relationship means that the risk allocation ratio in the second round is smaller than in the third round. Thus, the negotiation bargaining process would not move into the third round. Similar to the risk ratio of the public sector in round 2, if the risk allocation plan offered by the public sector makes the risk ratio expectation of private sector $P_1 > P_2$, then the private sector in the second round would reject the first round to make the game move into the second round. Thus, the optimal strategy for the public sector in the first round is $P_1 = P_2$.

$$p_1(1 - r_1 + \alpha_1) + (1 - p_1)(1 - r_1) = \xi_p p_1(1 - r_2 + \alpha_2) + \xi_p(1 - p_1)(1 - r_2)$$

then,

$$r_1 = 1 + p_1 \alpha_1 - \xi_p\left(1 - \xi_g k_3 + \xi_g p_1 \alpha_3\right)$$

In an infinite round bargaining process, the results are consistent whether the reverse is set in the third or first rounds. That is,

$$r_1 = r_3.$$

If α is assumed constant, then the bargaining consequences for the public and private sectors are shown in equations 4.22 and 4.23, respectively:

$$r = \frac{\xi_p - 1}{\xi_p \xi_g - 1} + p_1 \alpha \tag{4.22}$$

$$1 - r = \frac{\xi_p \xi_g - \xi_p}{\xi_p \xi_g - 1} - p_1 \alpha. \tag{4.23}$$

When $p_1 = 1$, the public sector would use its strong position to force the private sector to accept an additional ratio of risk transfer. When $p_1 = 0$, the public sector would not transfer any additional risk ratios to the private sector. When $0 < p_1 < 1$, the public sector cannot fully utilise its strong position to force the private sector to accept additional risk transfer. The nominal and actual ratios for the public and private sectors are shown in Table 4.3. The risk allocation in TPPP projects is determined by the negotiation loss factors of the public and private sectors (ξ_p and ξ_g), the possibility of the public sector forcing additional risks to the private sector (p_1) and the risk ratio that may be transferred (α).

Table 4.3 Risk allocation ratio for the public and private sectors

Stakeholder	Nominal ratio	Actual ratio
Public sector	$\frac{\xi_p - 1}{\xi_p \xi_g - 1} + p_1 \alpha$	$\frac{\xi_p - 1}{\xi_p \xi_g - 1}$
Private sector	$\frac{\xi_p \xi_g - \xi_p}{\xi_p \xi_g - 1} - p_1 \alpha$	$\frac{\xi_p \xi_g - \xi_p}{\xi_p \xi_g - 1}$

4.4 CASE STUDY

After having presented the proposed methodology, the results of an empirical case study conducted in a TPPP project are provided in this section to adopt the risk evaluation and allocation methods. The actual name of this case is not given for

confidentiality reasons. Thus, this case will be called Project X in this study. Project X is one of the ten most popular PPP projects in B&R countries nominated by the China Public Private Partnerships Center (Center, 2017). Project X was called the 'Star project' in C country, which shows significance and importance. Thus, many public data and information on this project can be retrieved online. Another reason for choosing this project as a case study is the popularity of TPPP power projects, particularly in emerging Asian economies with increasing energy demand (Atmo and Duffield, 2014).

4.4.1 Project background

The practical case applied in the current research is a power plant project in a developing southeast country, which is a BOT project invested in by a Chinese construction company. Table 4.4 provides the background information of the project.

Table 4.4 Primary information of project X

Primary information	Description
Project Name	X Hydropower station PPP project in country C
Project Type	New project
Sector	Electrical Power——Hydroelectric
Project Content	The main works include dams, water intakes, diversion tunnels, 230 KV switch stations, 10 KM 230 KV double circuit transmission lines, supporting distribution and diversion projects, tail water control weir, and other temporary works and electromechanical installation works.
Concession period	Construction period: 4 years Operation period: 40 years
Total investment	280.5 million US Dollars
PPP type	BOT (Building—Operation—Transfer)
Public sector	Ministry of Industry and Mineral Resources of C country
Private sector	Sinohydro Corporation Limited (China)
Financing institution	The Export-Import Bank of China: provide loans of 72% fixed asset (202 million US Dollars)
Users	X country National Electricity Company: sign the 'take or pay' contract with private sector; take responsibility for purchase and payment

4.4.2 Identification of CRFs for Project X

After a comprehensive literature review on the relevant studies of TPPP risk (Yu et.

al., 2017), 42 CRFs were identified in the general TPPP projects (see Table 2.6). Through primary documentary review of contract documentation, country and market report, secondary documentary analysis of industry and professional reports, and newspaper articles, 22 risk factors were identified that may be related to Project X. These risk factors were grouped into four major risk categories, namely, (1) financial/commercial, (2) legal and social-political, (3) technical and natural and (4) partnership. These clusters were derived primarily on the basis of similar categorisations of PPP risk factors in the literature (Xu et al., 2010b, Ozdoganm and Talat Birgonul, 2000, Salman et al., 2007). Merna and Smith (1993) discussed that the concession contract can afford a useful source of information because it is the basis of a long-term contract between public and private stakeholders. To make this identification and categorisation considerably reasonable, the financing, construction, operation and revenue packages of Project X were also referred to (Ameyaw et al., 2017). Table 4.5 summarises the risk factors identified and grouped for the questionnaire survey.

Table 4.5 Risk categories for TPPP project

No.	Risk factor	Definition
Category1(r_1): Financial/Commercial risk category		
r_{11}	Tariff risk	The price of the services offered by TPPP project infrastructure.
r_{12}	Financing risk	The availability and cost of financing.
r_{13}	Currency risk	Related to interest rate or foreign exchange rate.
r_{14}	Demand and revenue risk	The market demand and operational revenue of services offered by TPPP.
r_{15}	Tax risk	About the tax regulation in host country.
r_{16}	Payment risk	Government pay for the private sector and project company pay for the loan.
Category2(r_2): Legal and Socio-political risk category		
r_{21}	Legal risk	Weak or unstable legal framework.
r_{22}	Corruption risk	Dishonest or illegal behavior by stakeholders.
r_{23}	Political risk	Threatens from the political environment.
r_{24}	Administrative risk	Host country government inefficiency or lengthy bureaucratic procedures in administrative procedures.
r_{25}	Lack of government support	Lack of local government assistance when facing problems.
Categoey3(r_3): Technical and natural risk category		

r_{31}	Technology risk	Risks related to technology capacity and quality.
r_{32}	Construction risk	Construction cost and schedule.
r_{33}	Operation risk	Operation cost and productivity.
r_{34}	Force majeure	Superior or irresistible force cannot be anticipated or controlled.
r_{35}	Natural environment risk	Geotechnical conditions, population density impact, environmental problems.
Category4(r_4): Partnership risk category		
r_{41}	Cooperation risk	Conflicts between public sector and private sector during the cooperation.
r_{42}	Credit risk	Stakeholders' unreliability to perform contract.
r_{43}	Worker risk	Risks about staff and labor problem.
r_{44}	Competitiveness risk	Risks caused by potential competitors.
r_{45}	Cultural impediments	Conflicts between stakeholders caused by different culture.
r_{46}	Language differences	Inconvenience and high cost caused by language differences.

4.4.3 Participants and survey process

Questionnaire survey is an effective technique for soliciting experts' perceptions (Spector, 1994). Previous studies on PPP risk management have been conducted through questionnaire survey (Ameyaw and Chan, 2015a, Zeng et al., 2008, Ke et al., 2011a, Ebrahimnejad et al., 2010). Subsequently, the established 22 risk factor list was used to design a questionnaire for a survey. With the objective to measure each risk factor on the basis of IFAHP, the questionnaire was designed according to this methodology. An expert refers to someone who has special skills, knowledge or experiences by his or her leadership and work in professional organisations; someone holding an office in professional organisations; a presenter in national conventions or someone who has published in recognised journals (Cabaniss, 2002). Hence, the five experts in the current study were selected on the basis of their knowledge, experience and understanding of Project X, which was evidenced by their job position and experience in this project. The expert selection process is reasonable, acceptable and adopted in many previous risk management studies (e.g.., (Ng and Loosemore, 2007, Ameyaw et al., 2017, Thomas et al., 2006). Although the size of this risk assessment group is small, reliable measurement

results is anticipated because the five experts are high-level management officials with direct involvement and important decision-making power in the project planning, risk allocation, contract negotiations and lifecycle management of Project X. Li and Zou (2011) invited five experts to evaluate the risk factors of an actual PPP expressway project based on the FAHP methodology. Ebrahimnejad et al. (2010) selected five experts to establish a BOT projects risk ranking team to assess the risk factors using a fuzzy multi-attribute decision making model. These previous studies have supported the reliability of the limited sample.

Table 4.6 summarises the participants' profile: two from the private sector, one from the public sector, one from the construction contractor and one from the consulting company for this project. The different backgrounds of these experts would help determine the likely consensus in the practitioners' opinions on the degree of probability and severity of the risk factors. Given the public sector's location outside China and time limitations, the questionnaire was delivered online to the expert from the Ministry of Industry and Mineral Resources of C country. However, the questionnaire was delivered physically to the other four experts in China, whilst the respondents were doing the interview and questionnaire face to face with authors.

Table 4.6 Designation of the risk assessment team members

Identifier	Participant position	Participant organization	Years of working experience in TPPP	Familiarity to Project X	Participant role
1	Project manager	Sinohydro Corporation Limited	15	Very familiar	Involved in the whole life cycle of this project, in charge of project control.
2	Director	Ministry of Industry and Mineral Resources of C country	3	Very familiar	Involved in tariff review, risk allocation and contract negotiations.
3	Project investment and development	Sinohydro Corporation Limited	10	Very familiar	Project planning, Contract negotiations with other stakeholders.
4	Consultant manager	Consultant	4	Very familiar	Provided professional consultation during the life of project X.
5	Technical worker	Construction Contractor	7	Very familiar	Involved in project survey, design and construction.

4.4.4 Process of risk assessment by IFAHP

This study adopted the IFAHP method in the questionnaire to collect measurement data for each risk factor from two dimensions (occurrence possibility and severity). Taking the process of evaluating the possibility as an example, each participant in the questionnaire survey had to provide the evaluation in five tables. The first level of risk categories included the specific risk factors for financial/commercial (A_1), legal and socio/political (A_2), technical and natural (A_3) and partnership (A_4). In each comparison matrix, decision makers needed to develop an IFV to describe the preferences between alternatives. The 0.1 to 0.9 scale satisfies the reciprocal condition (see Table 4.7).

Table 4.7 Intuitionistic preference matrix for the risk categories

0.1-0.9 scale	Meaning
0.1	Extremely not preferred
0.2	Very strongly not preferred
0.3	Strongly not preferred
0.4	Moderately not preferred
0.5	Equally preferred
0.6	Moderately preferred
0.7	Strongly preferred
0.8	Very strongly preferred
0.9	Extremely preferred
Other values between 0-1	Intermediate values used to present compromise

After all these experts have provided their evaluation matrix, each matrix was adopted into consistency checking. The arithmetic average of each participants' grade is the final matrix.

Step 1: Build the intuitionistic fuzzy judgment matrix

This study used two dimensions, namely, occurrence possibility and severity, to evaluate the risk impact. The questionnaire survey was adopted twice to measure the possibility and severity. Five experts responded to these tables to show their intuitionistic measurement of each risk factor of this power plant TPPP project. Taking Expert 1 as an example, the intuitionistic preference matrix are shown in Tables 4.8 to 4.12.

Table 4.8 Intutionistic preference matrix for the risk categories

level 1	P/S*	A_1	A_2	A_3	A_4
A_1	P	(0.5,0.5)	(0.55,0.3)	(0.65,0.25)	(0.7,0.2)
	S	(0.5,0.5)	(0.4,0.5)	(0.45,0.5)	(0.6,0.3)
A_2	P	(0.3,0.55)	(0.5,0.5)	(0.5,0.4)	(0.6,0.35)
	S	(0.5,0.4)	(0.5,0.5)	(0.35,0.6)	(0.6,0.35)
A_3	P	(0.25,0.65)	(0.4,0.5)	(0.5,0.5)	(0.65,0.3)
	S	(0.5,0.45)	(0.6,0.35)	(0.5,0.5)	(0.7,0.1)
A_4	P	(0.2,0.7)	(0.35,0.6)	(0.3,0.65)	(0.5,0.5)
	S	(0.3,0.6)	(0.35,0.6)	(0.1,0.7)	(0.5,0.5)

*Note: P=possibility; S=severity.

Table 4.9 Intuitionistic preference matrix for risks in financial/commercial category

A_1		C_1	C_2	C_3	C_4	C_5	C_6
C_1	P	(0.5,0.5)	(0.2,0.6)	(0.1,0.8)	(0.4,0.3)	(0.45,0.35)	(0.2,0.7)
	S	(0.5,0.5)	(0.2,0.7)	(0.4,0.45)	(0.5,0.4)	(0.4,0.35)	(0.3,0.6)
C_2	P	(0.6,0.2)	(0.5,0.5)	(0.25,0.7)	(0.6,0.25)	(0.5,0.4)	(0.35,0.6)
	S	(0.7,0.2)	(0.5,0.5)	(0.4,0.45)	(0.6,0.35)	(0.7,0.15)	(0.35,0.55)
C_3	P	(0.8,0.1)	(0.7,0.25)	(0.5,0.5)	(0.8,0.1)	(0.75,0.2)	(0.45,0.35)
	S	(0.45,0.4)	(0.45,0.4)	(0.5,0.5)	(0.6,0.35)	(0.7,0.2)	(0.4,0.45)
C_4	P	(0.3,0.4)	(0.25,0.6)	(0.1,0.8)	(0.5,0.5)	(0.3,0.4)	(0.3,0.6)
	S	(0.4,0.5)	(0.35,0.6)	(0.35,0.6)	(0.5,0.5)	(0.5,0.3)	(0.3,0.5)

C_5	P	(0.35,0.45)	(0.4,0.5)	(0.2,0.75)	(0.4,0.3)	(0.5,0.5)	(0.4,0.5)
	S	(0.35,0.4)	(0.15,0.7)	(0.2,0.7)	(0.3,0.5)	(0.5,0.5)	(0.2,0.65)
C_6	P	(0.7,0.2)	(0.6,0.35)	(0.35,0.45)	(0.6,0.3)	(0.5,0.4)	(0.5,0.5)
	S	(0.6,0.3)	(0.55,0.35)	(0.45,0.4)	(0.5,0.3)	(0.65,0.2)	(0.5,0.5)

Table 4.10 Intuitionistic preference matrix for risks in legal and social/political category

A_2		C_1	C_2	C_3	C_4	C_5
C_1	P	(0.5,0.5)	(0.6,0.3)	(0.65,0.2)	(0.5,0.4)	(0.8,0.1)
	S	(0.5,0.5)	(0.55,0.4)	(0.5,0.4)	(0.6,0.3)	(0.45,0.4)
C_2	P	(0.3,0.6)	(0.5,0.5)	(0.4,0.5)	(0.35,0.6)	(0.6,0.2)
	S	(0.4,0.55)	(0.5,0.5)	(0.2,0.7)	(0.2,0.6)	(0.4,0.5)
C_3	P	(0.2,0.65)	(0.5,0.4)	(0.5,0.5)	(0.3,0.6)	(0.5,0.4)
	S	(0.4,0.5)	(0.7,0.2)	(0.5,0.5)	(0.6,0.2)	(0.6,0.3)
C_4	P	(0.4,0.5)	(0.6,0.35)	(0.6,0.3)	(0.5,0.5)	(0.6,0.2)
	S	(0.3,0.6)	(0.35,0.6)	(0.2,0.6)	(0.5,0.5)	(0.5,0.4)
C_5	P	(0.1,0.8)	(0.6,0.2)	(0.4,0.5)	(0.2,0.6)	(0.5,0.5)
	S	(0.4,0.45)	(0.5,0.4)	(0.3,0.6)	(0.4,0.5)	(0.5,0.5)

Table 4.11 Intuitionistic preference matrix for technical and natural risk categories

A_3		C_1	C_2	C_3	C_4	C_5
C_1	P	(0.5,0.5)	(0.6,0.2)	(0.65,0.3)	(0.75,0.1)	(0.7,0.2)
	S	(0.5,0.5)	(0.5,0.4)	(0.6,0.3)	(0.1,0.85)	(0.25,0.7)
C_2	P	(0.2,0.6)	(0.5,0.5)	(0.5,0.3)	(0.8,0.15)	(0.7,0.25)
	S	(0.4,0.5)	(0.5,0.5)	(0.55,0.4)	(0.25,0.7)	(0.4,0.5)
C_3	P	(0.3,0.65)	(0.3,0.5)	(0.5,0.5)	(0.7,0.1)	(0.6,0.3)
	S	(0.3,0.6)	(0.4,0.55)	(0.5,0.5)	(0.1,0.85)	(0.2,0.6)
C_4	P	(0.1,0.75)	(0.15,0.8)	(0.1,0.7)	(0.5,0.5)	(0.2,0.7)
	S	(0.8,0.1)	(0.7,0.25)	(0.85,0.1)	(0.5,0.5)	(0.6,0.35)
C_5	P	(0.2,0.7)	(0.25,0.7)	(0.3,0.6)	(0.7,0.2)	(0.5,0.5)
	S	(0.7,0.25)	(0.5,0.4)	(0.6,0.2)	(0.35,0.6)	(0.5,0.5)

Table 4.12 Intuitionistic preference matrix for risks in partnership risk category

A_4		C_1	C_2	C_3	C_4	C_5	C_6
C_1	P	(0.5,0.5)	(0.3,0.6)	(0.25,0.7)	(0.5,0.3)	(0.4,0.5)	(0.35,0.6)
	S	(0.5,0.5)	(0.55,0.4)	(0.55,0.3)	(0.6,0.25)	(0.55,0.4)	(0.5,0.4)
C_2	P	(0.6,0.3)	(0.5,0.5)	(0.3,0.6)	(0.6,0.2)	(0.4,0.45)	(0.25,0.7)
	S	(0.4,0.55)	(0.5,0.5)	(0.5,0.35)	(0.6,0.35)	(0.6,0.3)	(0.55,0.35)
C_3	P	(0.7,0.25)	(0.6,0.3)	(0.5,0.5)	(0.5,0.35)	(0.45,0.5)	(0.35,0.6)
	S	(0.3,0.55)	(0.35,0.5)	(0.5,0.5)	(0.6,0.35)	(0.5,0.4)	(0.6,0.3)
C_4	P	(0.3,0.6)	(0.2,0.6)	(0.2,0.7)	(0.5,0.5)	(0.2,0.7)	(0.25,0.7)
	S	(0.3,0.5)	(0.25,0.6)	(0.35,0.3)	(0.5,0.5)	(0.3,0.5)	(0.35,0.5)

C_5	P	(0.5,0.4)	(0.45,0.4)	(0.5,0.45)	(0.7,0.2)	(0.5,0.5)	(0.55,0.4)
	S	(0.4,0.55)	(0.3,0.6)	(0.4,0.5)	(0.5,0.3)	(0.5,0.5)	(0.5,0.4)
C_6	P	(0.6,0.35)	(0.7,0.25)	(0.6,0.35)	(0.7,0.25)	(0.4,0.55)	(0.5,0.5)
	S	(0.4,0.5)	(0.35,0.55)	(0.3,0.6)	(0.5,0.35)	(0.4,0.5)	(0.5,0.5)

Step 2: Consistency checking

Absolute consistency cannot be achieved because of the subjective judgement of experts. However, the reasonable consistency of pairwise comparisons should be ensured according to the numerical equation of consistency checking. The intuitionistic preference relation constructed by the experts are consistently with unacceptable multiplicative consistency owing to lack of knowledge or the difficulty of discriminating the degree to which some alternatives are more serious than others. Accordingly, the comparison matrix for possibility in level 1 is taken as an example to check the consistency. Firstly, equations (2) and (3) are applied to obtain $\overline{\mathrm{R}}$. Taking $\overline{r}_{14}$ as an example:

$$\overline{\mu}_{14} = \frac{\sqrt[4-1-1]{\mu_{12}\mu_{24} \times \mu_{13}\mu_{34}}}{\sqrt[4-1-1]{\mu_{12}\mu_{24} \times \mu_{13}\mu_{34}} + \sqrt[4-1-1]{(1-\mu_{12})(1-\mu_{24}) \times (1-\mu_{13})(1-\mu_{34})}}$$

$$= \frac{\sqrt{0.4 \times 0.6 \times 0.45 \times 0.7}}{\sqrt{0.4 \times 0.6 \times 0.45 \times 0.7} + \sqrt{0.6 \times 0.4 \times 0.55 \times 0.3}} = 0.7155$$

$$\overline{v}_{14} = \frac{\sqrt[4-1-1]{v_{12}v_{24} \times v_{13}v_{34}}}{\sqrt[4-1-1]{v_{12}v_{24} \times v_{13}v_{34}} + \sqrt[4-1-1]{(1-v_{12})(1-v_{24}) \times (1-v_{13})(1-v_{34})}}$$

$$= \frac{\sqrt{0.5 \times 0.35 \times 0.5 \times 0.1}}{\sqrt{0.5 \times 0.35 \times 0.5 \times 0.1} + \sqrt{0.5 \times 0.35 \times 0.5 \times 0.1}} = 0.1537$$

We can construct the perfect multiplicative consistent intuitionistic preference relation $\overline{\mathrm{R}} = \left(\overline{r}_{ij}\right)_{4\times4}$ of the intuitionistic preference relation R of the possibility risk category:

$$\overline{\mathrm{R}} = \begin{bmatrix} (0.5,0.5) & (0.55,0.3) & (0.55,0.2222) & (0.7155,0.1537) \\ (0.3,0.55) & (0.5,0.5) & (0.5,0.4) & (0.65,0.2222) \\ (0.2222,0.55) & (0.4,0.5) & (0.5,0.5) & (0.65,0.3) \\ (0.1537,0.7155) & (0.2222,0.65) & (0.3,0.65) & (0.5,0.5) \end{bmatrix}$$

By calculating the distance between R and $\overline{\mathrm{R}}$ via equation (1), we obtain $d(\overline{R}, R) = 0.1006 > 0.1$. That is, the intuitionistic preference relation is of unacceptable consistency. Therefore, we need to repair the consistency. Equations (4) and (5) are used to calculate the fused intuitionistic preference relation $\widetilde{\mathrm{R}}$. Let $\sigma = 0.6$:

$$\widetilde{\mathrm{R}} = \begin{bmatrix} (0.5,0.5) & (0.55,0.3) & (0.591,0.2331) & (0.7093,0.1711) \\ (0.3,0.55) & (0.5,0.5) & (0.5,0.4) & (0.6303,0.2691) \\ (0.2331,0.591) & (0.4,0.5) & (0.5,0.5) & (0.65,0.3) \\ (0.1711,0.7093) & (0.2691,0.6303) & (0.3,0.65) & (0.5,0.5) \end{bmatrix}$$

Equation (6) can be used to calculate the distance between $\overline{\mathrm{R}}$ and $\widetilde{\mathrm{R}}$, whilst $\mathrm{d}(\overline{\mathrm{R}}, \widetilde{\mathrm{R}}) = 0.03689 < 0.1$, which means $\widetilde{\mathrm{R}}$ is with acceptable multiplicative consistency. The consistency checking and repairing process of other matrixes for each expert can be performed following the same process. This process is continued until all comparison matrixes can pass consistency checking and no longer needs to be repaired.

Step 3: Calculate the weighted matrixes

After all the comparison matrixes of each expert passed consistency checking, the measurement information was collected to obtain the weight of each risk factor. We calculated the average intuitionistic fuzzy set of each comparison matrix on the basis of the consistency repairing results of the five experts' evaluation tables. Taking the possibility measurement of level 1 as an example, the equations

$$r_{ij} \oplus r_{tl} = (\mu_{ij} + \mu_{tl} - \mu_{ij}\mu_{tl}, \upsilon_{ij}\upsilon_{tl}) \quad \text{and}$$

$$\lambda r_{ik} = \left(1-(1-\mu_{ik})^{\lambda}, \upsilon_{ik}^{\lambda}\right), \lambda > 0$$

were used to calculate the weighted average $\overline{\overline{\mathrm{R}}}$:

$$\overline{\overline{\mathrm{R}}} = 0.2 \times (r_1 + r_2 + r_3 + r_4 + r_5)$$

$$= \begin{bmatrix} (0.5,0.5) & (0.6263,0.2491) & (0.4878,0.3141) & (0.5956,0.222) \\ (0.2646,0.6163) & (0.5,0.5) & (0.3654,0.5055) & (0.4689,0.3261) \\ (0.3231,0.4778) & (0.5356,0.3519) & (0.5,0.5) & (0.5940,0.2862) \\ (0.239,0.5723) & (0.3475,0.4501) & (0.3058,0.5870) & (0.5,0.5) \end{bmatrix}$$

All the weighted matrixes followed the same process to obtain the outcome.

Step 4: Integrating the information

In the following step, the deriving priority vector of each acceptable consistent intuitionistic preference relation can be counted. By using equation (9), the weights of each risk factor group and each risk factor alternative are shown in Table 4.13.

Table 4. 13 Weight of each risk factor

Level 1 P	Level 2 P	Overall P	Level 1 S	Level 2 S	Overall S
(0.2444,0.6205)	(0.0893,0.7859)	(0.0218,0.9188)	(0.1792,0.7239)	(0.0815,0.8144)	(0.0146,0.9488)
	(0.1342,0.7504)	(0.0328,0.9053)		(0.1388,0.7574)	(0.0249,0.9330)
	(0.1724,0.7141)	(0.0421,0.8915)		(0.1410,0.7553)	(0.0253,0.9324)
	(0.0776,0.8127)	(0.0190,0.9290)		(0.1101,0.7846)	(0.0197,0.9405)
	(0.0992,0.7845)	(0.0242,0.9182)		(0.1013,0.7881)	(0.0181,0.9415)
	(0.1369,0.7431)	(0.0335,0.9025)		(0.1540,0.7242)	(0.0276,0.9238)
(0.1768,0.7131)	(0.1895,0.7856)	(0.0335,0.9385)	(0.2301,0.6747)	(0.1939,0.7864)	(0.0446,0.9305)
	(0.1962,0.7829)	(0.0347,0.9377)		(0.1743,0.7955)	(0.0401,0.9335)
	(0.1841,0.7878)	(0.0326,0.9391)		(0.2014,0.7849)	(0.0463,0.9300)
	(0.2008,0.7820)	(0.0355,0.9375)		(0.1837,0.7930)	(0.0423,0.9327)
	(0.1632,0.7908)	(0.0289,0.9400)		(0.1960,0.7866)	(0.0451,0.9306)
(0.216,0.6667)	(0.2068,0.7738)	(0.0447,0.9246)	(0.2488,0.6496)	(0.1860,0.7842)	(0.0463,0.9244)
	(0.1996,0.7763)	(0.0431,0.9254)		(0.1839,0.7842)	(0.0457,0.9252)
	(0.1808,0.7785)	(0.0390,0.9262)		(0.1591,0.8026)	(0.0396,0.9308)
	(0.1422,0.8039)	(0.0307,0.9346)		(0.2068,0.7780)	(0.0514,0.9222)
	(0.1890,0.7784)	(0.0408,0.9261)		(0.2001,0.7801)	(0.0498,0.9230)
(0.154,0.736)	(0.0942,0.7624)	(0.0145,0.9372)	(0.1608,0.7307)	(0.1267,0.6997)	(0.0204,0.9191)
	(0.1007,0.7682)	(0.0155,0.9388)		(0.1259,0.7100)	(0.0202,0.9219)
	(0.1438,0.7291)	(0.0222,0.9284)		(0.1085,0.7290)	(0.0175,0.9270)
	(0.0787,0.7978)	(0.0121,0.9466)		(0.0822,0.7606)	(0.0132,0.9355)
	(0.1306,0.7330)	(0.0201,0.9294)		(0.0985,0.7388)	(0.0158,0.9296)
	(0.1297,0.7338)	(0.0200,0.9297)		(0.0819,0.7583)	(0.0132,0.9349)

Thereafter, based on the $impact = (possibility \times severity)^{0.5}$, applying the IFS calculation rules, the final IFS of the impact of each risk factor in this project was

counted, whilst the ρ was calculated using equation (13) (see Table 12). The lower the value of $\rho(\alpha)$, the higher the IFV α in the sense of the amount of the information. Table 4.14 shows the ranking with detailed scores of each risk factor for this TPPP project using the IFAHP methodology.

Table 4.14 Ranking of the risk factors impact in the TPPP case

Rank	Risk factor	IFV	$\rho(\alpha)$
1	Technology risk	(0.045467,0.924494)	0.491603
2	Natural environment risk	(0.045069,0.924559)	0.491967
3	Construction risk	(0.044405,0.925316)	0.492265
4	Administrative risk	(0.038747,0.93511)	0.493192
5	Political risk	(0.038847,0.934743)	0.493268
6	Legal risk	(0.038667,0.934641)	0.493497
7	Corruption risk	(0.037299,0.935641)	0.494376
8	Force majeure	(0.039747,0.928693)	0.495279
9	Lack of government support	(0.036069,0.935447)	0.495694
10	Operation risk	(0.039309,0.92855)	0.495784
11	Currency risk	(0.032619,0.914385)	0.509324
12	Financing risk	(0.028561,0.920339)	0.51054
13	Payment risk	(0.030384,0.913827)	0.511855
14	Demand and revenue risk	(0.019341,0.934984)	0.512725
15	Tax risk	(0.020977,0.930827)	0.513104
16	Tariff risk	(0.017853,0.935479)	0.513991
17	Worker risk	(0.019665,0.927728)	0.515954
18	Competitiveness risk	(0.012655,0.941302)	0.516403
19	Credit risk	(0.017714,0.930844)	0.516409
20	Cultural impediments	(0.017845,0.929544)	0.516914
21	Language differences	(0.016219,0.932335)	0.517196
22	Cooperation risk	(0.017196,0.928748)	0.517966

4.4.5 Discussion of key factors evaluated in Project X

The results in Table 4.11 shows that the top five risk factors in TPPP projects are technology, natural environment, construction, administrative and political. These five risk factors are discussed as follows.

4.4.5.1 Technology risk

Technology was assessed as the top-ranked risk amongst the risk factors in Project X (Table 4.11). This result suggests that TPPP projects involve complex technologies that could pose a serious risk to the project. This finding is critical because potential technology difficulty necessarily exists in Project X and may be related to every TPPP project. For example, lack of innovation in design (Babatunde et al., 2015a), lack of reliability and quality of the technical proposal (Wang et al., 1998b) and technological obsolescence (Ramakrishnan, 2014b) are technological challenges of working in a foreign market. Technology risk adversely affected Project X because of the inaccurate and non-specific geological prospecting data and the feasibility study report provided by the local government. After winning the contract, the private sector hired a professional team to undertake the geological survey again and provided reasonable suggestions for engineering technology and design. Therefore, technology risk seriously affected the TPPP project in terms of cost and time.

4.4.5.2 Natural environment risk

The risk regarding the environment of the host country reminds the investors of TPPP projects to comprehensively investigate the natural conditions of the project location before implementing or even considering the project. The result indicates that the risk assessment team is highly concerned with the natural environment of

Project X. In this project, the seasonal shortage of river water resources is one of the serious environmental problems that may lead to a lack of energy supply. Moreover, this hydropower station is in the tropic area, with changeable climate, snakes, mosquitoes and the possibility of landslides or other adverse events. Another primary reason is that the host country's jungle is replete with landmines because C country was engaged in a war with a neighboring country for many years. Local media reports indicate that these mines cause approximately 200 casualties annually. This situation caused problems for the reconnaissance and construction. To ensure the safety of workers, the host government sent soldiers to check the exploration, construction and the reservoir areas. Over 500 landmines were recovered by the soldiers. Therefore, serious natural environment affected construction safety and convenience of Project X, thereby increasing the cost and time of the project. The effect of poor natural environment on TPPP project is supported by previous research, including geotechnical conditions, weather, environment and population density (Muller, 2003a, Jacobs and Franceys, 2008).

4.4.5.3 Construction risk

The project hints that the risk assessment team is more concerned with the construction stage than the operation stage. Project X is in the southwest of C country and 15 kilometres away from a large city. The dam in this project is a roller compacted concrete gravity dam with a total installed capacity of 193,200 kilowatts and annual average generating capacity of 498 million degrees. The main function of this hydropower station is to generate electricity and have auxiliary functions, such as urban water supply and irrigation. Given the huge scale and construction complexity of this project, the potential construction risks and challenges are serious as well. The potential implications of the construction risks in Project X

may include low project quality, high project cost and long construction period, thereby possibly affecting the long-term sustainability of the project. The construction contractor used the contract as basis to consider the entire construction risk without government support, thereby making the potential construction risk impact considerably serious. If the construction risk is reasonably mitigated, then the project quality can be improved and the potential risks in the operation stage can be decreased. Additionally, the high rank of construction risk in this study corroborates the findings of previous research (Chou and Pramudawardhani, 2015; Meduri and Annamalai, 2013).

4.4.5.4 Administrative risk

The risk related to administration ranked fourth and reflects the complexity of conducting PPP projects in another country. This finding suggests that different countries have various administrative systems, which may easily cause conflicts during the collaboration amongst different stakeholders. Such policies as importing equipment or materials and restriction on land acquisition have serious effects on the project.

Project X did not consider the strict policy of importing materials. Some materials were seized by customs, thereby resulting in project delays. Evidently, government support is important to solve administrative problems. On the one hand, the relevant Chinese government department (i.e. Chinese Embassy in C country) assisted in handling the relationship amongst Chinese-funded enterprises, project companies and local governments during the entire development and implementation periods for Project X. The China Export-Import Bank, China Development Bank and China Export & Credit Insurance Corporation supported the project in terms of project

financing and guarantee. On the other hand, the C country government provided considerable attention and strong support. To enhance the enthusiasm of Chinese enterprises, the host government implemented preferential policies, such as tax exemption period and import tax exemption. The Chinese prime minister and C Country prime minister attended the ground-breaking ceremony, thereby indicating that Project X was the largest and most dazzling 'Star Project' in C country.

4.4.5.5 Political risk

Political risk reminds private investors of the difficulties in investing in foreign countries for TPPP projects. In TPPP, private investors engage in business in politically sensitive sectors with powerful local governments. Thus, these investors need sound and legal and political support to ensure fairness, transparency and long-term sustainability (Wibowo and Alfen, 2015). However, political instability affects infrastructure projects in the majority of developing countries, thereby leading to insufficient payment and even expropriation in a few cases (Babatunde et al., 2015a).

For Project X, the political system of the host country is fragile and contradictions and disputes amongst different parties abound. The national risk of this host country in the China International Trust and Investment Corporation (CITIC) insurance risk rating is in the eighth category, which means that political risk is high. That is, the political system is affected by the military strength of the parties, thereby resulting in potential threat to the project. However, the current government has been working on domestic political stability. Particularly, the government implemented the opening and free market economic strategy and attached importance to infrastructure projects.

Other potential political risk factors in TPPP projects include political interference in the procurement process, political reneging during such a long period, withdrawal of government support network, termination of concession by the government, revocation, expropriation, sequestration or political force majeure events (Wang and Tiong, 2000b, Chou and Pramudawardhani, 2015b). On the basis of the fair risk allocation principle, governments will benefit from retaining the majority of the political risks (Lobina, 2005), given their ability to take on this responsibility.

4.4.6 Process of risk allocation by BGT

Step 1

The bargaining process aims to calculate the risk ratios for risk factors, which are shared by both stakeholders. Hence, the 22 risk factors can be divided into 2 groups, namely, risks that should be allocated to one stakeholder and risks that should be shared by the public and private sectors. In the first step, experts were invited to provide the primary perception of the risk allocation plan for each risk factor for Project X. For each risk factor, the experts can choose to allocate it to the public sector, private sector or share between the two sectors. Principles for equitable risk allocation of TPPP projects (see Table 1) were introduced to experts firstly to help participants give rational responses. When the five experts agreed to allocate one risk factor to the public or private sector, this consensus is the final allocation strategy for such a risk factor unless other factors will be included in the second step to bargain the allocation ratio between the two stakeholders. Table 4.15 summarises the result of the primary risk allocation from the five experts.

Table 4. 15 Primary risk allocation results from the five experts for TPPP Project X

Rank	Risk factor	E1	E2	E3	E4	E5	Agree
1	Technology risk	P	P	S	S	S	
2	Natural environment risk	S	S	S	S	S	√ S
3	Construction risk	P	P	P	P	P	√ P
4	Administrative risk	S	P	S	G	S	
5	Political risk	G	G	G	G	G	√ G
6	Legal risk	G	G	G	G	G	√ G
7	Corruption risk	S	S	G	S	S	
8	Force majeure	S	S	S	S	S	√ S
9	Lack of government support	G	G	G	G	G	√ G
10	Operation risk	P	P	S	P	P	
11	Currency risk	S	S	S	S	S	√ S
12	Financing risk	S	P	S	P	S	
13	Payment risk	S	G	S	G	S	
14	Demand and revenue risk	S	P	S	S	S	
15	Tax risk	G	G	G	G	G	
16	Tariff risk	S	P	S	P	G	
17	Worker risk	S	P	S	S	S	
18	Competitiveness risk	S	P	G	G	S	
19	Credit risk	S	P	G	S	S	
20	Cultural impediments	S	S	S	S	S	√ S
21	Language differences	S	S	S	S	S	√ S
22	Cooperation risk	S	S	S	S	S	√ S

Note: E1-E5 = Expert 1 to 5 participated in the questionnaire survey; P = this risk factor should be allocated to the private sector; G = this risk factor should be allocated to the public sector; S = this risk factor should be shared by both the public and private sectors. √ = the perceptions of the five experts are consistent.

'Construction risk', 'political risk', 'legal risk' and 'lack of government support' are the only four factors solely allocated to one stakeholder. Table 4.15 shows that construction risk is the only factor that all experts agree to allocate to the private sector in Project X. This project is a major dam with a total installed capacity of 193,200 kilowatts and annual average generating capacity of 498 million degrees. The main function of this hydropower station is to generate electricity and have auxiliary functions, such as urban water supply and irrigation. Given the huge scale and complexity of this project, the potential construction risks and challenges are serious. This factor is the main reason for C country government's preference to adopt the TPPP scheme in this project. The private sector took the entire

construction risk because it is the main stakeholder and manager of the construction period. The potential implications of construction risks in Project X may include low project quality, high project cost and long construction period, thereby possibly affecting the long-term sustainability of the project and the private sector's costs and benefits. Given that the private sector is responsible for the construction and operation stages, well-managed construction risks can decrease the potential operation risks and improve the project quality.

Additionally, the five experts agreed to allocate political and legal risks and lack of government support to the private sector. Political risk is difficult to prevent when the private sectors attempts to invest in a foreign country. For Project X, the national risk of C country in CITIC is ranked in the eighth category, which means that the political risk is high. Many potential political situations include contradictions and disputes amongst different parties, political reneging during such a long period, withdrawal of government support network, termination of concession by the government, revocation, expropriation, sequestration or political force majeure events (Wang and Tiong, 2000b, Chou and Pramudawardhani, 2015b). Given that C country is a developing country, its government should assume the entire responsibility of political risk to provide sound and legal political support, thereby ensuring fairness, transparency and long-term sustainability. Law is an important factor considered by the private sector because it provides a regulatory, legal and institutional framework for the private sector and the project (Khalifa and Essaouabi, 2003). The legal system in C country is immature and unstable. Hence, the private sectors should adapt to local policies and industry regulations and attempt to use fair negotiations to solve policy debates. The legislation in this country has been revised regularly. Thus, the government should take the legal risk to provide

guaranty for the private investor. Moreover, the private sector has no power to ask support from the local government even if such an assistance is critical for project success. Therefore, the public sector could assume the entire risk of lack of government support. Except for these four risk factors, all the other 18 risk factors were considered to be shared between the public and private sectors and subsequently placed in the next step for allocation on the basis of BGT.

Step 2

To apply BGT in calculating the risk allocation ratio for the 18 sharing risk factors, various parameters, including $\xi_g, \xi_p, p_1 \; and \; \alpha$, should be obtained from the experts. The questionnaire explained the definition of these parameters in detail and experts were invited to rate them. Table 4.16 shows the mean values from the five experts.

Table 4.16 Related parameter values

Risk factor	ξ_g	ξ_p	p_1	α
Technology risk	1.23	1.25	0.8	0.1
Natural environment risk	1.1	1.15	0.7	0.13
Administrative risk	1.07	1.17	0.6	0.15
Corruption risk	1.08	1.2	0.6	0.14
Force majeure	1.13	1.15	0.7	0.11
Operation risk	1.19	1.2	0.9	0.24
Currency risk	1.17	1.23	0.8	0.2
Financing risk	1.20	1.24	0.8	0.12
Payment risk	1.13	1.22	0.7	0.19
Demand and revenue risk	1.15	1.16	0.9	0.11
Tax risk	1.05	1.19	0.6	0.10
Tariff risk	1.07	1.22	0.8	0.14
Worker risk	1.17	1.19	0.7	0.19
Competitiveness risk	1.05	1.1	0.7	0.15
Credit risk	1.15	1.18	0.6	0.14
Cultural impediments	1.04	1.07	0.6	0.11
Language differences	1.08	1.1	0.6	0.13
Cooperation risk	1.19	1.23	0.7	0.15

Step 3

The risk allocation ratio for the 18 risk factors can be calculated from the equations shown in Table 3. Taking technology risk as an example, where $\xi_g = 1.23, \xi_p =$

$1.25, p_1 = 0.8\ and\ \alpha = 0.1$, the mean values were adopted in the equations.

The risk allocation nominal ratio for the public sector is as follows:

$$r_g = \frac{\xi_p - 1}{\xi_p \xi_g - 1} + p_1 \alpha = \frac{1.25-1}{1.25\times1.23-1} + 0.8 \times 0.1 = 0.5451.$$

The risk allocation nominal ratio for the private sector is as follows:

$$r_p = \frac{\xi_p \xi_g - \xi_p}{\xi_p \xi_g - 1} - p_1 \alpha = \frac{1.25\times1.23-1.25}{1.25\times1.23-1} - 0.8 \times 0.1 = 0.4549.$$

The risk allocation actual ratio for the public sector is as follows:

$$\widetilde{r_g} = \frac{\xi_p - 1}{\xi_p \xi_g - 1} = \frac{1.25-1}{1.25\times1.23-1} = 0.4651.$$

The risk allocation actual ratio for the private sector is as follows:

$$\widetilde{r_p} = \frac{\xi_p \xi_g - \xi_p}{\xi_p \xi_g - 1} = \frac{1.25\times1.23-1.25}{1.25\times1.23-1} = 0.5349.$$

Applying the data from Table 8 in the equations from Table 3, the risk allocation ratio of the nominal and actual ratios for each risk factor were calculated and shown in Table 4.17.

Table 4. 17 Risk allocation ratio of Project X

Risk factor	Nominal Ratio		Transfer Ratio	Actual Ratio	
	Public	Private		Public	Private
Technology risk	54.51%	45.49%	8.0%	46.51%	53.49%
Natural environment risk	65.70%	34.30%	9.1%	56.60%	43.40%
Administrative risk	76.49%	23.51%	9.0%	67.49%	32.51%
Corruption risk	75.97%	24.03%	8.4%	67.57%	32.43%
Force majeure	57.78%	42.22%	7.7%	50.08%	49.92%
Operation risk	68.33%	31.67%	21.6%	46.73%	53.27%
Currency risk	68.38%	31.62%	16.0%	52.38%	47.62%
Financing risk	58.78%	41.22%	9.6%	49.18%	50.82%
Payment risk	71.41%	28.59%	13.3%	58.11%	41.89%
Demand and revenue risk	57.80%	42.20%	9.9%	47.90%	52.10%
Tax risk	82.15%	17.85%	6.0%	76.15%	23.85%
Tariff risk	83.24%	16.76%	11.2%	72.04%	27.96%
Worker risk	61.73%	38.27%	13.3%	48.43%	51.57%
Competitiveness risk	75.02%	24.98%	10.5%	64.52%	35.48%
Credit risk	58.82%	41.18%	8.4%	50.42%	49.58%
Cultural impediments	68.66%	31.34%	6.6%	62.06%	37.94%
Language differences	60.99%	39.01%	7.8%	53.19%	46.81%
Cooperation risk	60.10%	39.90%	10.5%	49.60%	50.40%

4.4.7 Discussion of the risk allocation result of Project X

The actual ratio indicates the sharing proportion of each risk factor for the public and private sectors. The three forms of allocation are as follows based on the result of applying BGT in TPPP Project X: allocation in which the (1) public sector assumes the majority of the risks, (2) private sector assumes the majority of the risks and (3) risks are shared equally between the public and private sectors.

4.4.7.1 Allocation in which the public sector takes more risks

The public sector has more risk ratio than the private sector in terms of the natural environment, administrative, corruption, currency, payment, tax, tariff, competitiveness, cultural impediments and language difference. This overall outcome is no longer surprising because the host country government has more rights and power than the private sectors in Project X to manage these risk issues. Nearly all these risks have the same characteristic (i.e. they are related to the national environment or government policy and officers' actions) (Ke et al., 2010b). These risks can be divided into three subcategories, namely, risks related to the national environment, local participating government and at the project level.

Four risks, namely, currency, tax, cultural impediments and language differences, could be counted in the national environment-level risk in Project X. The economic market and cultural environment vary from one project and country to another (Sachs et al., 2007). Given the long concession period of Project X (44 years), fluctuation in currency exchange rate and difficulty of convertibility may occur during this period. Although the main stakeholders have agreed to use US dollars as the main transaction currency in this project, the operation revenues paid by users are local currency. If an economic crisis occurs during the operational period, then

the local government is the party that can help the project company deal with such a risk. Therefore, for the public sector to assume more currency risk than the private sector is reasonable. Tax risk is a business and governance issue and should be assigned to the public sector because the government has the power to control the local tax policy. In Project X, the host country is a religious country and the majority of the population can only speak their local language. Therefore, cultural impediments and language difference are unavoidable. Moreover, the majority of the Chinese staff and local officials cannot speak English. Hence, they need professional translators to help communicate. The operational costs and the potential for communication, marketing and operational errors of investors originating from countries with different languages and business practices are considerably high (Pothukuchi et al., 2002). Therefore, the local government should have an open attitude to the Chinese investor, assume additional risks caused by culture or language differences and exert effort to help the Chinese sector adapt to the local environment. Additionally, risks in this category may be caused by the different national environment for the public and private sectors. The local public sector must help foreign investors to avoid contravening the macro environment (Wang and Tiong, 2000a).

The second category relative to the local public sector consists of three risk factors, namely, administrative, payment and corruption risks. The administrative systems in different countries are different from one another. Such policies as importing equipment or materials and restriction on land acquisition have serious impact on the project. Project X is considered a significant project in C country because of the cooperation of the country and the Chinese government to support this project. The local government plays a key role in project administration, from project approval,

land acquisition, granting tax and import tax exemptions, to the implementation of import policies. The Chinese Embassy in C country helped in handling the relationship between investors and the local government. Thus, the public sector must assume more administrative risk than the private sector. The revenue for Project X is from the users' fee and government subsidy. The local government has undertaken to pay the concessionaire annuities on each annuity payment date as per the annuity payment schedule (Singh and Kalidindi, 2006). Given the dire economic situation of C country government, the local government in this country may occasionally be unable to pay for the subsidy on time. This risk is reasonable to be predominantly borne by the public sector. Moreover, the private sector should assume the responsibility of providing high-quality services and remind the government regularly to avoid payment risks. In TPPP projects, the private sector must strive for the government's cooperation and assistance, although this action may substantially result in corruption (Wang, 2002). If the local government lacks serious anti-corruption laws or policies for officials, then project companies may have to provide additional funding, time and effort in dealing with the relationship they have with the local government, thereby possibly exerting a negative influence on the efficiency and profits of projects (Ke et al., 2010b). This situation may explain the reason why the public sector should assume additional corruption risks.

The remaining risks, namely, natural environment, tariff and competitiveness, are included in the third category relative to Project X. These risks are predominantly borne by the public sector to show government incentives and support (Ke et al., 2010b). The natural environment deals with geotechnical conditions and environmental problems that may be hardly changed or controlled by manpower. In Project X, the changeable climate and seasonal shortage of river water resources

may lead to a lack of energy supply. The project is located in the tropics and snakes and mosquitoes are common in this area. The public sector should be considerably familiar with the local environment and history. Thus, the public sector is capable of assuming the majority of the environmental risk. Whether the promised tariff changes would materialise is a key risk to private investors. An important revenue source of Project X is the users' payment for electricity. One of the most critical factors to evaluate PPP projects, which should particularly be considered by the public, is an acceptable level of tariff (Ng et al., 2012). For Project X, the local government has the authority to adjust the price of electricity to balance the revenue of the project company and satisfaction of the general users. If the tariff has to be revised because of the market or inflation during the long concession period, then the government should renegotiate with the private sector on agreement of the tariff policy. Understandably, the public sector must assume the majority of the tariff risk. Another possible risk is that new projects can provide similar or advanced electric power to compete or even replace Project X. Government support would be offered to ensure that no similar competitive project will be approved; thus, the market volume would not be undermined by the other projects (Ke et al., 2010b). For Project X, the local government should make a suitable macro-level plan of power provider, whilst the private sector should attempt to consistently provide high-quality services. Thus, these two risks should be shared by the public and private sectors, whilst the former should assume additional share in the risks.

4.4.7.2 Allocation in which the private sector takes more risks

For technology operation, demand, revenue and worker risks, the private sector assumes risks more than the public sector. These risks were sourced endogenously (i.e. risk events and their consequences occurring within the system boundaries of

the project) (Bing et al., 2005). In Project X, Sinohydro Corporation Limited (private sector) is the main stakeholder that assumed the construction and operation technology because of its experiences and resources. Therefore, this risk should predominantly be borne by the private sector. The local government must provide the primary feasibility study report and local technical support. Many potential risks can manifest in the 40-year operation stage, such as the operation cost overrun, operator default, quality of operation, frequency of maintenance, low operating productivity (Xu et al., 2010b). The operation risk allocations confirm the developer's responsibility for the quality of operation services (Nguyen et al., 2018). To bear this risk, the private sector must balance the budget in the construction stage and efficient delivery with high-quality assets and services. The private sector is the main stakeholder responsible for the project operation, whilst the credibility of the local government is critical in determining whether a long-term project operation can be maintained (Choi et al., 2010a). Therefore, operation risk to public and private stakeholders should be assumed, whilst the latter should assume additional risks. Demand and revenue are mainly related to electric power quality and price, respectively, provided by Project X, as well as related to local economic development. Thus, the private sector can take additional risks to ensure quality service and affordable price for local users. One critical potential risk for the transnational project is the worker problem. This risk may be caused by the high costs associated with construction worker injuries or low professional skills and productivity (Gambatese and Hinze, 1999). Staff should be suitably employed and managed to ensure their safety and guarantee project productivity. An infrastructure megaproject requires considerable manpower, particularly in the construction stage. Thus, the direct project manager-private company should assume more labor

problem risks.

4.4.7.3 Allocation in which the risks are shared equally between the public and private sectors

When the actual risk ratios of the public and private sectors are between 49% and 51%, these risks (i.e. force majeure, financing, credit and cooperation risk) should be shared equally between the two parties. The nature of these four risk factors is such that the public or private sector may be unable to individually deal with them. Hence, a shared mechanism would be the best option (Bing et al., 2005). Force majeure means the circumstances that are out of control of the foreign and local partners, such as flood, storms, war, hostilities and embargo (Ke et al., 2010b). This risk is generally considered serious but have low probability of occurrence. The public or private sector cannot predict force majeure and facing such circumstances individually can be difficult. Thus, to share equally these kinds of risks is fair to the two stakeholders. The private sector is more familiar and experienced in commercial project financing techniques and financial markets than the public sector (Bing et al., 2005). Meanwhile, the government can attach importance to this project as a significant public infrastructure and provide financing support. Hence, an equal sharing mechanism would be the best option. Any stakeholder that fails to fulfil obligations in the concession contract can negatively affect the project directly or indirectly (Song et al., 2013). Both stakeholders in Project X should be honest and strictly follow the contract to avoid credit risks. Additionally, cooperation risk should also be equally shared by the two stakeholders because the public and private sectors should contribute to good relationship and collaboration.

4.5 CHAPTER SUMMARY

This chapter attempted to solve two important risk management problems in the

TPPP project management process.

Firstly, IFAHP was adopted to evaluate the risk factor impact. This methodology was explained systematically. A hydropower case (i.e. Project X in country C) showed that the IFAHP method can be used to evaluate and prioritise risk factors in terms of their occurrence possibility and severity. The risk assessment results showed that the top five risk factors in the TPPP project are technology, natural environment, construction, administrative and political. This study provided a risk evaluation process, which would help industry practitioners and stakeholders of TPPP projects, including the public and private sectors, to identify and measure the risks in TPPP projects. Furthermore, the process could identify the most critical risk factors in a specific project and formulate the appropriate strategies to allocate and mitigate potential risks.

Secondly, critical risk factors were allocated to the public and private sector by using BGT. The hydropower case of Project X was adopted to show the process of this method. The risk allocation results in this project showed detailed risk ratio assumed by the public and private sectors. This method indicated that the risk allocation ratio is associated with the negotiation loss factor and the asymmetric degree of knowledge and position of both parties. The ratio is influenced by unequal status because the public sector can leverage its strong position to transfer additional risks to the private sector. What should be emphasised is that the risk allocation principles should be considered during the allocation negotiation to provide suitable values for each parameter. Additionally, risk identification and evaluation should be conducted before the allocation to help stakeholders understand the risk situations and potential impact, thereby possibly enabling their

preparation for an appropriate allocation plan. A fair and optimal risk allocation can reduce time and money expenditure and facilitate the achievement of TPPP project excellence.

Risk evaluation is a complicated task, in which the vagueness and uncertainty of experts are nearly unavoidable. The IFAHP method adopted in this study is suitable for dealing with the uncertainties in expert judgements. To extend and validate the wide applicability of the IFAHP technique and the identified risk factors, further research is required to test the applicability of the risks across infrastructure sectors where TPPP is applied or increasingly considered by the government or private sector.

BGT used in this section and the determination of the equilibrium solution determine the distribution ratio of each risk factor for TPPP projects, as well as provide decision-making basis for the scientific, rational and fair allocation of risks. The results contribute to the PPP literature through the development of a risk allocation process and enrich the current body of knowledge and understanding of academics and practitioners in the TPPP procurement approach to achieve equitable risk sharing. For practitioners in TPPP projects, the risk allocation method provided by this study is beneficial in formulating risk management strategies and reducing the subjectivity in the risk allocation process.

CHAPTER 5 KEY SUCCESS FACTORS FOR TPPP PROJECTS

5.1 INTRODUCTION

Many successful PPP cases around the world, such as the Jamaican North-South Expressway PPP, Chengdu No. 6 Water and Sri Lanka Colombo Port City project, can be used as demonstration benchmarks for future projects. However, not all PPP projects have achieved the same success. Continuous assessment and exploration of CSFs is important to the success of PPP projects (Osei-Kyei and Chan, 2017c). For government agencies and private sectors that recently attempted to adopt the PPP model or participate in the overseas PPP market, identifying CSFs can maximise the advantages of the project and facilitate in projecting stakeholders to focus clearly on the key issues (Cheung et al., 2012a).

PPP has been used in many developed countries and developing countries. Compared with DPPP, TPPP is a multinational business strategy and a special cross-boarder partnership. The implementation of PPP projects in other countries is different from that in the home country for investors (Bing et al., 2005). For government agencies, the partnership and management are different when the investor is from another country. These differences need special attention and consideration. The importance of CSFs in TPPP and DPPP is not the same. The current chapter will prove this hypothesis and focus on TPPP.

In the past several decades, many studies have discussed CSFs for PPP projects (Li et al., 2005, Osei-Kyei and Chan, 2017d). Additionally, researchers have attempted to conduct comparative studies to analyse the differences in CSFs amongst

countries. However, CSFs for TPPP projects have not been analysed systematically, particularly through a comparative study between TPPP and DPPP. This chapter aims to compare the identified similarities and differences between TPPP and DPPP. The results are intended to increase the participants' knowledge of TPPP specificity and avoid the experience of directly applying DPPP projects when implementing TPPP projects.

5.2 COMPARATIVE STUDY

5.2.1 Questionnaire survey

In the final questionnaire, the instructions are in detail and meant to gather background information of the respondents. Thereafter, the questionnaire presented 27 identified success factors and asked the respondents to value the importance of each factor by using a five-point Likert scale (i.e. 1 = extremely unimportant, 2 = unimportant, 3 = neutral, 4 = important, 5 = extremely important). This study adopted the five-point Likert scale because it provides unambiguous results that are easy to interpret (Ekanayake and Ofori, 2004). The experts' opinions on TPPP are collected as a part of the entire questionnaire of the current study, whilst the data for DPPP CSF were adopted from Robert Osei-Kyei (2017). That study assessed the similarities and differences between CSFs in developed and developing economies and the data can represent DPPP. Table 5.1 summarises the background information of the respondents for TPPP and DPPP.

Table 5.1 Background information of the respondents

Characteristics		**DPPP**		**TPPP**	
		No. of respondents	Percent (%)	No. of respondents	Percent (%)
Sector of PPP	Academic	21	20.39	30	47.62
	Public	47	45.63	12	19.05
	Private	35	33.98	21	33.33
	Total	103	100	63	100
Years of	5 years and below	38	36.89	30	47.62

industrial and/ or research experience	6-10 years	39	37.86	12	19.05
	11-15 years	16	15.53	9	14.28
	16-20 years	6	5.83	3	4.76
	21 years and above	4	3.89	9	14.29
	Total	103	100	63	100

5.2.2 Comparative results and discussion

5.2.2.1 Consistency of respondents in each group

Table 5.2 shows that Kendall's coefficient of concordance (W) was applied for each independent group at a significance level of 0.05. The test was conducted with a hypothesis that no consistency exists in the ranking of factors amongst the respondents in a respondent group. The result of Kendall's coefficient of concordance (W) for all of the factors in the two groups are 0.24 (DPPP) and 0.246 (TPPP). These groups are statistically significant at the 0.000 level. However, the chi-square value should be employed rather than the W value because the number of critical factors was set to be above 7. For the DPPP group, the critical chi-square value is 44.985 with reference to the accepted critical values of the chi-squared distribution, under the degree of freedom (df:31) and allowable level of significance of 5%. This result suggests that the actual calculated chi-squared value is 765.44, which is above the critical value 44.985. For the TPPP group, the critical chi-square value is 68.984 with reference to the accepted critical values of chi-squared distribution, under the degree of freedom (df:26) and allowable level of significance of 5%. The actual calculated chi-squared value is 402.469, which is also above the critical value. This result implies that a significant degree of agreement exists amongst the respondents in the DPPP and TPPP groups, thereby reaffirming the validity and genuineness of the survey respondents for further analysis.

Table 5.2 Results of Kendall's concordance analysis

Characteristics	DPPP	TPPP
Number of survey respondents (N)	103	63
Kendall's Coefficient of Concordance (W)	0.24	0.246
Chi-square	765.44	402.469

Degree of freedom (df)	31	26
Critical value of chi-square	44.985	68.984
Asymp. Sig.	0.000	0.000

5.2.2.2 Mean ranking and quartile groupings in each group

Table 5.3 shows the mean ranking of CSFs. When the mean values of at least two CSFs are the same, the one with a lower standard deviation is ranked higher (Field, 2013). The mean values range from 2.78 to 4.4 for TPPs and from 3.34 to 4.56 for DPPPs. The last column in Table 7.4 shows the significant test results on the ranking of PPP project success factors amongst the respondents for TPPP and DPPP. The test was conducted at a pre-defined significance test value of 0.05. Thus, a success factor with a p-value of below 0.05 indicates that the respondents from both countries view the importance of this criterion differently. Table 5.3 shows that 12 CSFs have significance test values below 0.05. This result suggests that the respondents have different views and opinions on the importance of the 12 CSFs. This finding supports the assertion that PPP success factors are different for DPPP and TPPP.

Table 5.3 Results of the Mean Whitney U test of CSFs for DPPP and TPPP projects amongst the respondents

PPP/TPPP Project CSF	TPPPs			DPPPs			PPPs		Mann-Whitney U test		
	Mean	σ	Rank	Mean	σ	Rank	Mean	Rank	U	Z	p
Favorable legal framework	4.4	0.7	1	4.56	0.52	1	4.46	1	2917	-1.245	0.213
Long term demand for the project	4.17	0.83	2	3.45	0.84	20	3.90	8	2420.5	-3.079	**0.002**
Appropriate risk allocation and sharing	4.14	0.77	3	3.96	0.85	5	4.07	2	2849.5	-1.426	0.154
Selecting the right project	4.08	0.78	4	3.84	0.78	6	3.99	4	3000	-0.878	0.380
Choosing the right partner	4	0.69	5	3.76	0.99	9	3.91	6	2863.5	-1.356	0.175
Clarity of roles and responsibilities among parties	3.95	0.74	6	4.21	0.6	3	4.05	3	2640.5	-2.243	0.125
Strong private consortium	3.94	0.89	7	3.56	0.91	18	3.80	11	2487.5	-2.660	**0.008**
Strong commitment by both parties	3.87	0.92	8	3.68	0.69	10	3.80	10	2841.5	-1.456	0.145
Political support	3.84	0.98	9	3.82	0.68	7	3.83	9	3082	-0.585	0.558
Suitable environment	3.81	0.92	10	3.35	0.78	24	3.64	13	2259.5	-3.484	**0.000**
Transparent procurement	3.73	0.89	11	4.25	0.95	2	3.93	5	2182	-3.744	**0.000**
Political stability	3.71	0.98	12	4.21	0.65	4	3.90	7	2310	-3.345	**0.001**
Reliable service delivery	3.71	0.72	13	3.61	0.74	14	3.67	12	3025.5	-0.795	0.426
Government providing guarantees	3.7	0.94	14	3.17	0.91	27	3.50	16	2300.5	-3.310	**0.001**
Clear project brief and design development	3.59	0.75	15	3.67	0.75	11	3.62	14	3002	-0.879	0.380
Well organized and committed public agency	3.52	0.61	16	3.57	0.71	16	3.54	15	3104.5	-0.517	0.605

Stable macroeconomic condition	3.4	0.97	17	3.41	0.97	23	3.40	18	3238	-0.023	0.982
Acceptable level of tariff	3.37	0.84	18	3.45	0.70	22	3.40	19	3092.5	-0.545	0.586
Public/community support	3.32	0.89	19	3.2	0.8	26	3.27	24	3022.5	-0.801	0.423
Sound economic policy	3.27	0.84	20	3.45	0.72	21	3.34	20	2913.5	-1.198	0.231
Competitive procurement	3.21	0.84	21	3.48	1.05	19	3.31	21	2626.5	-2.161	**0.031**
Detailed project planning	3.21	0.76	22	3.8	0.66	8	3.43	17	1901.5	-4.889	**0.000**
Open and constant communication	3.13	0.88	23	3.57	0.74	15	3.3	23	2332.5	-3.260	**0.001**
Mature and available financial market	3.11	0.86	24	3.63	0.74	13	3.31	22	2141.5	-3.936	**0.000**
Clear goals and objectives	3.08	0.84	25	3.57	0.75	17	3.27	25	2261	-3.545	**0.000**
Technology innovation	2.92	0.88	26	3.05	0.88	29	3.00	26	2979	-0.944	0.345
Streamline approval process	2.78	0.84	27	3.34	0.72	25	2.99	27	2012.5	-4.446	**0.000**

The importance scores of the 12 CSFs were significantly different between the DPPP and TPPP groups, including long-term demand for the project, strong private consortium, suitable environment, transparent procurement, political stability, government providing guarantees, competitive procurement, detailed project planning, open and constant communication, mature and available financial market, clear goals and objective and streamline approval process.

The TPPP and DPPP respondents ranked 'political stability' 12th and 4th, respectively. PPP project is closely related to the political environment of the host country (Li et al., 2005). A stable political system is conducive to creating a good investment environment that can reduce or eliminate concerns from the private sector. In view of the government's absolute control over the private sector of the country, domestic project investors are in a weak position in a partnership with the local government. However, foreign investors in a TPPP project may have some negotiation power based on national relations and diplomatic influences.

'Government guarantee' was ranked 14th and 27th in TPPP and DPPP, respectively. In PPP projects, the government assumes the roles of managers and participants. The support from the government and political leaders can attract additional investors to bid for a project and improve the competitiveness of the bidding process. For TPPP projects, government guarantees will enhance the confidence of foreign investors and the ability to cope with risks. Therefore, government guarantee is important in TPPPs.

PPP is a useful strategy to use the expertise and capital from the private sectors to promote infrastructure development (Grimsey and Lewis, 2002). In developing countries, the private sectors are involved in PPP projects by contributing to

financing and operation technology. 'Strong private consortium' can improve the possibility of project success. Thus, selecting a private sector with superior capabilities and extensive experiences is critical to project success. The local government should judiciously implement the bidding process and provide sufficient support to attract and select the best private sector to participate in a TPPP project. This result can explain the significant difference in the importance ranking of 'strong private consortium', which was ranked 7th and 18th in TPPP and DPPP, respectively.

The importance of 'transparent procurement' and 'competitive procurement' are significantly different in TPPP and DPPP projects. 'Transparent procurement' is ranked 11th and 2nd in TPPP and DPPP, respectively. Transparency should apply to the bidding process and be used in the entire project lifecycle. 'Competitive procurement' for TPPP and DPPP was ranked 21st and 19th, respectively. The importance of these two factors in TPPP are significantly higher than that in DPPP because achieving transparency and fair competition is difficult in the 'acquaintance society' in a local country.

The importance of 'mature and available financial market' is significantly different between TPPP and DPPP, which ranked 24th and 13th, respectively. The majority of PPP projects require huge investments, thereby emphasising that project financing is a key factor to achieve project success (Corbett and Smith, 2006). Mature and available financial markets with low financing costs and diversified financial products are attractive to the private sectors (Rockart, 1980). Financial market is not that important in TPPP projects. The possible reason is that the majority of TPPP projects are supported by international organisations, such as the

World Bank, Asian Infrastructure Investment Bank and Silk Road Fund. In numerous cases, foreign investors do not rely on the financial market from project located countries but prepare for financing before entering the market. Except for the financial environment, the 'natural environment' is important. PPP projects should consider environmental factors, such as environmental policies (e.g. sustainable material requirements, wastewater discharge restrictions), sustainable material supply and prices, and environmental aspects of the project. 'Suitable environment' as a CSF is ranked 10th and 24th in TPPP and DPPP, respectively. For TPPP projects, foreign private sectors are unfamiliar with the local environment of project location, thereby needing substantial attention. Product/service demands determine the importance and benefits of a project. The importance of 'long term demand for the project' is ranked 2nd and 20th in TPPP and DPPP, respectively. The possible reason is that if demand risk occurs, to renegotiate with local governments is easy as well as obtaining additional compensation in DPPP projects.

The importance of 'clear goals and objective' and 'detailed project planning' are significantly different between TPPP and DPPP and both are ranked higher in TPPP than in DPPP. Given the difficulty in obtaining data and conducting field study in TPPP projects, project objectives and plans may be changed during the implementation. The importance of 'open and constant communication' in DPPP is significantly higher than that in TPPP. In DPPP projects, the multiple roles of government may confuse the relationship between the public and private sectors. Therefore, open and constant communication is important to maintain healthy partnerships and smooth transaction process.

5.2.2.3 Similarities and differences on the ranking of CSFs in each group

Table 5.4 presents the quartile groupings (i.e. upper and lower quartiles) of CSFs for each group (i.e. DPPPs and TPPPs). The upper quartile subset contains the 25% highest mean values of CSFs for PPP projects, whereas the lower quartile subset comprises the 25% lowest mean values of CSFs. The values of the upper quartile subset are 3.94 and 3.82 for TPPP and DPPP, respectively. Moreover, the lower quartile cut-off values are 3.21 (TPPP) and 3.45 (DPPP).

The upper quartile subsets of TPPP and DPPP contained 7 CSFs, with mean values of 4.10 and 4.12, respectively. Three CSFs (i.e. favourable legal framework, appropriate risk allocation and sharing, clarity of roles and responsibilities amongst parties) appeared in the TPPP and DPPP upper quartile subsets. Meanwhile, favourable legal framework is the only factor with the same ranking position (i.e. 1st) between the two respondent groups.

The current findings are consistent with those of previous studies. Cheung et al. (2012a) identified favourable legal and regulatory framework as extremely significant factors towards achieving PPP project success in Hong Kong. The law is critical for private stakeholders cooperating with the local government because it provides a regulatory, legal and institutional framework, in which the interests of all parties are considered (Khalifa and Essaouabi, 2003). For TPPP projects, investors should gain familiarity with the host countries' regulatory requirements and comply with them when doing business (Yu et al., 2017). Particularly, sound legal basis or well-established legal frameworks are limited in the majority of developing countries (Smith et al., 2004, Zhang and Kumaraswamy, 2001a). For example, in the case of disputes, determining a principle to solve problems will be

difficult when a well-established legal framework is lacking, whilst the private sector will have insufficient power to negotiate with a powerful local government. In Hong Kong and many other developed countries, a favourable legal framework is critical for PPP project success (Hwang et al., 2013). Therefore, a favourable legal framework is essential for DPPP and TPPP projects.

Risks should be allocated efficiently and fairly between the key stakeholders to control risks substantially and achieve success for PPP projects. Researchers have conducted systematic studies on risk allocation (Abednego and Ogunlana, 2006, Bing et al., 2005, Jin and Doloi, 2008). The principles on allocating risks between the public and private sectors should be shown prior to providing the process or result of risk allocation. The identified risk allocation principles indicate that each risk should be allocated to a party that can manage it using the best method (Hwang et al., 2013, Ibrahim et al., 2006). The risk should be borne by the agent who is able to bear the risk at the lowest cost (Cooper, 2005, Loosemore and McCarthy, 2008) and a party can best handle to meet the value for money requirement (Jin and Doloi, 2008). Fair and optimal risk allocation between the public and private sectors is considered an important topic and have been analysed in many studies. Ke et al. (2010b) conducted a two-round Delphi survey to analyse risks and their allocations for PPP projects in China. Xu et al. (2010a) conducted a two-round Delphi survey with 34 participants to build a fuzzy risk allocation model. Bing et al. (2005) used a questionnaire survey to explore preferences in risk allocation in the UK. The case study is a beneficial technique to explore the efficient risk allocation scheme. Abednego and Ogunlana (2006) used a case study on a toll way project in Indonesia to discover the perception of proper risk allocation of each party involved and utilised the findings as the foundation to develop the concept of good project

governance. Heravi and Hajihosseini (2011) provided a case study of the Tehran-Chalus Toll Road project in Iran to suggest methods to improve risk allocation, thereby enhancing project performance. These previous studies have focused on various backgrounds, countries and projects. Attempts have been made to use various methods to provide an optimal allocation scheme. Conflicts of interest, whether for TPPP or DPPP, cannot be avoided because of the different objectives of the public and private sectors. However, a scientific and reasonable risk allocation scheme can facilitate the achievement of project success and improvement of the partnership.

The selection of the appropriate project contributes to success in TPPP and DPPP projects. Evidently, not all projects are suitable for adopting the PPP model. Hence, public and private agreements over the advantages of a particular concept have to offer necessity (Jefferies et al., 2002). Project feasibility is essential to show the evidence of viability, whilst VFM should be calculated to prove the suitability of using the PPP model instead of traditional project models. Accordingly, project selection is for the public and private sectors. For the local government, macro-level city planning and infrastructure design are the main concerns. Meanwhile, private investors are concerned with profitability and strategic significance to participate in a few projects. If the private sector wants to conduct TPPP in another country, then the selection of country, market and project are necessary to determine the target project.

The lower quartile subsets contain 7 CSFs with mean values of 3.06 and 3.34 for TPPP and DPPP, respectively. The majority of CSFs in this group are different and have been discussed in previous contexts. The streamline approval process is the

only CSF in the lower group for the TPPP and DPPP groups. Streamlined and clarified process of conducting PPP projects can improve productivity and reduce project costs (Lee, 2013). Unnecessary procedures can be canceled, whilst specific approval procedures may be combined. In TPPP projects, the private sector should consider limitations and specific policies for foreign companies.

Table 5.4 Quartile groupings of CSFs for PPP projects

Quartiles	**TPPP**		**DPPP**	
	CSFs for TPPPs	**Mean**	**CSFs for DPPPs**	**Mean**
Upper Quartiles $Q_{3\ (TPPP)}=4.10$ $Q_{3\ (DPPP)}=4.12$	Favorable legal framework	4.4	Favorable legal framework	4.56
	Long term demand for the project	4.17	Transparent procurement	4.25
	Appropriate risk allocation and sharing	4.14	Clarity of roles and responsibilities among parties	4.21
	Selecting the right project	4.08	Political stability	4.21
	Choosing the right partner	4	Appropriate risk allocation and sharing	3.96
	Clarity of roles and responsibilities among parties	3.95	Selecting the right project	3.84
	Strong private consortium	3.94	Political support	3.82
Lower Quartile $Q_{1\ (TPPP)}=3.06$ $Q_{1\ (DPPP)}=3.34$	Competitive procurement	3.21	Sound economic policy	3.45
	Detailed project planning	3.21	Acceptable level of tariff	3.45
	Open and constant communication	3.13	Stable macroeconomic condition	3.41
	Mature and available financial market	3.11	Suitable environment	3.35
	Clear goals and objectives	3.08	Streamline approval process	3.34
	Technology innovation	2.92	Public/community support	3.2
	Streamline approval process	2.78	Government providing guarantees	3.17

5.2.3 Key success factor framework for TPPP

Fig. 5.1 shows that the top-ranking CSFs and specific CSFs form the CSF framework for TPPP projects. The top-ranking CSFs are five factors with the highest mean values of importance from the questionnaire survey. Specific CSFs

means factors are significantly more important in TPPP than those in DPPP. The two criteria to define the specific CSFs are as follows: (1) the Mann–Whitney test result shows that the ranking of the factor is significantly different between TPPP and DPPP and (2) ranking of this CSF in TPPP is higher than DPPP.

The top-ranking CSFs and specific CSFs in implementing TPPP projects were identified on the basis of the results of the comparative study. The top five ranking CSFs to implement TPPP projects are (1) favourable legal framework, (2) long-term demand for the project, (3) appropriate risk allocation and sharing, (4) selecting the right project and (5) choosing the right partner. The comparative study shows the similarities and differences of the importance of CSFs in TPPP and DPPP projects. The four factors that are significantly more important in TPPP than those in DPPP are long-term demand for the project, strong private consortium, suitable environment and government providing guarantees. Given that the government and private sectors have considerable experience in DPPP, directly adopting DPPP experience into TPPP projects is easy. However, they may disregard the characteristics of TPPP and use inappropriate success measures and strategies.

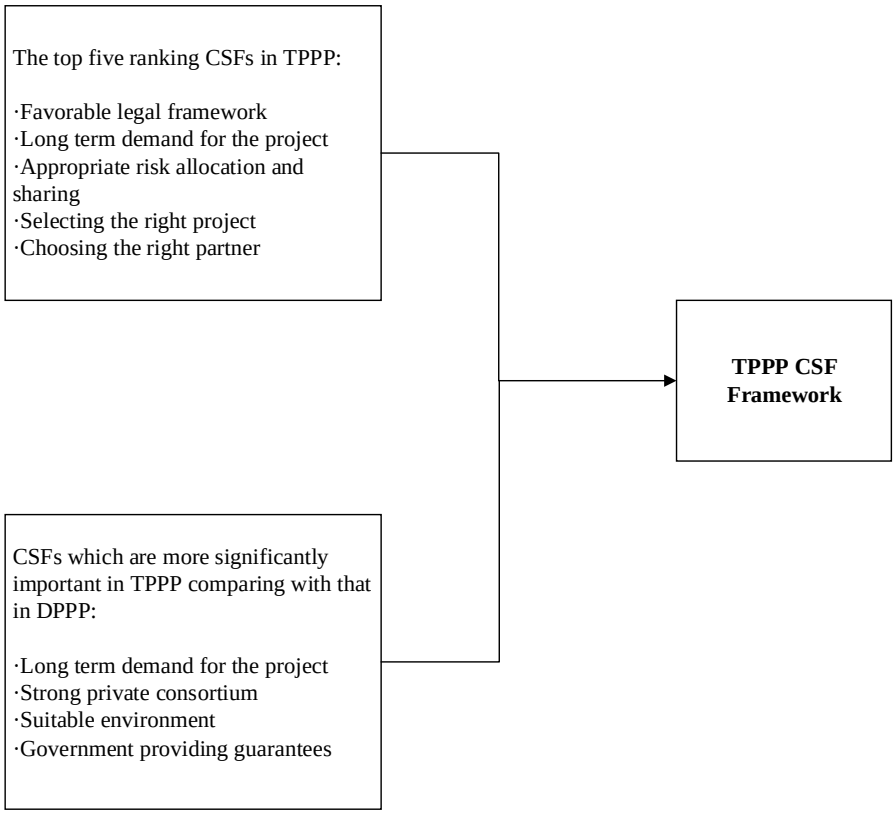


Fig. 5.1 Top and specific CSFs in TPPP projects

5.3 CHAPTER SUMMARY

This chapter empirically compared CSFs in TPPP and DPPP projects. An empirical questionnaire survey was conducted and involved participants with TPPP and DPPP experience. A preliminary test of Kendall's coefficient of concordance and mean ranking were used to analyse the survey responses. Kendall's coefficient of concordance test result indicated the consistency and agreement of responses on the ranking of CSFs in each respondent group. Mean score analysis was performed to evaluate the level of importance of CSFs by each group. Additionally, the Mann–Whitney U test was used to evaluate the differences of each CSF between the TPPP and DPPP groups. Of the 27 CSFs identified in the current study, the ranking of 12 factors are significantly different. By contrast, similarities in the top and bottom rankings were identified using quartile groupings. The TPPP CSF framework was established by combining the top-ranking and specific factors. The comparative

results indicate the differences in the DPPP and TPPP projects to achieve project success.

CHAPTER 6 DEVELOPING SUSTAINABILITY INDEX FOR TPPP PROJECTS[5]

6.1 INTRODUCTION

In the last couple of decades, many studies have been conducted in PPPs particularly on 'PPP project success' and 'critical success factors'. However, only a few, if any, have exclusively investigated the sustainability of PPP projects, particularly TPPPs. Although the social and economic impact of TPPPs is huge, issues on how sustainability can be enhanced have been completely disregarded in the normative literature. Therefore, this study aims to investigate the sustainability of TPPPs by developing a reliable and practical tool that can be used to determine the sustainability index of TPPP projects. The findings of this study enrich the theoretical research of the sustainability in TPPP projects. Moreover, the sustainability index equation can be used to evaluate the sustainability levels of TPPP projects. This study will enable practitioners to determine whether their TPPP projects have been adequately sustainable.

6.2 SUSTAINABILITY CATEGORIES FOR TPPP PROJECTS

6.2.1 Concept of sustainability

The concept of sustainable development originated in the 1960s, when environmentalists started debating on the impact of economic growth on the environment. Since then, many experts and scholars have started discussing the definitions of sustainability and sustainable development (Environment Bureau).

[5]This chapter is largely based upon:

Chen, C., Yu, Y., Osei-Kyei, R., Chan, A. P. C., & Xu, J. 2019. Developing a Project Sustainability Index for Sustainable Development in Transnational Public Private Partnership Projects. *Sustainable Development.* sd 1954. (Accepted)

The most popular research was published in the Brundtland Report, which concentrated on environmental protection and economic development (Brundtland and Khalid, 1987). Studies offer extensive explanation of sustainability. The most adopted one is that sustainability harmonises three core elements, namely, economic growth, social inclusion and environmental protection (Nations, Koppenjan and Enserink, 2009). These elements refer to the triple bottom line of the three-P concept discussed by Elkington and Rowlands (1999) and acknowledged by Adams (2006) as the 'three pillars' of sustainability, namely, social, environmental and economic (illustrated in Figure 6.1). The concept suggests that the three dimensions are interrelated and may influence one another in multiple ways.

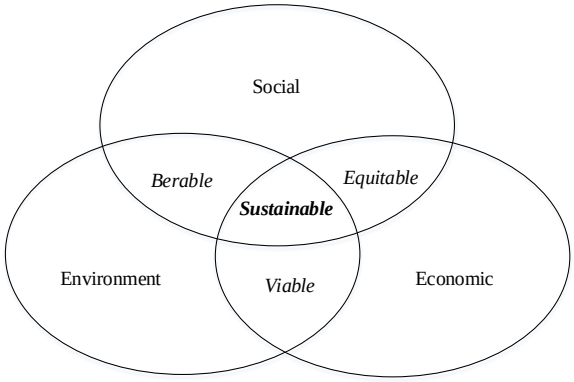


Fig. 6.1 Triple-P concept of sustainability
(A J Gilbert Silvius et al., 2012)

The construction industry has a detrimental impact on the economy, environment and society (Darko and Chan, 2016). Accordingly, the aforementioned three aspects should be considered to assess the sustainability of infrastructure projects (Mostafa and El-Gohary, 2014b, Wang et al., 2013, Zhang et al., 2014). Economic category means generating prosperity at different levels from the project to society and addressing the cost effectiveness of all business activities. Environmental category means conserving and managing resources and contributing to the environmental

protection of the project location. Social factors mean respecting human rights and equal opportunities and improving community development (Bjärstig, 2017). These three groups of categorising sustainability factors are popularly adopted in the related studies on project sustainability (Ugwu et al., 2006, Shen et al., 2002). Martens and Carvalho (2017) performed a cross-model analysis to identify sustainability factors by introducing the three dimensions (i.e. environmental, social, and economic). Yu et al. (2018) reviewed 26 related papers to identify 38 sustainability factors for PPP projects, which were categorised into the three groups.

6.2.2 Sustainability for TPPP projects

Topics on project sustainability have been addressed by countless studies. Accordingly, integrating sustainability issues into project management can help ensure that an organisation is selecting the appropriate project and attain its business strategy and stakeholders demands (Sánchez, 2015). Moreover, projects that integrated sustainability issues can achieve a company's mission and contribute to the environmental and social dimensions. Key performance indicators (KPI) were adopted to value the sustainability performance of projects. For example, Gan et al. (2017) identified 42 key sustainability performance indicators (KSPIs) that are useful to guide the affordable housing to become more sustainable. Ugwu et al. (2006) discussed the 25 KPIs encapsulated from the analytical model through six categories: environment, health and safety, economy, societal, resource utilisation and project administration. Martens and Carvalho (2017) identified key aspects of sustainability in the project management context through the triple-bottom line perspective of economic, social, and environmental and to understand the importance based on project managers' lens. Other researchers have focused to find efficient strategies to achieve project sustainability. Aarseth et al. (2017) identified

and described eight distinct strategies used by the project organisation, host government or both in collaboration to support sustainability goals. McConville and Mihelcic (2007) presented a lifecycle thinking approach to assess how project sustainability can be improved throughout the project.

Similar to sustainability research in traditional project management, the sustainable development of PPP projects were considered by other studies. Atmo and Duffield (2014) presented the development of the VFM framework to improve investment sustainability of PPP power projects in emerging Asian economies. This study found that the project outcome can be improved through consideration of VFM, energy security and environmental sustainability. Du et al. (2018) identified the critical factors influencing the capital structure of PPP projects from a sustainability perspective and analysed the relationships between these factors and capital structure through qualitative comparative analysis. Shen et al. (2016) considered the distribution of the contribution on project investment as the key variable affecting sustainability performance of PPP projects and developed a model for the assessment of the level of sustainability through proper investment arrangement.

The purpose of infrastructure development is to keep up with standards of living and create conditions for sustainable development. Governments attempt to attract private companies involved in public projects to provide investment and infrastructure implementation technologies and experiences (Koppenjan and Enserink, 2009). However, the potential conflict is countered by concerns with the private sector's focus on short-term return on investment and long-term perspective needed to realise sustainability targets. Evidently, the literature shows the importance of sustainability achievement for projects and PPP projects. This notion

implies a lack of existing standard to evaluate the sustainability of TPPP projects. Moreover, the main dimensions of sustainability factors are economic, environment and social categories. Previous studies have presented sustainability-related analyses of PPP projects that considerably focus on the barriers or strategies to achieve the sustainable objectives (Ojelabi et al., 2018, Shen et al., 2016). For TPPP projects, the host country aims to build infrastructure that can serve local residents for a long period and create additional macro social values. A well-suited TPPP project sustainability measurement model is a challenge for both partners and can lead stakeholders to adopt suitable strategies to achieve project sustainability. Therefore, the current study contributes to the call for a continuous investigation into the sustainability measures for TPPP projects in developed and developing countries.

Although only a few studies have focused on identifying the factors to evaluate the sustainability of PPP projects, other studies (see Table 2) have attempted to explore the related sustainability factors. Yu et al. (2018) presented a clear list of 38 factors, which was developed from the comprehensive literature review. The final sustainability measurement factors are based on this list and adjusted by the qualitative survey on the characteristics of TPPP projects.

6.2.3 Categories of sustainability factors

Identification of PTFs (project Sustainability Factors) for TPPP projects is the first stage. An initial list of sustainability factors was derived on the basis of Yu et al. (2018). The initial list of factors was divided into three major categories. Three experts were invited to comment and revise the initial framework. Some factors were added and revised on the basis of feedback from the experts and considering

the characteristics of TPPP project. For example, the experts suggested the inclusion of 'ongoing product service provision' and 'promote relations between two countries'. Another group (i.e. people-oriented category) was introduced. Table 6.1 shows the final list of PTFs for TPPP.

Table 6.1 CTFs for TPPP projects
(Adapted and modified from Yu et al. (2018))

Sustainability factors for TPPP projects	References
Group 1: Economic factors	
E1: Improve resource performance and efficiency	Horsley et al. (2003); Koppenjan (2015); Kyvelou et al. (2011); Lund-Thomsen (2009b); Patil et al. (2016); Regan et al. (2011b); Wang et al. (2013); Massoud et al. (2003); Wuisan et al. (2012); Zegras and Grillo (2014)
E2: Profitability	Bennett (1998); Haughton and McManus (2012); Koppenjan (2015); Lenferink et al. (2013); Patil et al. (2016); Smyth (2008); Dohrman and Aiello (1999); Martins et al. (2011); Salman et al. (2007); Couth and Trois (2012)
E3: Innovation	Haughton and McManus (2012); Koppenjan (2015); Lenferink et al. (2013); Patil et al. (2016); Regan et al. (2011b); Wang et al. (2013); Dohrman and Aiello (1999); Martins et al. (2011); Clark II (2007); Salman et al. (2007); Zegras and Grillo (2014)
E4: Improve project quality	Horsley et al. (2003); Kyvelou et al. (2011); Pardo-Bosch and Aguado (2016); Patil et al. (2016); Regan et al. (2011b); Wang et al. (2013); Martins et al. (2011); Massoud et al. (2003); Wuisan et al. (2012)
E5: Cost reduction	Kyvelou et al. (2011); Lenferink et al. (2013); Pardo-Bosch and Aguado (2016); Regan et al. (2011b); Wang et al. (2013); Martins et al. (2011); Owen (2013); Salman et al. (2007); Massoud et al. (2003); Zegras and Grillo (2014)
E6: Efficient maintenance	Lenferink et al. (2013); Lund-Thomsen (2009b); Patil et al. (2016); Smyth (2008); Massoud et al. (2003)
E7: Adaptability and flexibility	Koppenjan (2015); Lenferink et al. (2013); Pardo-Bosch and Aguado (2016); Regan et al. (2011b); Dohrman and Aiello (1999); Martins et al. (2011); Wuisan et al. (2012); Zegras and Grillo (2014); Pullen et al. (2010); Turcotte and Geiser (2010)
E8: Ensure projects running on time and budgets	Haughton and McManus (2012); Lenferink et al. (2013); Regan et al. (2011b); Massoud et al. (2003)
E9: Proper payment	Patil et al. (2016); Dohrman and Aiello (1999); Owen (2013); Zegras and Grillo (2014)
E10: Support local business	Brereton and Temple (1999)
E11: Influence wider market	Horsley et al. (2003)
E12: Ongoing product service provision	Expert comment
E13: Smooth project transfer	Expert comment
Group 2: Environment factors	
T1: Effective emission management system	Bossink (2002a); Kyvelou et al. (2011); Lund-Thomsen (2009b); Patil et al. (2016); Regan et al. (2011b); Wang et al. (2013); Dohrman and Aiello (1999); Forsyth (2005); Massoud et al. (2003); Couth and Trois (2012)
T2: Water protection and efficiency	Bennett (1998); Kyvelou et al. (2011); Pardo-Bosch and Aguado (2016); Patil et al. (2016); Regan et al. (2011b); Owen (2013); Clark II (2007)
T3: Effective environment management system	Bossink (2002a); Koppenjan (2015); Pardo-Bosch and Aguado

	(2016); Patil et al. (2016); Wang et al. (2013); Dohrman and Aiello (1999); Martins et al. (2011); Forsyth (2005); Owen (2013); Takahasi (2004); Salman et al. (2007); Massoud et al. (2003); Couth and Trois (2012)
T4: Improve climate resilient and air quality	Koppenjan (2015); Patil et al. (2016); Wang et al. (2013)
T5: Improve environmental policy	Bossink (2002a); Koppenjan (2015); Kyvelou et al. (2011)
T6: Effectively utilizing sustainable design and materials	Bossink (2002a); Wang et al. (2013); Martins et al. (2011); Clark II (2007); Couth and Trois (2012)
T7: Reduce carbon emissions	Horsley et al. (2003); Koppenjan (2015)
T8: Land use efficiency and soil protection	Lund-Thomsen (2009b); Patil et al. (2016); Dohrman and Aiello (1999)
T9: Noise prevention	Patil et al. (2016)
T10: Biodiversity protection	Patil et al. (2016)
T11: Landfill protection	Dohrman and Aiello (1999); Clark II (2007); Couth and Trois (2012)
T12: Forest protection	Clark II (2007)
T13: Disaster resistance	De Azevedo et al. (2010); Charoenkit and Kumar (2014)
Group 3: Social factors	
S1: Ensure accountability, legitimacy and transparency	Abramov (2009a); Brereton and Temple (1999); Haughton and McManus (2012); Koppenjan (2015); Lund-Thomsen (2009b); Patil et al. (2016); Dohrman and Aiello (1999); Forsyth (2005); Salman et al. (2007); Wuisan et al. (2012); Zegras and Grillo (2014)
S2: Keep close partnership between stakeholders	Brereton and Temple (1999); Koppenjan (2015); Kyvelou et al. (2011); Regan et al. (2011b); Smyth (2008); Dohrman and Aiello (1999); Forsyth (2005); Takahasi (2004); Wuisan et al. (2012)
S3: Improve service standard	Bossink (2002a); Lenferink et al. (2013); Regan et al. (2011b); Wang et al. (2013)
S4: Meet demands and provide great service	Kyvelou et al. (2011); Smyth (2008); Martins et al. (2011); Zegras and Grillo (2014)
S5: Promote integrity, honesty and impartiality	Brereton and Temple (1999)
S6: working altruistically for the public good	Brereton and Temple (1999)
S7: Improve local policy	Kyvelou et al. (2011)
S8: Protect cultural heritage	Patil et al. (2016)
S9: Appropriate resettling, rehabilitation, and compensation	Patil et al. (2016)
S10: Promote relations between the two countries	Expert comment
Group 4: People-oriented factors	
P1: Affordable user cost	Patil et al. (2016); Regan et al. (2011b); Owen (2013); Zegras and Grillo (2014); Winston and Eastaway (2008)
P2: Serve and benefit local residents	Abramov (2009a); Brereton and Temple (1999); Haughton and McManus (2012); Lund-Thomsen (2009b); Regan et al. (2011b); Wang et al. (2013)
P3: Provide jobs	Lund-Thomsen (2009b); Pardo-Bosch and Aguado (2016); Patil et al. (2016); Martins et al. (2011); Couth and Trois (2012)
P4: Ensure worker health and safety	Lund-Thomsen (2009b); Patil et al. (2016); Wang et al. (2013)
P5: Protect human rights	Lund-Thomsen (2009b); Patil et al. (2016)
P6: Effective communication with users	Bossink (2002a); Takahasi (2004)

6.3 RESEARCH METHODOLOGY

6.3.1 Research process to establish the TPPPSI

The current research was conducted systematically and the process is shown in Fig.

6.2. A hybrid research method was adopted in this study to build the sustainability

index (SI) for TPPP projects. In stage 1, a systematic literature review was conducted to draw a preliminary list of PTFs. In stage 2, a questionnaire survey was used to investigate the criticality of these factors from the public and private sectors' perspectives. In stage 3, the FSE technique was applied to calculate the weighting and fuzzy membership function for each CTF. In stage 4, SI for TPPP projects was developed.

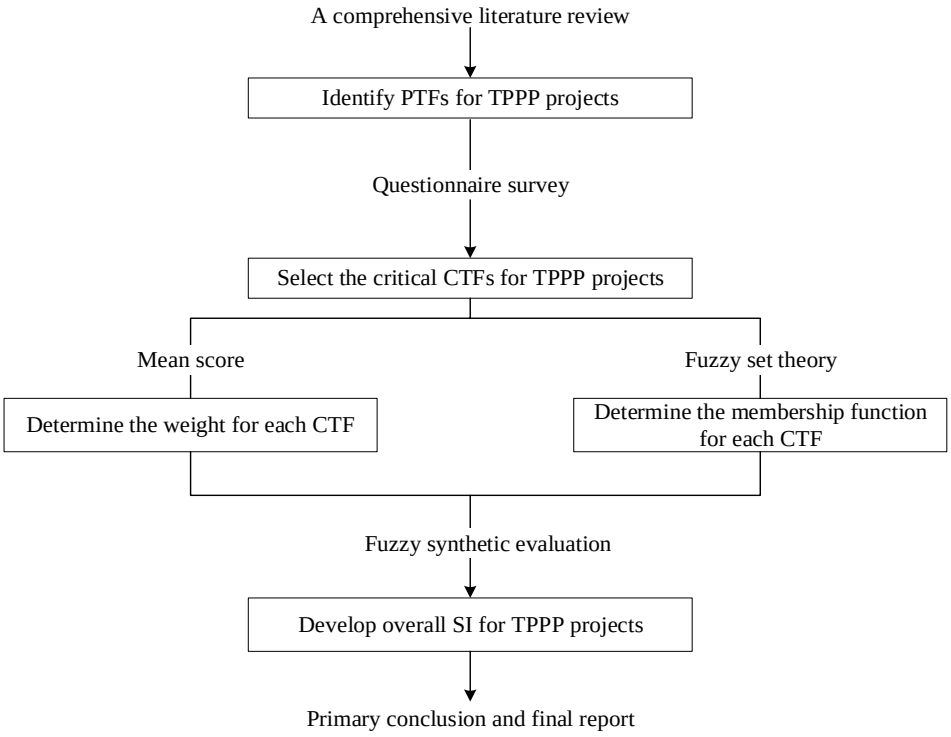


Fig. 6.2 Process of developing a sustainability index for TPPP projects (Adapted from Xu et al. (2010a))

6.3.2 Mean score ranking and selection of CTFs

Table 6.2 shows the mean value and ranking of PTFs in each category. The mean values for each group range from 4.571 (reliable project quality) to 2.952 (support local business) for the economic group, 4.286 (effectively utilising sustainable design and materials) to 2.571 (forest protection) for the environment group, 4.857 (meet demand and provide great service) to 2.714 (working altruistically for the public good) for the social group and 4.476 (serve and benefit local residents) to

3.048 (effective communication with users) for the people-oriented group. To identify the CTFs, factors with normalisation values equal to or above 0.50 are selected to build the TPPP sustainability index (Osei-Kyei and Chan, 2017a). After this selection, CTFs included nine factors in the economic group, five factors in the environment group, four factors in the social group and four factors in the people-oriented group. These 22 critical factors were adopted in the next analysis stage.

Table 6.2 Ranking of CTFs in TPPP projects

Group 1: Economic factors				Group 2: Environment factors				Group 3: Social factors				Group 4: People-oriented factors			
Rank	SF	Mean	Norm.	Rank	SF	Mean	Norm.	Rank	SF	Mean	Norm.	Rank	SF	Mean	Norm.
1	E4	4.571	1.000	1	T6	4.286	1.000	1	S4	4.857	1.000	1	P2	4.476	1.000
2	E1	4.476	0.941	2	T3	4.238	0.972	2	S10	4.143	0.667	2	P1	4.381	0.933
3	E6	4.429	0.912	3	T1	3.952	0.806	3	S1	3.921	0.563	3	P5	3.905	0.600
4	E12	4.286	0.824	4	T13	3.762	0.694	4	S3	3.810	0.511	4	P4	3.889	0.589
5	E8	4.238	0.794	5	T8	3.667	0.639	5	S9	3.524	0.378	5	P3	3.667	0.433
6	E5	3.905	0.588	6	T7	3.238	0.389	6	S8	3.429	0.333	6	P6	3.048	0.000
7	E7	3.857	0.559	7	T2	3.190	0.361	7	S5	3.349	0.296				
8	E2	3.810	0.529	8	T5	3.127	0.324	8	S2	3.333	0.289				
9	E9	3.810	0.529	9	T4	3.095	0.306	9	S7	3.000	0.133				
10	E13	3.619	0.412	10	T11	3.000	0.250	10	S6	2.714	0.000				
11	E3	3.571	0.382	11	T10	2.810	0.139								
12	E11	3.095	0.088	12	T9	2.619	0.028								
13	E10	2.952	0.000	13	T12	2.571	0.000								

Note: Norm. = Normalization = (Actual value – Minimum value) / (Maximum value – Minimum value)

6.3.3 Fuzzy Synthetic Evaluation

This study used FSE to build SI for TPPP projects. Two different levels were established before conducting the fuzzy modelling. The first level has four categories (i.e. economic, environment, social and people-oriented), whilst the second level includes the 22 selected CTFs. The FSE basic procedure used in this study is provided as follows (Xu et al., 2010a, Liu et al., 2013):

1. Given the four categories, an evaluation index system can be built by defining the four categories as the first-level index system as $\pi = \{\pi_E, \pi_T, \pi_S, \pi_P, \}$. The selected CTFs are also defined as the second index system:

$\pi_E = \{E_1, E_2, E_3, E_4, E_5, E_6, E_7, E_8, E_9\}$

$\pi_T = \{T_1, T_2, T_3, T_4, T_5\}$
$\pi_S = \{S_1, S_2, S_3, S_4\}$
$\pi_P = \{P_1, P_2, P_3, P_4\}$

2. The grade alternatives are labelled $\mathrm{E} = \{L_1, L_2, L_3, L_4, L_5\}$. A five-point Likert scale was used to require respondents to evaluate the importance of each CTF (where L_1 = least important, L_2 = fairly important, L_3 = important, L_4 = very important and L_5 = extremely important).

3. The weight of CTF in each group is determined. The weight is calculated by a mean score of each factor from the questionnaire survey:

$$W_i = \frac{M_i}{\sum_{i=1}^{n} M_i}, 0 \le W_i \le 1, \quad (6.1)$$

where W_i = weighting; M_i = mean score of each KSPI and in each group (i.e. economic, environment, social), $\sum_{E1}^{E9} W_i = 1, \sum_{T1}^{T5} W_i = 1, \sum_{S1}^{S4} W_i = 1, \sum_{P1}^{P4} W_i = 1$.

4. FSE is adopted to establish membership functions (MF) for each CTF and group. MF of the identified KSPI is obtained through the following equations (see Hsiao (1998), Li et al. (2013b)):

$$MF_{E_i} = \frac{X_{1_{E_i}}}{L_1} + \frac{X_{2_{E_i}}}{L_2} + \frac{X_{3_{E_i}}}{L_3} + \frac{X_{4_{E_i}}}{L_4} + \frac{X_{5_{E_i}}}{L_5}, \; i=1,2,3\ldots,9 \quad (6.2)$$

$$MF_{T_i} = \frac{X_{1_{T_i}}}{L_1} + \frac{X_{2_{T_i}}}{L_2} + \frac{X_{3_{T_i}}}{L_3} + \frac{X_{4_{T_i}}}{L_4} + \frac{X_{5_{T_i}}}{L_5}, \; i=1,2,3,4,5 \quad (6.3)$$

$$MF_{S_i} = \frac{X_{1_{S_i}}}{L_1} + \frac{X_{2_{S_i}}}{L_2} + \frac{X_{3_{S_i}}}{L_3} + \frac{X_{4_{S_i}}}{L_4} + \frac{X_{5_{S_i}}}{L_5}, \; i=1,2,3,4 \quad (6.4)$$

$$MF_{P_i} = \frac{X_{1_{P_i}}}{L_1} + \frac{X_{2_{P_i}}}{L_2} + \frac{X_{3_{P_i}}}{L_3} + \frac{X_{4_{P_i}}}{L_4} + \frac{X_{5_{P_i}}}{L_5}, \; i=1,2,3,4 \quad (6.5)$$

where E_i represents the *i*th economic CTF, T_i represents the *i*th environmental KSPI factor, S_i represents the *i*th social KSPI factor and P_i represents the *i*th people-oriented KSPI. X_{j_μ} (j=1,2,3,4,5; $\mu = E_i, T_i, S_i, P_i$) is the percentage of the survey respondents who scored j for the importance of a specific CTF, which

denotes the degree of membership function; X_{j_μ}/L_i represents relation between X_{j_μ} and its grade alternative instead of fractions.

MF of a specific CTF is written as follows:

$$MF_{E_i} = \left|X_{1_{E_i}}, X_{2_{E_i}}, X_{3_{E_i}}, X_{4_{E_i}}, X_{5_{E_i}}\right| \quad (6.6)$$

$$MF_{T_i} = \left|X_{1_{T_i}}, X_{2_{T_i}}, X_{3_{T_i}}, X_{4_{T_i}}, X_{5_{T_i}}\right| \quad (6.7)$$

$$MF_{S_i} = \left|X_{1_{S_i}}, X_{2_{S_i}}, X_{3_{S_i}}, X_{4_{S_i}}, X_{5_{S_i}}\right| \quad (6.8)$$

$$MF_{P_i} = \left|X_{1_{P_i}}, X_{2_{P_i}}, X_{3_{P_i}}, X_{4_{P_i}}, X_{5_{P_i}}\right| \quad (6.9)$$

5. MFs and weight of all CTFs in a category are processed to obtain its final FSE evaluation matrix.

$$MF_E = \left|W_{E_1}, W_{E_2} \ldots, W_{E_9}\right| \times \begin{vmatrix} MF_{E_1} \\ MF_{E_2} \\ . \\ . \\ . \\ MF_{E_9} \end{vmatrix} \quad (6.10)$$

$$MF_T = \left|W_{T_1}, W_{T_2}, W_{T_3}, W_{T_4}, W_{T_5}\right| \times \begin{vmatrix} MF_{T_1} \\ MF_{T_2} \\ MF_{T_3} \\ MF_{T_4} \\ MF_{T_5} \end{vmatrix} \quad (6.11)$$

$$MF_S = \left|W_{S_1}, W_{S_2}, W_{S_3}, W_{S_4}\right| \times \begin{vmatrix} MF_{S_1} \\ MF_{S_2} \\ MF_{S_3} \\ MF_{S_4} \end{vmatrix} \quad (6.12)$$

$$MF_P = \left|W_{P_1}, W_{P_2}, W_{P_3}, W_{P_4}\right| \times \begin{vmatrix} MF_{P_1} \\ MF_{P_2} \\ MF_{P_3} \\ MF_{P_4} \end{vmatrix} \quad (6.13)$$

6. The final FSE evaluation matrix for each category is calculated using the following formulas:

$$SI_E = |L_1, L_2, L_3, L_4, L_5| \times {MF_E}^T \quad (6.14)$$

$$SI_T = |L_1, L_2, L_3, L_4, L_5| \times {MF_T}^T \quad (6.15)$$

$$SI_S = |L_1, L_2, L_3, L_4, L_5| \times {MF_S}^T \quad (6.16)$$

$$SI_P = |L_1, L_2, L_3, L_4, L_5| \times {MF_P}^T \quad (6.17)$$

In the last stage, the coefficient of each group can be calculated, whilst the total SI can be determined by integrating the four categories' sustainability performance.

6.4 DATA ANYLYSIS AND RESULTS

The data analysis follows the stages discussed in the methodology section. The weightings of each CTF was calculated by using formula (6.1) and the mean score of factors. Taking environment category as an example, the weightings of each factor in this group are as follows:

$$W_{T_6} = \frac{4.286}{4.286 + 4.238 + 3.952 + 3.762 + 3.667} = 0.215$$
$$W_{T_3} = \frac{4.238}{4.286 + 4.238 + 3.952 + 3.762 + 3.667} = 0.213$$
$$W_{T_1} = \frac{3.952}{4.286 + 4.238 + 3.952 + 3.762 + 3.667} = 0.199$$
$$W_{T_{13}} = \frac{3.762}{4.286 + 4.238 + 3.952 + 3.762 + 3.667} = 0.189$$
$$W_{T_{13}} = \frac{3.667}{4.286 + 4.238 + 3.952 + 3.762 + 3.667} = 0.184$$

Similarly, the weighting of the environment category is calculated as follows by using the same formula to calculate the weighting in the first level:

$$W_T = \frac{19.905}{37.381+19.905+16.730+16.651} = 0.220.$$

The weightings of all CTFs and each first level group can be determined by the same method. Table 6.3 shows the results of the weightings.

Table 6.3 Weightings of CTFs for the TPPP projects

Code	Factors	MS	Weighting
Category1: Economic factors		Total score: 37.381	0.412
E_4	Improve project quality	4.571	0.122
E_1	Improve resource performance and efficiency	4.476	0.120
E_6	Efficient maintenance	4.429	0.118
E_{12}	Ongoing product service provision	4.286	0.115
E_8	Ensure projects running on time and budgets	4.238	0.113
E_5	Cost reduction	3.905	0.104
E_7	Adaptability and flexibility	3.857	0.103
E_2	Profitability	3.810	0.102
E_9	Proper payment	3.810	0.102

Category2: Environment factors		Total score: 19.905	0.220
T_6	Effectively utilizing sustainable design and materials	4.286	0.215
T_3	Effective environment management system	4.238	0.213
T_1	Effective emission management system	3.952	0.199
T_{13}	Disaster resistance	3.762	0.189
T_8	Land use efficiency and soil protection	3.667	0.184
Category3: Social factors		Total score: 16.730	0.185
S_4	Meet demands and provide great service	4.857	0.290
S_{10}	Promote relations between the two countries	4.143	0.248
S_1	Ensure accountability, legitimacy and transparency	3.921	0.234
S_3	Improve service standard	3.810	0.228
Category 4: People-oriented factors		Total score: 16.651	0.184
P_2	Serve and benefit residents	4.476	0.269
P_1	Affordable user cost	4.381	0.263
P_5	Protect human rights	3.905	0.235
P_4	Ensure worker health and safety	3.889	0.234

MF is the degree of an alternative's membership in a fuzzy set and is derived from level 2 (CTFs) to level 1 (four categories). Thus, MF of each CTF is first obtained before calculating the MF of four groups. Moreover, MF of each CTF is calculated by adopting formulas (6.10) to (6.13). Taking T_6 (effectively utilising sustainable design and materials) as an example, the questionnaire results of the importance of this factor in determining TPPP project sustainability are as follows: 0% of respondents rated T_6 as 'least important', 4.8% as 'fairly important', 4.8% as 'important', 47.6% as 'very important' and 42.9% as 'extremely important'. Hence, MF of T_6 is derived as follows (by using formula (6.3)):

$$MF_{T_6} = \frac{0.000}{least\ important} + \frac{0.048}{fairly\ important} + \frac{0.048}{important} + \frac{0.476}{very\ important} + \frac{0.429}{extremely\ important}$$

By adopting formula (6.7), MF_{T_6} is written as $MF_{T_6} = |0.000, 0.048, 0.048, 0.476, 0.429|$. Following the same approach, MFs of all KSPIs can be determined. Thereafter, MF of level 1 was integrated by considering the weights and MFs of all CTFs in the same category (formula (6.10) to (6.13)).

As an example, the MF of environment category was calculated by using the weights and MFs of all five factors (T_6, T_3, T_1, T_{13}, T_8) in this group:

$$MF_T = |0.215, 0.213, 0.199, 0.189, 0.184| \times \begin{vmatrix} 0.000, 0.048, 0.048, 0.476, 0.429 \\ 0.000, 0.000, 0.095, 0.571, 0.333 \\ 0.000, 0.000, 0.190, 0.667, 0.143 \\ 0.000, 0.000, 0.381, 0.476, 0.143 \\ 0.000, 0.048.0.333, 0.524, 0.095 \end{vmatrix}$$
$$= |0.000, 0.019, 0.202, 0.543, 0.236|$$

In a similar manner, MFs of the economic, social and people-oriented categories are as follows:

$$MF_E = |0.000, 0.010, 0.169, 0.459, 0.362|$$
$$MF_T = |0.000, 0.019, 0.202, 0.543, 0.236|$$
$$MF_S = |0.000, 0.000, 0.190, 0.397, 0.413|$$
$$MF_P = |0.000, 0.011, 0.178, 0.430, 0.381|$$

MFs of all CTFs and four categories are shown in Table 6.4.

Table 6. 4 Membership Functions for CTFs and four categories for TPPP projects

Code	Weight	MF for CTF					MF for Category				
Category1: Economic factors							0.000	0.010	0.169	0.459	0.362
E_4	0.122	0.000	0.000	0.000	0.429	0.571	—	—	—	—	—
E_1	0.120	0.000	0.000	0.000	0.524	0.476	—	—	—	—	—
E_6	0.118	0.000	0.000	0.048	0.476	0.476	—	—	—	—	—
E_{12}	0.115	0.000	0.000	0.048	0.619	0.333	—	—	—	—	—
E_8	0.113	0.000	0.000	0.095	0.571	0.333	—	—	—	—	—
E_5	0.104	0.000	0.000	0.381	0.333	0.286	—	—	—	—	—
E_7	0.103	0.000	0.048	0.238	0.524	0.190	—	—	—	—	—
E_2	0.102	0.000	0.048	0.381	0.286	0.286	—	—	—	—	—
E_9	0.102	0.000	0.000	0.429	0.333	0.238		—	—	—	—
Category2: Environment factors							0.000	0.019	0.202	0.543	0.236
T_6	0.215	0.000	0.048	0.048	0.476	0.429	—	—	—	—	—
T_3	0.213	0.000	0.000	0.095	0.571	0.333	—	—	—	—	—
T_1	0.199	0.000	0.000	0.190	0.667	0.143	—	—	—	—	—
T_{13}	0.189	0.000	0.000	0.381	0.476	0.143	—	—	—	—	—
T_8	0.184	0.000	0.048	0.333	0.524	0.095					
Category3: Social factors							0.000	0.000	0.190	0.397	0.413
S_4	0.290	0.000	0.000	0.000	0.143	0.857	—	—	—	—	—
S_{10}	0.248	0.000	0.000	0.190	0.476	0.333	—	—	—	—	—
S_1	0.234	0.000	0.000	0.333	0.413	0.254	—	—	—	—	—
S_3	0.228	0.000	0.000	0.286	0.619	0.095	—	—	—	—	—
Category 4: People-oriented factors							0.000	0.011	0.178	0.430	0.381
P_2	0.269	0.000	0.000	0.095	0.333	0.571	—	—	—	—	—
P_1	0.263	0.000	0.000	0.143	0.333	0.524	—	—	—	—	—
P_5	0.235	0.000	0.000	0.286	0.524	0.190					
P_4	0.234	0.000	0.048	0.206	0.556	0.190					

Based on MFs and weighting values of the economic, environment, social and

people-oriented categories, the TPPP project sustainability index for each category is calculated by using formula (6.14) to (6.17). SI for each category is as follows (as shown in Table 6.5):

$$SI_E = |1,2,3,4,5| \times |0.000,0.010,0.169,0.459,0.362|^T = 4.174$$
$$SI_T = |1,2,3,4,5| \times |0.000,0.019,0.202,0.543,0.236|^T = 3.996$$
$$SI_S = |1,2,3,4,5| \times |0.000,0.006,0.190,0.397,0.413|^T = 4.222$$
$$SI_P = |1,2,3,4,5| \times |0.000,0.011,0.178,0.397,0.413|^T = 4.180$$

Table 6. 5 SI for the four categories for TPPP projects

Category No.	Category name	Sustainability Index (SI)	Coefficients*
1	Economic category	4.174	0.252
2	Environment category	3.996	0.241
3	Society category	4.222	0.255
4	People-oriented category	4.180	0.252
Total		16.572	1.000

Note: Coefficient = SI for each category / $\sum$SI for all catogories

To develop the overall TPPPSI model, a linear and additive approach was adopted. A linear equation model is easy and simple to understand and this method has been used in previous studies to develop a performance index (Hu et al., 2016, Lam et al., 2008, Yeung et al., 2009). SI of each group is normalised, such that they sum up to one/unity (Osei-Kyei and Chan, 2017). Therefore, the TPPP project sustainability index is expressed by the following equation:

$$\begin{aligned}\text{SI} = {} & 0.252 \times (\text{economic category}) + 0.241 \times (\text{environment category}) \\ & + 0.255 \times (\text{social category}) + 0.252 \times (\text{people} \\ & - \text{oriented category})\end{aligned} \tag{6.18}$$

6.5 DISCUSSION

Equation (6.18) shows that social category obtained the highest coefficient (0.255) in the evaluation model, followed by the economic (0.252), people-oriented (0.252) and environment (0.241) categories. Given that all data had been normalised, the sum of the four coefficients is 1.

6.5.1 Economic category

The economic category has an SI of 4.174 and a coefficient value of 0.252. This result indicates that economic viability is critical to the sustainable performance of TPPP projects.

6.5.1.1 Cost-revenue factors

Cost-revenue factors include cost reduction, profitability and proper payment in the economic category. These factors are directly related to economics and attempt to build a rational cost and payment mechanism amongst the main stakeholders (e.g. public sector, private sector and users). Managing these factors helps provide continuous and high-quality projects, which are relevant in achieving sustainability.

PPP is an innovative strategy that combines the different stages, including the entire lifecycle stages of a project, in one contract. The private sector is generally regarded to have a considerable ability and efficiency to immediately deliver at a substantially low cost (De Bettignies and Ross, 2004). Moreover, bundling the phases could encourage up-front investment and contribute to reducing cost during the project's lifecycle. However, as cost reduction may negatively influence the quality of the infrastructure or service, PPP is superior to traditional projects only when that quality and efficiency can be verified and specified (e.g. by using VFM) (Välilä, 2005). The cost of the TPPP project has an impact on tariff and the project revenue. When the costs are reduced, users are likely to pay only a few tariffs, thereby enhancing the residents' standard of living, particularly for low-income people (Yu et al., 2018).

Evidently, attracting foreign investors is difficult without a sufficient profitability expectation of the project (Zhang, 2005a). Profitability is the key to guarantee the

continuous operation of a project. The challenge is in setting up a suitable tariff that can balance the profitability of project company and the economic acceptability of residents. If the PPP service is paid by end users, then appropriate tariff levels should be established to avoid public opposition. For TPPP projects that are not financially viable but of significant social, political and environmental value, the host government should provide the necessary support or guarantees, such as tax reduction, foreign exchange guarantee and government subsidy, to make the project financially feasible (Zhang, 2005a). Overall, a scientific and rational tariff and subsidy mechanism will lead to considerable profitability and support project companies to operate the project continuously to serve local residents.

The payment structure is critical and should be designed to safeguard the interests of the public and private sectors and users. The main principle is to link payment to service delivery (Zhang, 2005b). This step can ensure that the project company can continuously improve its performance and provide quality services to obtain a reasonable but not excessive return that reflects its performance. Three payment methods often obtain revenue, namely, government and public user payments and government subsidy. Suitable payment should not be started until the project has been passed to operate and met specifications. This payment mechanism may reduce the majority of the contractor risks and ensure the provision of quality infrastructure and service (Shen et al., 2006).

6.5.1.2 Performance-quality factors

Several factors in the economic category may not directly relate to economic issue but are about project performance, efficiency and quality. These factors also have an impact on project effectiveness.

The key objective to achieve in the construction stage of PPP projects is to ensure that projects are running on time and budget. When the public sector proposes a 'partnership', what they mean is to transfer the responsibility and risk to private sectors and to use a lower budget than adopting traditional projects (Bovaird, 2004). The proper management of time and budget can ensure project delivery based on the plan. A PPP infrastructure project can be divided into six phases, namely, project identification and preparation, procurement, implementation, transfer, and post-transfer (Bao et al., 2018). Ongoing project service is achieved by a proper lifecycle management. After completing construction, the contractor typically delivers the project for operation. After implementation for several years, TPPP projects will be transferred to the government by the end of the concession period. Thereafter, the government should take over the project or seek a new operator. During the long period of concession, transfer and post-transfer phases, the project should provide ongoing and continuous service to public users, thereby achieving the basic principle of sustainability. The long operation period and complex stakeholder relationship require that project companies are flexible and can immediately respond to changing circumstances. Compared with the government, the private sectors are considered able to adapt to new environment or situations. Moreover, being prepared to manage changes will reduce future difficulties regarding the contractual arrangement and make the TPPP project more sustainable (Demirel et al., 2017).

One important reason and driver for governments adopting the infrastructure can be maintained well in the previous stage, as the following stages will be hardly problematic, and the project can be used for a long time. The private partner is expected to be efficient to provide well maintenance in TPPP projects because they

are involved in the construction and operation stages and consider the cost of the whole concession period as a package (Sharma and Cui, 2012). Maintenance affects the project quality and sustainability, thereby subsequently influencing user satisfaction (Patil et al., 2016). The improvement of project quality was considered a critical sustainability factor. Proper quality control and management are necessary to satisfy the required output specifications and can extend the project life period. Moreover, TPPP is effective in enhancing project productivity by improving resource performance, which is important to maintain long-term integrity and sustainable socioecological systems. The application of TPPP has become increasingly popular in developed countries for gaining advantages of improving efficiency and sustainability (Shen et al., 2006).

6.5.2 Environmental category

Environmental category ranked fourth with an SI of 3.996 and coefficient value of 0.241. Although this category ranked the lowest amongst the four categories, the SI value means that the factors in this group are important.

PPP has been developed to provide sustainable infrastructure by cutting costs and retaining an acceptable level of service for the infrastructure asset, without harming the environment and exhausting natural resources (Ahmad et al., 2018). Establishing an effective environment management system could guide project managers to adopt the proper environment-friendly measures (Pardo-Bosch and Aguado, 2016). The system provides a structured approach to planning and implementing environment protection measures and integrates environment management into project's long-term planning, daily operations and other quality management systems (Chavan, 2005). A sustainable environment management

system contains many aspects, such as the impact on climate and air quality, carbon emissions, soil protection, noise prevention, biodiversity protection, landfill protection and forest protection. The implementation of environment and emission management is more difficult than formulation management system. Therefore, an efficient strategy is to integrate environment specifications into the quality assurance systems to push project managers to develop TPPP projects sustainably.

A sustainable system of environmental management should start with pollution prevention, emission management and expand thereafter into control and environmental design (Chavan, 2005). Environmental impact assessment is normally considered and conducted during the preliminary design stage of the project (Haapio and Viitaniemi, 2008, Hischier et al., 2005, Zhang et al., 2005). As the first stage of TPPP project life cycle, design immensely influences the sustainable performance of infrastructure projects. Designers and engineering consultants should provide professional advice on various alternatives and materials, costs and influences on project sustainability for stakeholder reference (Shen et al., 2010). A well-sustainable design proposal is the foundation of the project sustainability framework and should be the focus of all stakeholders.

In numerous countries, land use is restricted and controlled by the government. Various land use zoning schemes allocate land to restricted uses to ensure that valuable natural ecosystems are not converted (Lambin and Meyfroidt, 2011). Sustainable land management should consider local and regional factors shaping land use efficiency and protect the soil when constructing the infrastructure project. Perceptions are conflicting on disaster risk allocation. Others think this risk should be allocated fairly between the public and private sectors because this factor is force

majeure and unpredictable; by contrast, others insist that disaster risk should be shouldered by the government and a perception is that disaster risk management is a public good (Auzzir et al., 2014). Disaster risk has a low occurrence possibility but serious severity could destroy the entire project. Disaster resistance system is designed to protect the project to survive or recover from a disaster, which is the only way to achieve sustainability if the disaster happens.

6.5.3 Social category

Social category is ranked the highest amongst the four groups, with an SI of 4.222 and coefficient value of 0.255.

An honourable project environment is the booster force to make a project achieve sustainability and help the investor company's sustainable development. Ensuring accountability, legitimacy and transparency strengthens the confidence and trust of the partnership, and wins the favour and support from local users. Based on the positive environment, TPPP projects should provide extensive services and meet user demands. Only continuous demands from users ensure sustainable revenue and development.

Unlike the traditional approach, PPP contract offers output-based revenues. This feature indicates that private sectors could adopt innovative technologies and improve service standards to produce more products or attract more users. This strategy motivates investors to fulfill the requirements or even go beyond the expected output (Yu et al., 2018). In this regard, many developing countries along B&R are attempting to adopt the TPPP model to provide high-quality service and improve the service standard in the entire industry of the host country. Beyond the significance of the project, TPPP as a form of interaction between the project local

government and foreign investor contributes to the improvement of social and economic situation in the host country. TPPP is viewed in a broad context and is presented as a financial and non-financial system (e.g. social, political) between government and business (Pakhomova et al., 2017). For TPPP projects in B&R countries, many Chinese investors, particularly state-owned companies, are involved for business and political reasons. The long-term concession contract is a positive method to promote relations between the project and host countries and for future sustainable collaborations.

6.5.4 People-oriented category

The people-oriented category has an SI of 4.180 and coefficient value of 0.252. This category is similar to the economic category and followed by the social category.

Economic, environment and social factors form the classical triple framework of PPP sustainability. Sustainability issues cover promoting social progress, health, and well-being, aesthetic values, human quality of life and equity (Goodland, 1995, Lombardi, 2001). People engaged in TPPP projects benefit from the projects. However, people are often overlooked in the service delivery framework. People assume the roles of partners and users in TPPP projects. Citizens can contribute significantly to infrastructure project by supporting the project with payment of service charges. Moreover, they can improve the accountability and service quality of public and private stakeholders (Ahmed and Ali, 2006). TPPP projects should provide an affordable price for residents to use the service, particularly for low-income people. Moreover, the project stakeholders should provide social intervention programs and the provision of high-quality services to improve well-being living quality (Nordensvard et al., 2015). The community should be a part of

the project development and feel belongingness from the openness, coordination and transparency of the TPPP projects.

Apart from users, the staff involved in the TPPP projects are important to achieve project sustainability. Managers, particularly in foreign countries, should carefully take care of the local workers. Health and safety should be considered a priority to avoid any accidents or casualty risk. Such feature is the guarantee of the stable construction or operation of projects. The project company should formulate policies to protect the human rights of workers. Local workers should be paid with reasonable salary and their culture and belief should be respected. Staff from the investors' home country are required to be well paid and managed to avoid potential conflicts with the local people. A harmonious environment is a basis to achieve project success and sustainability.

6.5.5 Implications for TPPP practice

TPPP sustainability should be achieved in developed and developing countries because sustainability is a global objective. In this regard, the research output of this study offers useful and significant knowledge for practitioners to adopt this model in the evaluation of future projects. Firstly, the sustainability index quantifies the abstract concept of TPPP project sustainability, such that practitioners (i.e. public and private sectors) can practically and realistically evaluate the sustainability level of their projects. For practitioners to determine the sustainability index of a given project using the SI equation [Eq. (6.18)], they have to calculate the index for each sustainability factor group presented in the equation. Two methodological approaches, namely, any and ordinal scales, are available to calculate the index of a grouping. (1) Practitioners should assess the degree/extent

to which each sustainability factor under each grouping had been achieved in the given project on any scale of measurement (i.e. 5 or 7-point scale). Subsequently, the average sustainability index of each group should be determined and substituted in SI [Eq. (6.18)]. (2) Practitioners should assess the degree/extent to which each sustainability factor under each group had been achieved in the given project on any ordinal scale. Furthermore, the FSE procedure should be followed to drive the index for each factor grouping. Subsequently, the indices should be substituted in the SI equation [Eq. (6.18)].

Secondly, TPPPSI can be used by practitioners to compare sustainability levels of TPPP projects reliably and objectively for benchmarking and control purposes. Thirdly, the results inform practitioners to adopt proper management approaches to apply and the core areas to allocate resources to achieve TPPP project sustainability.

6.6 CHAPTER SUMMARY

This study developed a TPPP SI by using the FSE method. Firstly, a comprehensive review was conducted to generate a list of sustainable factors. Secondly, a questionnaire survey was conducted with experts who have in-depth knowledge and experience in TPPP projects. Thisrdly, fuzzy set theory was used to develop a pragmatic tool for evaluating the sustainability index of TPPP projects. The SI model consists of four sustainability factor groupings, namely, economic, environmental, social and people-oriented. The social category obtained the highest coefficient (0.255), followed by the economic (0.252), people-oriented (0.252) and environment (0.241) categories. The research outputs will enable practitioners interested in TPPP projects to evaluate reliably and objectively the sustainability level of their projects. Furthermore, practitioners can compare the sustainability

levels of two or more TPPP projects on the same basis.

TPPP success has been studied by countless research. However, sustainability as an important objective of TPPP infrastructure project has not attracted sufficient attention. In this regard, the outputs of this study are useful and significant. The TPPPSI index can be used to evaluate the sustainability level of TPPP projects considering the economic, environment, social and people aspects. For academics, this study expands the three-dimension sustainability framework to four dimensions by adding a set of people-oriented factors. The index emphasizes the importance of people in achieving sustainable development objective, which can be considered sustainability evaluation in other contexts.

CHAPTER 7 DEVELOPING A TPPP PROJECT EXCELLENCE MODEL

7.1 INTRODUCTION

Chapters 4, 5 and 6 analysed the risks, critical success and sustainability factors of TPPP project implementation, respectively, and established the underlying structures of the three aspects of key issues. Chapter 7 aims to develop a TPPP project excellence framework to identify the influences of these key factors to project success. To achieve this aim, this chapter firstly tests and confirms the factor structures. Thereafter, PLS-SEM is applied to investigate and model the influences of the various types of risks, success and sustainability factors. Lastly, this chapter uses the PLS-SEM findings as bases to propose the TPPP project success strategy to help stakeholders achieve success.

7.2 RESEARCH FRAMEWORK AND HYPOTHESES DEVELOPMENT

7.2.1 Research framework

Research framework is useful for developing new knowledge (Agherdien, 2007), which is based on theory or logic (Simon and Goes, 2011). The framework established in this section has a theoretical basis but has been modified and combined based on previous studies.

In many TPPP projects, the customer expects the highest quality for a project. This expectation means that the project team should deliver an excellent and outstanding project management. Everyone expects an innovative, flexible approach and outstanding results that go above the average standard. But how can the TPPP

project excellence be achieved and measured? How do key issues in TPPP projects influence the project excellence? One method to assess project excellence in TPPP is the TPPP Project Excellence Model (Grau, 2013).

Risk defined in this study have potential negative influences on project implementation. With respect to the use of risk management in projects, professionals state that risk management must be implemented because the project management handbooks says so and it should be done in the way the handbooks prescribes it (PMI, 2013a). Risk elements associated with construction projects influence time, cost and quality performance (Akintoye and MacLeod, 1997). Particularly for high risk projects, the risks associated with requirements, planning and control and the organisation are considerably evident (Wallace et al., 2004). According to the European Union Guidelines for Successful Public and Private Partnerships (2002), 'risk can be defined as any factor, event or influence that threatens the successful completion of a project' (Medda, 2007). Risk can also become the source of disputes amongst the different stakeholders. Therefore, risks are assigned a negative sign (−) in the TPPP project excellence.

Projects are often initiated in the context of a turbulent, unpredictable and dynamic environment. Consequently, the project manager would be well served by extensive information on the specific factors critical to project success (Pinto and Slevin, 1988). In PPP projects, one critical step in the development of a successful project is to identify, analyse and categorise various factors that are critical to the success of PPPs in general (Zhang, 2005a). CSFs are used to explicitly emphasise the key areas that are essential for management success (Boynton and Zmud, 1984). CSFs are defined as 'those key areas of activity in which favorable results are absolutely

necessary for a manager to reach his/her goals' (Li et al., 2005). Thus, to consider CSFs positive (+) to TPPP project excellence is reasonable.

In the last several decades, the concept of sustainability has grown in recognition and importance (SILvIuS et al., 2012). In previous studies, scholars have attempted to explore the relationship between sustainability and project management as one of the developments in project management (Silvius and Schipper, 2016). In PPP research, several studies have focused on sustainability research or project success (e.g. Li et al. (2005), Zou et al. (2014), Shen et al. (2016)). Although these related topics are frequently studied, the relationship between considering sustainability in a TPPP project and its success remains unexplored. Accordingly, understanding the sustainability factors associated with success is a prerequisite for the integration of sustainability into project success management practices (Pade et al., 2008). The rationale behind this hypothesis is that project managers logically strive for project success and that considering sustainability may have an influence on project success or the perception of this success (Silvius and Schipper, 2016). Therefore, risks are assigned a negative sign (−) in the TPPP project excellence.

The hypotheses research framework is shown in Fig. 7.1. The hypothesis is that three issues (i.e. risks, success and sustainability factors) collectively influence the TPPP project excellence. Therefore, these factors should be simultaneously analysed.

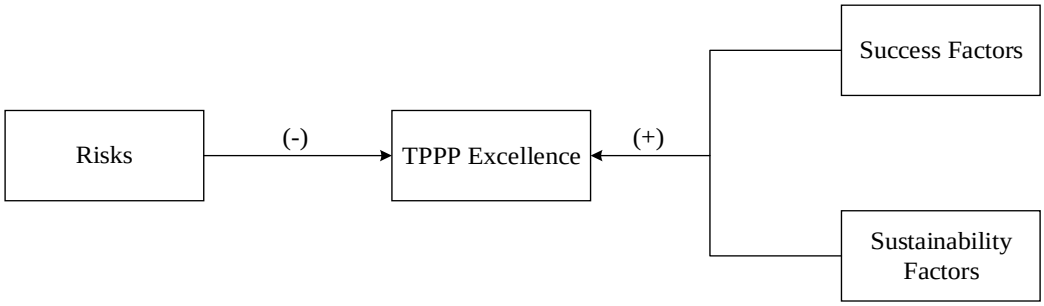


Fig. 7.1 Hypotheses for the TPPP project excellence model

7.2.2 Statement of TPPP project excellence

This study adapted the Project Excellence Model based on the European Foundation for Quality Management (EFQM) model to identify the key issues for the TPPP project excellence. EFQM was developed in 1988 with the objective of helping European companies become competitive in the international market (Gómez Gómez et al., 2011). The original EFQM Excellence Model is a non-prescriptive framework based on nine criteria (see Fig. 7.2). Five are 'Enablers' and four are 'Results'. 'Enablers' cover what an organisation does, whilst the 'Results' criteria cover what an organisation achieves. 'Results' are caused by 'Enablers' (Gómez Gómez et al., 2011). The EFQM model uses differ from the majority of the approaches used in project management. However, this model cannot readily be transferred to project situations. Therefore, Westerveld (2003) modified the EFQM model to suit project characteristics. In the modified model for projects, project success criteria can be seen as result areas (See Fig. 7.2). The Project Excellence Model is based on the assumption that to manage a project successfully, the project organisation has to be focused on (Westerveld, 2003).Given that TPPP is a type of project, the Project Excellence Model can also be modified and adopted in TPPP projects.

Following the Project Excellence Model, the TPPP Project Excellence Model also considers project success criteria into six areas, including achieving project results, appreciation by the client, appreciation by project personnel, appreciation by users, appreciation by contracting partners and appreciation by stakeholders. Fig. 7.2 shows the TPPP Project Excellence Model. Therefore, TPPP excellence in the present study is measured using six items (see Table 7.1).

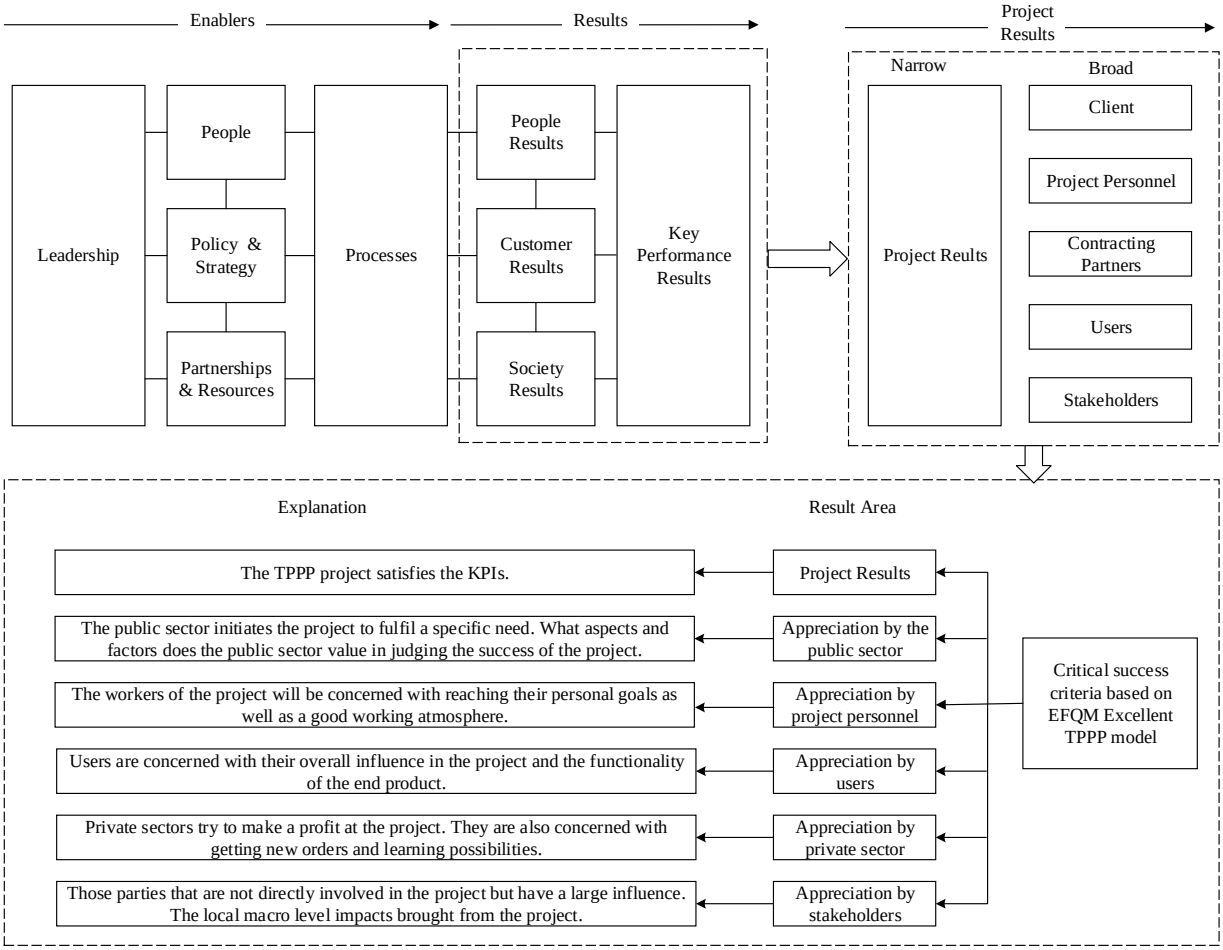


Fig. 7.2 TPPP Project Excellence statements
(modified from Westerveld (2003)

7.2.3 Hypothesis development

The appropriate hypotheses should be developed to investigate the influences of risk, success and sustainability factors on TPPP excellence. The development of the research hypotheses on this overall model is based on the comprehensive literature

review in Chapter 2, research framework (Fig. 7.1) and the empirical outcomes in Chapters 4 to 6. Based on the outcomes of previous stage, Table 7.1 summarises 13 constructs (i.e. constructs for TPPP projects' risk, success and sustainability factors and their respective measurement items). These items are used in the current chapter to examine and model the influences of these issues on TPPP project excellence.

Table 7.1 Constructs and their respective measurement items

Constructs	Code	Measurement items
Critical risk factors for TPPP projects		
Financial/Commercial risk category (FCR)	FCR1	Tariff risk
	FCR2	Financing risk
	FCR3	Currency risk
	FCR4	Demand and revenue risk
	FCR5	Tax risk
	FCR6	Payment risk
Legal and Socio-political risk category (LSPR)	LSPR1	Legal risk
	LSPR2	Corruption risk
	LSPR3	Political risk
	LSPR4	Administrative risk
	LSPR5	Lack of government support
Technical and natural risk category (TNR)	TNR1	Technology risk
	TNR2	Construction risk
	TNR3	Operation risk
	TNR4	Force majeure
	TNR5	Natural environment risk
Partnership risk category (PR)	PR1	Cooperation risk
	PR2	Credit risk
	PR3	Worker risk
	PR4	Competitiveness risk
	PR5	Cultural impediments
	PR6	Language differences
Critical success factors for TPPP projects		
Political and legal category (PLS)	PLS1	Political support
	PLS2	Transparent procurement
	PLS3	Favorable legal framework
	PLS4	Government providing guarantees
	PLS5	Political stability
	PLS6	Streamline approval process
	PLS7	Well organized and committed public agency
	PLS8	State relationship
Financial and economic category (FES)	FES1	Stable macroeconomic condition
	FES2	Acceptable level of tariff
	FES3	Mature and available financial market
	FES4	Sound economic policy
Technical category (TS)	TS1	Competitive procurement
	TS2	Detailed project planning
	TS3	Technology innovation

	TS4	Selecting the right project
	TS5	Clear project brief and design development
	TS6	Reliable service delivery
	TS7	Clear goals and objectives
	TS8	Consistent performance standard
Stakeholder relationship category (SRS)	SRS1	Appropriate risk allocation and sharing
	SRS2	Strong private consortium
	SRS3	Strong commitment by both parties
	SRS4	Clarity of roles and responsibilities among parties
	SRS5	Open and constant communication
	SRS6	Choosing the right partner
Social category (SS)	SS1	Public/community support
	SS2	Long term demand for the project
	SS3	Suitable environment
Critical sustainability factors for TPPP		
Economic sustainability category (ES)	ES1	Improve project quality
	ES2	Improve resource performance and efficiency
	ES3	Efficient maintenance
	ES4	Ongoing product service provision
	ES5	Ensure projects running on time and budgets
	ES6	Cost reduction
	ES7	Adaptability and flexibility
	ES8	Profitability
	ES9	Proper payment
Environment sustainability factors (NS)	NS1	Effectively utilizing sustainable design and materials
	NS2	Effective environment management system
	NS3	Effective emission management system
	NS4	Disaster resistance
	NS5	Land use efficiency and soil protection
Social sustainability factors (OS)	OS1	Meet demands and provide great service
	OS2	Promote relations between the two countries
	OS3	Ensure accountability, legitimacy and transparency
	OS4	Improve service standard
People-oriented sustainability factors (POS)	POS1	Serve and benefit residents
	POS2	Affordable user cost
	POS3	Protect human rights
	POS4	Ensure worker health and safety
TPPP projects Excellence criteria (TPEC)		
	TPEC1	Achieving project results is important to TPPP Project Excellence.
	TPEC2	Appreciation by the public sector is important to TPPP Project Excellence.

	TPEC3	Appreciation by project personnel is important to TPPP Project Excellence.
	TPEC4	Appreciation by users is important to TPPP Project Excellence.
	TPEC5	Appreciation by private sector is important to TPPP Project Excellence.
	TPEC6	Appreciation by stakeholders is important to TPPP Project Excellence.

Insights from the literature generally suggest that risks can bring difficulty for TPPP projects to achieve success. That is, risks have potentially negative influence on TPPP success. Meanwhile, success and sustainability factors have been argued to drive TPPP project success. In light of these insights and research framework (Fig. 7.1), the following research hypotheses are proposed:

H1a. Financial/commercial risks have negative influence on TPPP excellence.

H1b. Legal and socio-political risks have negative influence on TPPP excellence.

H1c. Technical and natural risks have negative influence on TPPP excellence.

H1d. Partnership risks have negative influence on TPPP excellence.

H2a. Political and legal success factors have positive influence on TPPP excellence.

H2b. Financial and economic success factors have positive influence on TPPP excellence.

H2c. Technical success factors have positive influence on TPPP excellence.

H2d. Stakeholder relationship success factors have positive influence on TPPP excellence.

H2e. Social success factors have positive influence on TPPP excellence.

H3a. Economic sustainability factors have positive influence on TPPP excellence.

H3b. Environment sustainability factors have positive influence on TPPP excellence.

H3c. Social sustainability factors have positive influence on TPPP excellence.

H3d. People-oriented sustainability factors have positive influence on TPPP excellence.

The hypothetical model is presented in Fig.7.3. The hypotheses are tested in this chapter, whilst the results contribute to deepening the understanding of the different key issues in influencing TPPP project excellence.

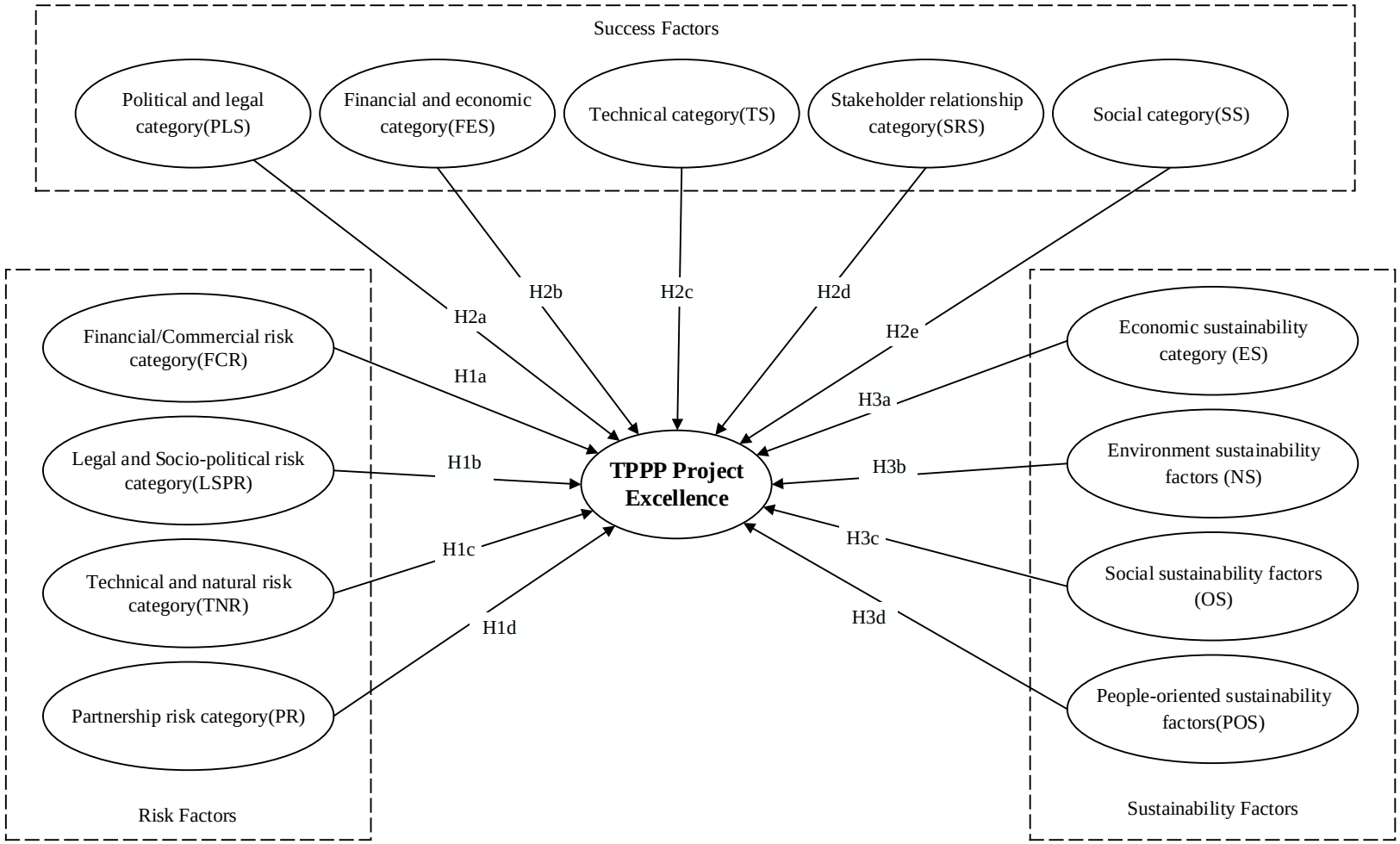


Fig. 7.3 Hypothetical model of the risk, success and sustainability factors influencing TPPP excellence

7.3 PLS-SEM RESULTS

7.3.1 Evaluation of the measurement model

Tables 7.2 to 7.4 show the evaluation results of the measurement models in the model of TPPP project excellence (see Fig. 7.2). Given that the CFA factor loading of the measurement items FCR1, FCR3, FCR4, FCR5, LSPR1, LSPR3, LSPR4, TNR2, TNR3, TNR5, PR1, PR2, PR3, PR4, PR6, PLS1, PLS2, PLS3, PLS4, PLS5, FES2, TS2, TS4, TS5, TS6, TS6, TS8, SRS1, SRS2, SRS3, SRS4, SRS6, SS2, SS3, SRS1, SRS2, SRS3, SRS4, SRS6, SS2, SS3, ES1, ES4, ES6, ES7, ES8, NS2, NS3, NS4, NS5, OS1, OS2, OS3, POS1, POS3, POS4, TPEC1, TPEC1, TPEC3, TPEC4, TPEC5 were below 0.60, these factors were deleted from the list of measurement items (Table 7.2). After the deletion of the measurement item with the lowest factor loading every time, the analysis was rerun. This procedure was repeated until reliable and valid measurement models were achieved (Darko et al., 2018). For some factors with low loading, their contribution to the explanatory power of the model would be insignificant. Nunnally and Bernstein (1967) claimed that these factors should be excluded from the model to avoid biases in the estimations of other measurement items. F. Hair Jr. et al. (2014) argued that in the PLS-SEM model, reflective measurement items are extremely correlated and interchangeable, whilst some items can be omitted without changing the meaning of the construct.

Table 7.2 shows that the composite reliability for all items are above 0.70, thereby providing an acceptable level of internal consistency reliability of the measurement items. Moreover, all factor loadings and AVEs are above 0.50, thereby indicating the convergent validity of the constructs. AVE with value above 0.50 shows that this construct can explain over 50% of the variance in its measurement items.

Additionally, Table 7.3 shows that the square roots of their AVEs were greater than the correlation amongst any two constructs or measurement items by examining the cross loadings, thereby providing the discriminant validity. Table 7.4 indicates the reliability and validity of the structural path model as each measurement item had the highest loadings on its corresponding construct.

Table 7.2 Measurement model evaluation

Construct	Measurement item code	Factor loading	Composite reliability	AVE
FCR	FCR2	1.000	1.000	1.000
LSPR	LSPR2	1.000	1.000	1.000
TNR	TNR1	0.818	0.808	0.678
	TNR4	0.829		
PR	PR5	1.000	1.000	
PLS	PLS6	0.642	0.782	0.650
	PLS7	0.942		
FES	FES1	0.749	0.784	0.549
	FES3	0.653		
	FES4	0.813		
TS	TS1	0.881	0.800	0.668
	TS3	0.749		
SRS	SRS5	1.000	1.000	1.000
SS	SS1	1.000	1.000	1.000
ES	ES2	0.649	0.863	0.615
	ES3	0.712		
	ES5	0.909		
	ES9	0.840		
NS	NS1	1.000	1.000	1.000
OS	OS4	1	1	1
POS	POS2	1	1	1
TPEC	TPEC2	0.837	0.786	0.647
	TPEC6	0.771		

FCR1,FCR3,FCR4,FCR5,LSPR1,LSPR3,LSPR4,TNR2,TNR3,TNR5,PR1,PR2,PR3,PR4,PR6,PLS1,PLS2,PLS3,PLS4,PLS5,FES2,TS2,TS4,TS5,TS6,TS6.TS8,SRS1,SRS2,SRS3,SRS4,SRS6,SS2,SS3,SRS1,SRS2,SRS3,SRS4,SRS6,SS2,SS3,ES1,ES4,ES6,ES7,ES8,NS2,NS3,NS4,NS5,OS1,OS2,OS3,POS1,POS3,POS4,TPEC1,TPEC1,TPEC3,TPEC4,TPEC5 were removed from the initial model because their factor loadings were below 0.60; FCR= Financial/Commercial risk; ES= Economic sustainability; NS= Environment sustainability; OS= Social sustainability; POS= People-oriented sustainability; TPEC= TPPP projects Excellence criteria; LSPR= Legal and Socio-political risk; TNR= Technical and natural risk ; PR= Partnership risk; PLS= Political and legal success factors; FES= Financial and economic success factors; TS= Technical success factors; SRS= Stakeholder relationship success factors; SS= social success factors.

Table 7.3 Cross loadings of measurement items

	FCR	ES	NS	OS	POS	TPEC	LSPR	TNR	PR	PLS	FES	TS	SRS	SS
FCR	**1.000**	-	-	-	-	-	-	-	-	-	-	-	-	-
ES	0.023	**0.784**	-	-	-	-	-	-	-	-	-	-	-	-
NS	0.054	0.012	**1.000**	-	-	-	-	-	-	-	-	-	-	-
OS	0.100	0.199	0.333	**1.000**	-	-	-	-	-	-	-	-	-	-
POS	0.195	0.404	0.148	0.166	**1.000**	-	-	-	-	-	-	-	-	-
TPEC	0.021	0.129	0.289	0.107	0.202	**0.805**	-	-	-	-	-	-	-	-
LSPR	0.181	0.011	0.189	0.128	0.033	0.152	**1.000**	-	-	-	-	-	-	-
TNR	0.095	0.008	0.048	0.101	0.153	0.206	0.174	**0.824**	-	-	-	-	-	-
PR	0.033	0.014	0.124	0.334	0.139	0.198	0.268	0.028	**1.000**	-	-	-	-	-
PLS	0.016	0.178	0.158	0.050	0.137	0.201	0.157	0.023	0.197	**0.806**	-	-	-	-
FES	0.048	0.082	0.071	0.146	0.078	0.299	0.131	0.116	0.369	0.572	**0.741**	-	-	-
TS	0.107	0.068	0.078	0.144	0.106	0.330	0.099	0.111	0.003	0.263	0.402	**0.817**	-	-
SRS	0.010	0.007	0.077	0.047	0.176	0.265	0.116	0.189	0.134	0.505	0.441	0.282	**1.000**	-
SS	0.024	0.147	0.063	0.300	0.312	0.378	0.026	0.226	0.441	0.276	0.434	0.430	0.334	**1.000**

The bold diagonal values are the squares root of average variance extracted of each construct, while other values are the correlations amongst constructs; FCR= Financial/Commercial risk; ES= Economic sustainability; NS= Environment sustainability; OS= Social sustainability; POS= People-oriented sustainability; TPEC= TPPP projects Excellence criteria; LSPR= Legal and Socio-political risk; TNR= Technical and natural risk ; PR= Partnership risk; PLS= Political and legal success factors; FES= Financial and economic success factors; TS= Technical success factors; SRS= Stakeholder relationship success factors; SS= social success factors.

Table 7.4 Cross loadings for individual measurement items

Measurement item code	ES	FCR	FES	LSPR	NS	OS	PLS	POS	PR	SRS	SS	TNR	TPEC	TS
ES2	**0.649**	0.137	0.093	0.060	0.267	0.015	0.189	0.289	0.008	0.101	0.019	0.021	0.083	0.106
ES3	**0.712**	0.042	0.026	0.008	0.061	0.179	0.114	0.291	0.008	0.172	0.140	0.141	0.044	0.004
ES5	**0.909**	0.038	0.117	0.027	0.044	0.272	0.200	0.335	0.070	0.056	0.198	0.016	0.150	0.089
ES9	**0.840**	0.038	0.055	0.055	0.146	0.078	0.018	0.376	0.104	0.171	0.049	0.000	0.066	0.054
FCR2	0.023	**1.000**	0.048	0.181	0.054	0.100	0.016	0.195	0.033	0.010	0.024	0.095	0.021	0.107
FES1	0.109	0.080	**0.749**	0.235	0.046	0.105	0.461	0.035	0.435	0.313	0.389	0.052	0.218	0.377
FES3	0.132	0.037	**0.653**	0.119	0.073	0.074	0.456	0.197	0.153	0.402	0.329	0.311	0.175	0.298
FES4	0.025	0.001	**0.813**	0.130	0.046	0.136	0.382	0.014	0.226	0.297	0.268	0.052	0.262	0.241
LSPR2	0.011	0.181	0.131	**1.000**	0.189	0.128	0.157	0.033	0.268	0.116	0.023	0.174	0.152	0.099

NS1	0.012	0.054	0.071	0.189	**1.000**	0.333	0.158	0.148	0.124	0.077	0.063	0.048	0.289	0.078
OS4	0.199	0.100	0.146	0.128	0.333	**1.000**	0.050	0.166	0.334	0.047	0.360	0.101	0.107	0.144
PLS6	0.004	0.128	0.522	0.091	0.098	0.011	**0.642**	0.174	0.053	0.486	0.137	0.166	0.090	0.386
PLS7	0.220	0.076	0.471	0.152	0.150	0.057	**0.942**	0.092	0.218	0.405	0.278	0.045	0.207	0.153
POS2	0.404	0.195	0.078	0.033	0.148	0.166	0.137	**1.000**	0.139	0.176	0.312	0.153	0.202	0.106
PR5	0.014	0.033	0.369	0.268	0.124	0.334	0.197	0.139	**1.000**	0.134	0.441	0.028	0.198	0.003
SRS5	0.007	0.010	0.441	0.116	0.077	0.047	0.505	0.176	0.134	**1.000**	0.334	0.189	0.265	0.282
SS1	0.147	0.024	0.434	0.023	0.063	0.360	0.276	0.312	0.441	0.334	**1.000**	0.226	0.378	0.430
TNR1	0.064	0.094	0.026	0.084	0.123	0.042	0.032	0.226	0.018	0.165	0.169	**0.818**	0.167	0.178
TNR4	0.075	0.063	0.164	0.200	0.041	0.124	0.006	0.029	0.028	0.146	0.204	**0.829**	0.171	0.007
TPEC2	0.118	0.039	0.269	0.163	0.274	0.055	0.044	0.167	0.150	0.213	0.300	0.244	**0.837**	0.344
TPEC6	0.088	0.009	0.209	0.076	0.187	0.121	0.300	0.158	0.170	0.216	0.311	0.075	**0.771**	0.175
TS1	0.010	0.056	0.427	0.060	0.067	0.017	0.200	0.077	0.037	0.244	0.338	0.133	0.309	**0.881**
TS3	0.120	0.133	0.200	0.113	0.061	0.309	0.242	0.102	0.059	0.218	0.378	0.033	0.221	**0.749**

Bold values show that each measurement item had the highest loading on its respective construct; ES= Economic sustainability; FCR= Financial/Commercial risk; FES= Financial and economic success factors; LSPR= Legal and Socio-political risk; NS= Environment sustainability; OS= Social sustainability; PLS= Political and legal success factors; POS= People-oriented sustainability; PR= Partnership risk; SRS= Stakeholder relationship success factors; SS= social success factors; TNR= Technical and natural risk; TPEC= TPPP projects Excellence criteria; TS= Technical success factors.

7.3.2 Evaluation of the structural model

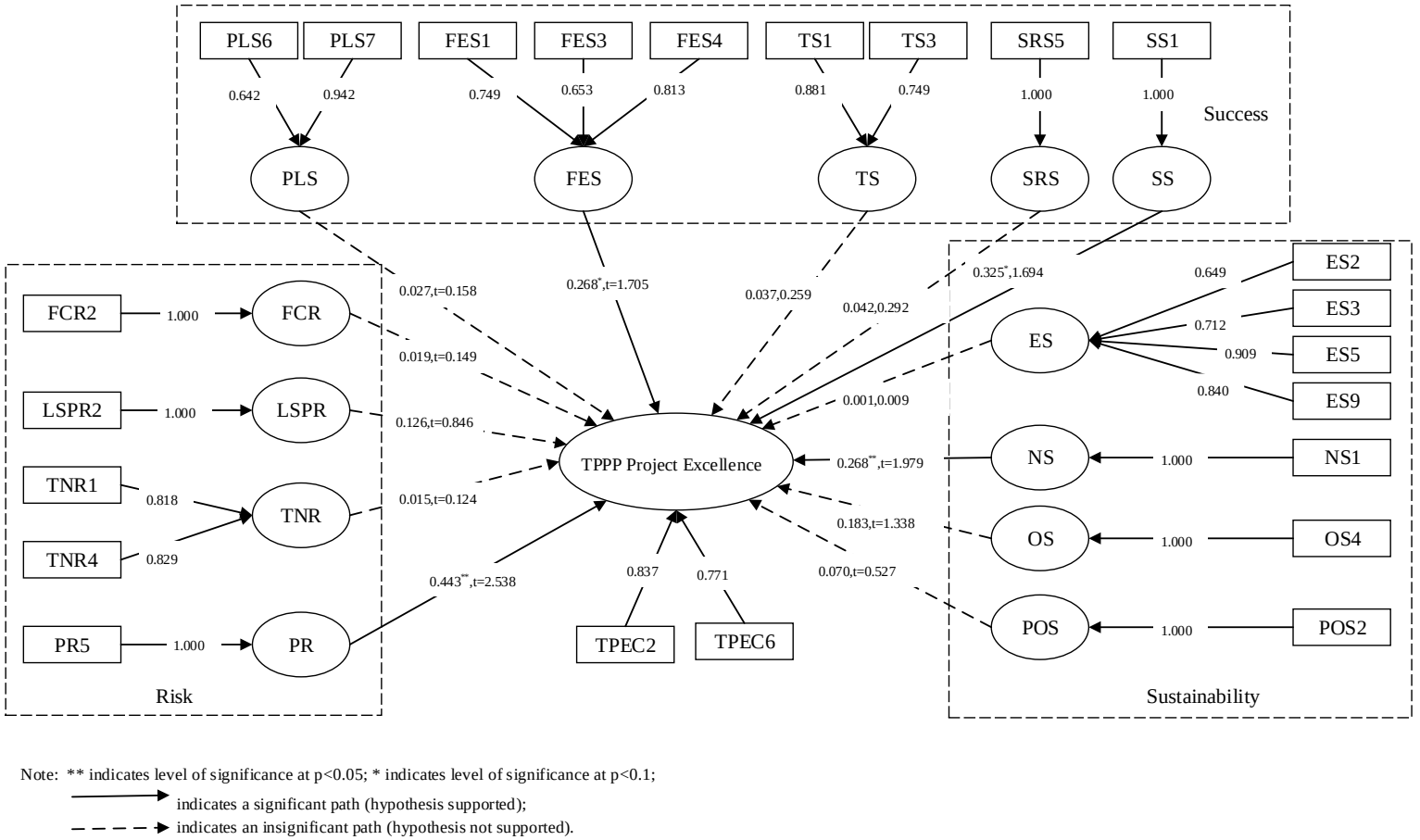
Table 7.5 shows the bootstrapping results for the model. The results show that (1) the path linking partnership risks to TPPP project excellence had a t-value above 2.58, thereby implying that it was statistically significant at the 0.05 level. Thus, H1d is supported. (2) The financial and economic success factors to TPPP project excellence had a t-value above 1.65, which means that it was statistically significant at the 0.1 level. Hence, H2b is supported. (3) The social success factors to TPPP project excellence had a t-value above 1.65, which means it was statistically significant at the 0.1 level. Therefore, H2e is supported. (4) The environment sustainability factors to TPPP project excellence had a t-value above 1.96, thereby implying that it was statistically significant at the 0.05 level. Thus, H3b is supported. However, the PLS-SEM model results did not provide significant support for H1a, H1b, H1c, H2a, H2c, H2d, H3a, H3c and H3d. The path coefficients of these items were low and the t-values were below 1.65 (at 0.1 significant level), 1.96 (at 0.05 significant level) and 2.58 (at 0.01 significant level). The final structural equation model depicting the influence of each factor is illustrated in Fig. 7.4.

Table 7.5 Structural model evaluation

Hypothetical path	Path coefficient	*t*-value	*p*-value	Interpretation
H1a: FCR ⟶ TPE	0.019	0.149	0.881	Not supported
H1b: LSPR ⟶ TPE	0.126	0.846	0.398	Not supported
H1c: TNR ⟶ TPE	0.015	0.124	0.901	Not supported
H1d: PR ⟶ TPE	0.443	2.538	0.011**	Supported
H2a: PLS ⟶ TPE	0.027	0.158	0.874	Not supported
H2b: FES ⟶ TPE	0.268	1.705	0.088*	Supported
H2c: TS ⟶ TPE	0.037	0.259	0.795	Not supported
H2d: SRS ⟶ TPE	0.042	0.292	0.770	Not supported
H2e: SS ⟶ TPE	0.325	1.694	0.090*	Supported
H3a: ES ⟶ TPE	0.001	0.009	0.993	Not supported
H3b: NS ⟶ TPE	0.268	1.979	0.048**	Supported
H3c: OS ⟶ TPE	0.183	1.338	0.181	Not supported
H3d: POS ⟶ TPE	0.070	0.527	0.598	Not supported

**The path coefficient is significant at p<0.05; *The path coefficient is significant at p<0.1.

ES= Economic sustainability; FCR= Financial/Commercial risk; FES= Financial and economic success factors; LSPR= Legal and Socio-political risk; NS= Environment sustainability; OS= Social sustainability; PLS= Political and legal success factors; POS= People-oriented sustainability; PR= Partnership risk; SRS= Stakeholder relationship success factors; SS= social success factors; TNR= Technical and natural risk; TPEC= TPPP projects Excellence criteria; TS= Technical success factors.



Note: ** indicates level of significance at p<0.05; * indicates level of significance at p<0.1;
indicates a significant path (hypothesis supported);
indicates an insignificant path (hypothesis not supported).

Fig. 7.4 Final structural equation model of the TPPP project excellence

7.4 DISCUSSION OF THE PLS-SEM RESULTS

7.4.1 Risks

The PLS-SEM results supported a significantly negative influence of partnership risk on TPPP project excellence. Furthermore, the results implied that partnership risks are the most significant risk hindering the TPPP project to achieve excellence. The result can be interpreted that the higher the partnership risk, the lower the level of TPPP excellence.

Partnership risk resulting from uneven cooperation and lack of communication among participants is due to pursuit of different interests (Li and Wang, 2018). Evidently, TPPP is a type of partnership. This scheme can achieve resource and risk sharing but can also improve (Mao and Zhang, 2017) communication and coordination costs (Mao and Zhang, 2017). Any conflicts or risks between the two main stakeholders (public and private sectors) in PPP may result in a chain of questions and ruin the trust and cooperation between them. In TPPP projects, foreign investors are unfamiliar with the local government before implementing the project and have different attitudes, management styles and corporate culture. These factors may hinder TPPP to achieve project excellence.

Amongst the partnership risk factors, cultural impediment was significantly important to the TPPP project excellence. Cultural impediments are common in international projects. When the culture distance between the home and host countries is large, assessing investment potential, transplanting managerial experience, and collecting intelligence can become problematic for foreign investors (Shane, 1994). Cultural impediments may lead to high transaction cost, misunderstanding or even conflicts. Potential problems are in communication and

operation errors originating from countries with different languages and business practices (Pothukuchi et al., 2002). If the private sector enters a country for the first time, the unfamiliarity with local environment, government or business partner might result in lower performance. The influence from cultural impediments for services firms may be more profound than manufacturing firms because the communication between stakeholders is considerably frequent and critical (O'Farrell and Moffat, 1991). TPPP projects are particularly complex with extensive stakeholders and close partnership relations with local government and companies and long cooperation period, which are risky and may lead to conflicts, mistakes and overall degrading of performance. Consequently, cultural impediments hamper excellence in TPPP projects.

7.4.2 Success factors

The PLS-SEM model results revealed that social success factors are the most significant issues to promote TPPP project excellence, followed by financial and economic factors. This result may further explain why sustainability factors were considered as important to project excellence. This result may also indicate that the respondents were consistent in their responses, thereby contributing to the reliability of the results. The results implied that social factors would have a significant positive influence on the TPPP project excellence. Several compelling arguments in the literature support this finding.

Overlooking social issues could lead to the abolition of a PPP project, thereby undermine the credibility of government (Ng et al., 2010). PPP projects are evidently public projects, thereby making their social character integral. The full understanding and acknowledgement of the social of PPP are important for the

success of a PPP project. The public and private sectors often have their social and economic interests, respectively. Thus, the private partner should be aware of the social character and vice versa (Kanakoudis et al., 2007). The research finding is consistent with Ng et al. (2012), who explained that social factors should be the most important concern of the general community when assessing the feasibility of a PPP project. Given that social acceptance is indispensable in the current society, the government should never commission a PPP project for expediting the facility or service provision without satisfying the community or local residents' requirements and expectation (Heinke and Wei, 2000). Therefore, the public should be engaged to become involved in the TPPP project implementation, make them realise the potential impact and benefits of the scheme and eventually gain their support and trust (Ho and Liu, 2002). The present study implies that the public/community support significantly influences the achievement of TPPP excellence. When Chinese companies invest in overseas markets in B&R countries, the residents' attitude and support are of importance to the project implementation.

Strong public support is insufficient for the development of a TPPP project but will contribute favourably to project implementation. Given that infrastructure has important influence on local residence, their feelings should be considered during implementing the projects for public and private sectors. Faced with demands and high-quality service, the public will find satisfaction in the project and support its continuous development. If local residents support a TPPP project, then investors would have an easier way to achieve an amiable relationship with the local government and a good reputation in that country.

Strong community support can only assist the projects' likelihood of success. The

support can result in quicker and more efficient approval (Jefferies et al., 2002). Brinkerhoff and Brinkerhoff (2011) suggested that PPPs that are higher in public than private benefits maybe be likely to enjoy greater public support and be accorded more legitimacy by citizens. In the current society, being transparent and accountable towards the public alone is no longer adequate. The government should focus on the soft issues because PPP projects are susceptible to severe political and social scrutiny (Freeman, 2003). Moreover, public or community support help improve the cooperation with local companies and workers. Therefore, an improved public/community support is essential to promoting TPPP project excellence.

Another key success factor group is financial and economic factors. Adopting appropriate financial methods is crucial to the success of PPPs (Yuan et al., 2011). Several approaches of VFM evaluation have been developed and focused purely on financial aspects (Tsamboulas et al., 2013). By using VFM to assess a PPP project, the main consideration is whether they can offer a cost-effective solution compared to other traditional project delivery forms, therebynecessitating careful scrutiny of the financial and economic issues (Hambros et al., 1999).

The current study has quantified the influence of financial and economic success factors on TPPP project excellence in stable macroeconomic conditions, mature and available financial market and sound economic policy. To achieve successful TPPP project implementation, governments must ensure that economic conditions are favourable (Li et al., 2005). A stable macro-economic environment shows the market exhibiting reasonable certainty and market risk is correspondingly low. This scenario can reduce the risks for private investors, attract competitive private investors and increase opportunities for success. Especially for foreign investors,

the macro-environment influences their selection of the investment country, market and project. Investors formulate the investment plan and project implementation based on the prediction of stable economic condition. A stable macro-economic market is considerably predictable, thereby lowering risks, such as interest, exchange, employment and inflation rates. Reducing risks and enabling a reasonable investment return for foreign private investors in TPPP projects are necessary (Cheung et al., 2012a). Therefore, the stable economic condition is helpful for TPPP to achieve project goals.

To attract private investors, a PPP project must be self-sustainable, financially viable and profitable (Ng et al., 2010). For transnational projects, investors wish to obtain low-cost financing from the local market. During the long period of project implementation, a sound economic environment can provide the financing support when necessary and ensure the stable demand from users. The availability of an efficient and mature financial market's low financing costs and diversified range of financial products would be a driver for attracting foreign investors. In a TPPP project, the government can help create and maintain a stable environment by manipulating economic policy to ensure stable prices and by maintaining a balanced budget. A sound macro-economic policy affects the credibility of a price system and trust in the convertibility of the currency, which are essential for foreign investors (Dailami and Klein, 1999). Governments should adopt economic policies to maintain a stable and growing platform for private sectors to operate with confidence (Li et al., 2005). Thus, a mature and available financial market will positively influence the TPPP project excellence.

7.4.3 Sustainability factors

The PLS-SEM results revealed that environmental sustainability factors are significant to promote TPPP project excellence. The general perception is that the private sector often focuses on its financial advantages while disregarding the social and environmental aspects of sustainable urban infrastructures (Koppenjan and Enserink, 2009). The World Bank report shows a remarkable disregard of problems and risks. The result of the current study implies the importance to improve the sustainability of the urban environment.

Effectively utilising sustainable design and materials were implied as the most significant factor influencing TPPP project excellence. Sustainable design is defined as 'a design philosophy that seeks to maximize the quality of the built environment, while minimizing or eliminating negative impacts to the natural environment' (McLennan, 2004). A slight increase in upfront costs of approximately 2% to support sustainable design results in life cycle savings of approximately 20% of total construction costs in average, which is over 10 times the initial investment (Kats et al., 2003). Using sustainable material is an important sustainable strategy, which can reduce needs for materials and instead, use recycled materials (Azhar et al., 2011). The influence may be substantially important in TPPP projects because the private sectors take responsibilities for constructing and operating the projects for a long period. Effectively utilising sustainable design and materials ensures the quality of projects and improves the project life period.

Several studies and sustainable design tools have provided numerous sustainable design options for designers. However, not all of these tools can be used in practice because of affordability and risks that the investors will have to consider (Wang et

al., 2010). The current study implies the importance of sustainable design and materials in implementing TPPP projects. A comprehensive feasibility study on the design options should be included in the decision-making process to calculate how much their project can benefit the environment by choosing the right design options.

7.5 CHAPTER SUMMARY

Risk, success and sustainability factors influence TPPP project excellence. However, only a few studies have focused on the quantitative influences of these factors on the TPPP project excellence. This chapter examined and modelled the quantitative influences of various categories of risk, success and sustainability factors on TPPP excellence. The data were collected from literature review and with professionals with TPPP experience. The PLS-SEM model was used to analyse the data. The results indicated that partnership risks have a significant negative influence on TPPP project excellence. Additionally, the results showed that financial and economic and social success factors have a significant positive influence on TPPP project excellence. Furthermore, environment sustainability factors have significant positive influences on TPPP project success.

The models and findings from this study could be of immense value and utility for academics, industrial practitioners, policy makers and advocates seeking empirical quantitative evidence and explanations about the influences of risk, success, and sustainability factors on TPPP project excellence. A clear understanding of which risk, success, and sustainability factors could significantly influence TPPP project excellence is beneficial to the promotion and development of TPPP projects in B&R countries. The awareness of risks that are significantly correlated to TPPP project success can aid public agencies and foreign private investors to devise strategies to

mitigate and respond to these risk issues. The appreciation of success factors may help stakeholders understand the key issues that can directly influence project achieving excellence. The relation of TPPP project sustainability to excellence may emphasise the importance of achieving project excellence, and thereafter help practitioners to focus on sustainability besides economic benefits. To the PPP body of knowledge, the key contribution of this study is developing quantitative models that explicate how various types of risk, success and sustainability factors influence the project excellence.

Although the research aim was achieved, limitations still emerged. Firstly, although the sample was adequate to adopt the PLS-SEM model, such a sample was relatively small. However, this study provides invaluable insights into the influences of different types of risk, success and sustainability factors on TPPP project excellence. Secondly, this study used nonprobability sampling approach due to the lack of sampling frame. This method selected respondents based on their willingness to participate in rather than selecting them from the population randomly.

Nonetheless, the findings and implications of this research may be useful to policy makers, government agencies, private sectors, stakeholders and advocates in implementing TPPP projects. In future studies, risk issues, success and sustainability factors should be updated and revised because the key issues might change over the time and the contexts of different projects might not be the same. Moreover, the method used in this study may be adopted in a specific country/market or project. Hence, the result may be considerably related to the focused context.

CHAPTER 8 VALIDATION AND CONCLUSIONS

8.1 INTRODUCTION

This chapter presents the validation of the proposed TPPP models to help achieve the TPPP objectives. A survey was designed to show all the research outputs and results of this study and experts were invited to validate this study. The perceptions of six experts on this study were adopted to evaluate the validity.

Chapters 1 to 8 presented various aspects of this study. Chapter 1 introduced the background and the entire research framework. Chapter 2 performed a comprehensive literature review on the various issues addressed in this study. Chapter 3 presented the research methodology. Chapters 4 to 7 reported the empirical research in various areas. Chapter 8 validated the research outputs and results. This chapter summarizes this study by reviewing each objective and research results. Moreover, the significance and value of the research to practice and academia are further expanded and discussed. Lastly, this chapter highlights the limitations encountered during the research and provides recommendations for future study.

8.2 VALIADATION OF THE RESEARCH FRAMEWORK

Validation is an essential final stage within a research cycle (Hu et al., 2016). Validation tests the credibility and acceptability of the research outputs and models (Cheung, 2009, Ameyaw, 2014, Osei-Kyei, 2017). The challenge in the process of validation is that no established procedure is available to identify or determine which validation methods and statistical tests should be used in the validation process (Sargent, 1991). Law (2008) described that the validation approach mainly

depends on the specific purpose of the research study.

Validation is concerned with 'doing the right things'. This process is used to ensure that the various stages of the research methodology used adhered to the highest quality standards, such that the generated results are credible and acceptable to practitioners. Botten et al. (1989) and Yeung (2007) highlighted the validation measures usability, adequacy, precision, accuracy and appropriateness of a framework or system. Lucko and Rojas (2009) divided the validation in construction engineering and management area into six types, including internal, external, face, content, construct and criterion validity.

Research validation process are grouped into two approaches, namely, quantitative and qualitative (Ameyaw, 2014, Yang et al., 2010). The qualitative approach utilises research designs that involve opinion-based rather than numerical data. The quantitative approach uses research designs that involve the use of objective and numerical data to test hypothesised relationships among variables (Lucko and Rojas, 2009). This study adopted a qualitative method of validation because the proposed models are associated with abstract constructs that are difficult to assess quantitatively (Ameyaw, 2014, Osei-Kyei, 2017, Hu et al., 2016). Therefore, to collect opinion-based data against prescribed evaluation criteria is substantially appropriate.

8.2.1 Validation Survey

Similar to Ameyaw (2014) and Osei-Kyei (2017), to validate the credibility, suitability and quality of the proposed frameworks, the questionnaire survey was conducted with experienced TPPP experts. The validation questionnaire was delivered by email to the targeted experts because this way allows a researcher to

reach and communicate to respondents easily (Andrews et al., 2003, Ameyaw, 2014). The validation survey was conducted face to face, whilst the entire process comprised several statements that were modified from Osei-Kyei (2017). The potential respondents were invited to participate in the validation survey. All respondents have over six years of experience within the TPPP area. Eventually, six experts from the academic and industrial sectors responded to the validation survey. This sample was deemed adequate and reasonable as the validation survey compared to six for the validation of Osei-Kyei (2017) and seven for Ameyaw (2014) in PPP-related studies. Table 8.1 shows the background of the experts.

Table 8.1 Background of experts for validation

Item	Position	Institution	Sector	Years of Experience
E1	Professor	Local University	Academic	10 years
E2	Project Manager	International construction firm	Private	8 years
E3	Project consultant	Consultancy	Consultancy	6 years
E4	Engineer	Government agency	Public	7 years
E5	Senior Lecture	University	Academic	8 years
E6	Project Investor Manager	Local investment firm	Private	11 years

Table 8.1 shows that all six experts occupy senior level positions and possess adequate TPPP experience. Furthermore, these experts are from different sectors (i.e. academic, public, private and consultancy), thereby rendering the ingenuity and authenticity of the validation responses.

8.2.2 Validation Results

The respondents were asked to use a five-point scale (1 = strongly disagree, 2 = disagree; 3 = natural; 4 = agree; 5 = strongly agree) for each of the validation statements to value their level of agreement. Table 8.2 shows the validation questionnaire results. These validity statements had mean scores above 3.00 and the

majority are above 4.00. These results imply that the proposed results are reasonable and reliable.

Table 8.2 Validation results of the proposed models

No.	Validation aspects/statements	Responses						Mean
		R1	R2	R3	R4	R5	R6	
The process model of risk management for TPPP projects								
1	The identified risk factors for TPPP projects are reasonable	5	4	4	5	5	5	4.67
2	The TPPP risk factors within each risk category are appropriate	4	3	5	4	5	4	4.17
3	The risk evaluation method is easily understandable and could be used in the industry	3	3	3	3	4	4	3.33
4	The risk allocation method is easily understandable and could be used in the industry	4	4	3	4	4	4	3.83
5	Overall, the risk management process model is suitable for helping to achieve TPPP project excellence	3	3	4	4	5	4	4.00
The success issues model for TPPP projects								
1	The identified success factors for TPPP projects are reasonable	4	5	5	4	4	5	4.50
2	The TPPP success factors within each success category are appropriate	3	4	4	5	4	5	4.17
3	The key success factors model is easily understandable and could be used in the industry	5	5	4	5	5	4	4.67
4	Overall, the success factor model is suitable for helping to achieve TPPP project excellence	4	5	3	5	4	5	4.33
The sustainability index model for TPPP projects								
1	The identified sustainability factors for TPPP projects are reasonable	5	4	4	4	5	5	4.50
2	The TPPP sustainability factors within each sustainability category are appropriate	4	5	4	5	4	4	4.33
3	The sustainability index model is easily understandable and could be used in the industry	4	4	3	4	3	5	3.83
4	Overall, the sustainability index model is suitable for helping achieve TPPP project excellence	5	4	4	5	4	3	4.17
The TPPP Project Excellence Model								
1	The significant risk factors, success factors, and sustainability factors identified are reasonable and correctly reflect the current situation in TPPP projects in the B&R countries	4	5	5	5	4	4	4.5
2	The TPPP project excellence model is inclusive	5	4	4	4	5	3	4.17
3	The appropriate use and management of the key risk factors, success factors and sustainability factors would definitely help to promote the TPPP excellence in the B&R	4	3	5	4	4	4	4.00

	countries							
4	Overall, the TPPP project excellence model is suitable for helping Chinese private investors to invest in TPPP projects in the B&R countries	4	5	4	4	5	4	4.33

Note: The six respondents are represented with R1-R6.

The validation focused on four main proposed results of the current study, including the process model of risk management and models of success issues, sustainability index and the overall TPPP project excellence. Regarding the risk management process model, statements 1 and 2 obtained scores of 4.67 and 4.17, respectively, thereby implying that the identification and categorisation of critical risk factors for TPPP projects are reasonable within the context of TPPP projects. Statements 3 and 4 indicate the practicality of the process model, whilst practicality was assessed to have mean scores of 3.33 and 3.83, respectively. This result indicates that the risk evaluation and allocation methods are satisfactory in the context of TPPP projects, whilst the mean value below 4.00 could suggest room for improvement. A possible reason for the low agreement may be the complicated mathematical formulas and equations involved in adopting the model. Several respondents found that these formulas are difficult to calculate and they recommended to design a software that could automatically generate the results. Moreover, statement 5 had a mean score of 4.00, thereby suggesting that the overall suitability of the risk management process for achieving TPPP project excellence is high. For the success issues provided in this research, all the statements had mean scores above 4.00. This result implies that the respondents considered all of the validation aspects of the success model to be adequate. Similarly, the agreement mean values for statements 1, 2 and 4 for the sustainability index model are above 4.00. Hence, experts have a very good agreement and confidence about the sustainability model. Moreover, the practicality mean value of statement 3 is 3.83. This result could have been the result

of the comprehensive equations involved in applying the index model. Regarding the TPPP project excellence model, the four validation aspects received a high level of agreement from the experts with mean values above 4.00. This result indicates that the majority of the experts are confident that the framework provided by the model can be replicated by researchers and practitioners in TPPP projects.This finding represents that the overall research design is logical and appropriate.

8.3 REVIEW OF THE RESEARCH OBJECTIVES AND CONCLUSIONS

The overall aim of this study was to develop a model to outline key issues to achieve project excellence in TPPP project management in the B&R countries. To achieve the aim, the following specific objectives are established:

1. To identify CRFs and develop a risk management process model for TPPP projects,
2. To identify CSFs and specific success factors for TPPP projects,
3. To identify CTFs and to develop an SI model for TPPP projects and
4. To develop a TPPP project excellence model and to identify the influences of key issues on TPPP project excellence.

A range of research methods was adopted to realise these objectives (see Chapter 3). The main findings and conclusions for each objective have been presented in Chapters 4 to 7, whilst the result validation was presented in Chapter 8. These objectives are summarised, highlighted and reviewed as follows.

Objective 1: To identify CRFs and develop a risk management process model

for TPPP projects

An extensive and comprehensive literature review of risk factors for TPPP projects was conducted from the related publications in Chapter 2. A total of 42 risk factors were identified on the basis of this systematic literature review. Thereafter, the factors were identified and categorised by experts. CRFs were divided into four risk categories, including (1) financial/commercial, (2) legal and socio-political, (3) technical and natural and (4) partnership. After risk identification, risk evaluation and allocation are the important two stages in TPPP risk management process. Through IFAHP, the ranking of importance among the various risk factors was established based on possibility and severity. Game theory was adopted in the risk allocation process. After having presented the proposed methodology, a case study was conducted to show the practicality of the proposed risk management model in TPPP projects.

Objective 2: To identify CSFs and specific success factors for TPPP projects

To identify the critical success factors for TPPP projects, a comprehensive review of relevant published literature was first carried out in chapter 2. The review extracted 27 success factors. The initial success factor list was updated and revised based on expert comments and were categorised into five groups, namely, (1) political and legal, (2) financial and economic, (3) technical, (4) stakeholder relationship and (5) social. To clearly understand the key and special success factors for TPPP projects, a comparative study was conducted by delivering questionnaires to TPPP and DPPP experts. The results showed that the top five CSFs in TPPP projects are (1) favourable legal framework, (2) long term demand for the project, (3) appropriate risk allocation and sharing, (4) selecting the right project and (5)

choosing the right partner. The success factors that are rank high in TPPP but not that important in DPPP are long-term demand for the project, choosing the right partner and clarity of roles and responsibilities among parties.

Objective 3: To identify CTFs and develop an SI model for TPPP projects

A total of 45 sustainability factors to TPPP implementation were identified via a comprehensive literature review conducted in Chapter 2. These sustainability factors were grouped into four categories, namely, (1) economic, (2) environment, (3) social and (4) people-oriented. The questionnaire results indicated that 22 sustainability factors were critical to the TPPP project excellence. Thereafter, the FSE method was adopted to establish the TPPP project SI. The SI index can be used for reliable and objective evaluation of the sustainability level of the TPPP project.

Objective 4: To develop a TPPP project excellence model and identify the influences of key issues on TPPP project excellence

The PLS-SEM technique was implemented to examine and model the influences of the various types of risk, success and sustainability factors. The TPPP project excellence model and hypothesis were established based on related literature. Based on the EFQM model, the six statements of TPPP project excellence were used to evaluate the project results. By analysing the data from 63 questionnaires responses, several hypotheses were supported. The results indicated that 'partnership risk factors', 'financial and economic success factors', 'social success factors' and 'environment sustainability factors' would have significant influences on the TPPP project excellence.

8.4 TPPP PROJECT EXCELLENCE MANAGEMENT

STRATEGY

Based on the discussion of the TPPP project excellence model and the research results of TPPP project risk, key success factors and sustainability, Figure 8.1 summarizes the key factors of the TPPP project excellence model and according to the TPPP project life cycle stages, and establish corresponding key activities and propose management strategies and recommendations. The model is divided into two main parts. The upper part is “the key factor of TPPP project excellence”, which mainly summarizes the research results of Chapters 4 to 7. The second part is “TPPP Project Excellence Management Strategy”. Mainly based on the characteristics of the TPPP project phase and the main tasks, the activities and management strategies needed to achieve excellence in each phase are proposed.

The focus on the key factors of the TPPP project should not be limited to a certain time or stage, but should be carried out throughout the life cycle of the project to achieve different milestones and prepare for the objectives or tasks of the next phase of the project. The TPPP project is divided into five phases, including project identification, project preparation, project procurement, project implementation, and project handover. Each phase contains several important activities and nodes to drive the orderly progress of the TPPP. The main activity in the project identification phase is to identify and screen potential TPPP projects. The TPPP project risk assessment, critical success factor assessment, sustainability assessment and project excellence assessment program established in this study can help project sponsors or investors to choose The basic situation of the project is evaluated, and limited project information can be quantified and different projects can be compared horizontally to select projects that have the potential to achieve project excellence. The project preparation phase is a process that must be experienced in

developing a TPPP project. It is necessary to concentrate the process of multi-party resources. At this stage, the necessary prerequisites for the construction of the TPPP project need to be resolved.

At this stage, the most important is the top-level design and project planning for the TPPP project, including but not limited to determining the financing structure, the basic operation mode of the project and the pricing mechanism. Adequate risk factor assessments, critical success factor assessments, sustainability assessments, and project excellence assessments at this stage are important for the subsequent quotation, negotiation, and finalization of project proposals by government and social capitalists. The most important part of the project procurement phase is the bidding process. Competitive bidding, negotiation and negotiation at this stage will determine the details of the project contract. The social capital party will evaluate and forecast the project, adequate risk assessment, critical success factor assessment, and Sustainability assessment and project excellence assessment will influence the bidder's quotation and implementation design. The project implementation phase is the most important phase of the TPPP project. It refers to the end of the franchise period from financing delivery to the end of the project franchise period. The time span is usually more than 10 years, and the period is full of complexity and uncertainty. At this stage, risk assessment, critical success factor assessment, sustainability assessment, and project excellence assessment can affect the dynamic adjustment of project risk management programs and implementations on the one hand, and help project managers or regulators conduct project excellence assessments on the other hand. The results of the project evaluation reflect the phased results of the construction or operation of the TPPP project. The project handover phase usually refers to the process of transferring the project from the

original project company back to the government and then re-determining the new project operator by the government when the project franchise contract is about to end. The process faces challenges such as performance appraisal, handover arrangements, and renegotiation between the two parties. Risk assessment, critical success factor assessment, sustainability assessment, and project excellence assessment are reasonable basis for assessing the project's operational outcomes at the time of the transition. The assessment results can help transfer performance assessments to determine the transition plan. For the TPPP project, there are transnational stakeholders and complex project relationships at various stages. The project excellence evaluation plan derived from this study fully considers the economic benefits, environmental benefits, social benefits and impacts of the TPPP project. The stage of the project is to estimate or evaluate the development of the project, and the results of the evaluation can be feedback to guide the formulation of management strategies and the development of management measures.

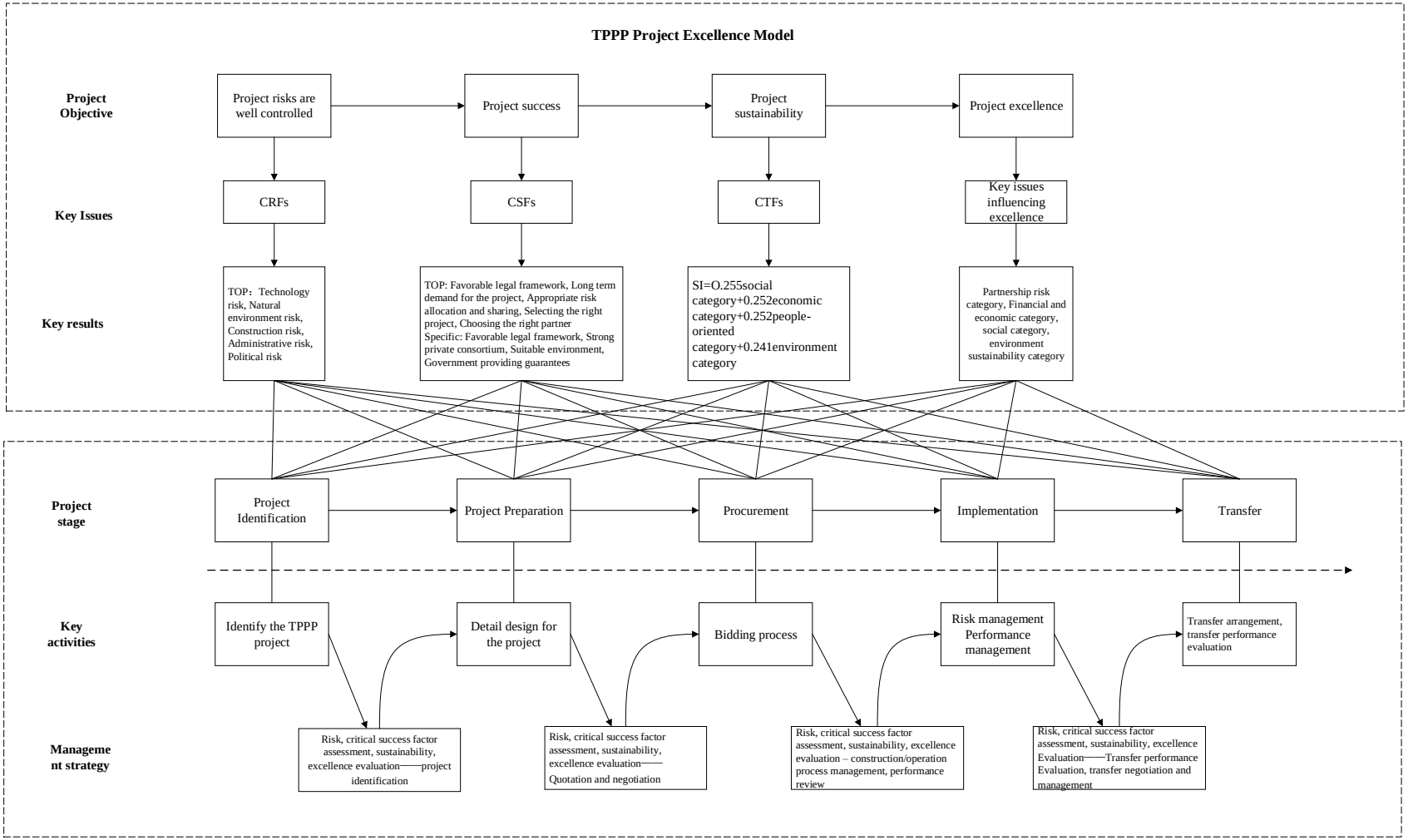


Fig.8. 1 TPPP project excellence management model

8.5 VALUES AND SIGNIFICANCE OF THE STUDY

The findings of this research have been presented and thoroughly discussed in Chapters 4 to 8. The results and developed PLS-SEM model may be of immense value and utility for researchers, policy makers, industry practitioners, public sector and private investors and advocates seeking empirical quantitative evidence and explanations on the influences of key issues on TPPP project excellence. Moreover, the significance, value and contributions of this study based on each research objective have been thoroughly discussed in these chapters. This chapter only briefly summarized the value and significance of this research. This study contributed significantly to the PPP project management body of knowledge and industrial practice, particularly for TPPP projects in B&R countries. The findings of each research objective offer valuable practical implications for implementing TPPP projects for B&R countries and foreign investors from China and other countries.

Firstly, this research identified the critical risk, success and sustainability factors for TPPP projects in the B&R countries. This thesis is the first systematic study to focus on transnational PPP projects and present clear understanding of the key issues to achieve project excellence in TPPP projects. The obtained key-issue lists are likely to help stakeholders identify and understand the TPPP projects and directly adopt them based on the specific project.

Secondly, the risk management process provided by the study will enable practitioners involved in the TPPP projects to quantify the possibility and severity of risk factors and rank them based on the impact. Moreover, the result informs the practitioners of the proper risk allocation strategies to apply in assigning risk factors

between public and private sectors to achieve TPPP project excellence.

Thirdly, the results from the comparative analysis offer useful insights and in-depth understanding into the risk factors of TPPP and DPPP projects. The findings have an impact because the results will inform international private investors to understand the similarities and differences to implement TPPP and DPPP, and to adopt corresponding actions and strategic to improve critical success to achieve TPPP project excellence.

Fourthly, practitioners involved in TPPP projects in B&R countries can use the TPPP project SI model to evaluate the practical and realistic aspects of the sustainability level of the projects. Practitioners can now reliably and objectively understand how to improve the project sustainability by focusing on key issues and comparing the sustainability levels of two or more TPPP projects for benchmarking and control purposes.

Fifthly, analysing the TPPP project excellence model provided findings that address important gaps in the PPP body of knowledge for transnational projects and are valuable for policy makers, practitioners, stakeholders, public and private sectors and advocates to promote TPPP adoption. The findings are beneficial for international and foreign investors before decided on a project or adopt suitable strategies to implement the TPPP project. Overall, this study is crucial for Chinese investors and private sectors from other countries to invest TPPP projects in other B&R countries, to well manage the TPPP project and achieve project excellence. Lastly, this study is significant to the PPP project management at large.

8.6 LIMITATION OF THE STUDY

Despite achieving the research aim and objectives, this study has certain limitations that should be acknowledged.

The first major limitation lies in the low responses obtained from the questionnaire survey. The number of TPPP projects invested in is limited compared with domestic projects. Thus, the questionnaires were based on relatively small samples of industry experts with TPPP experience. Although the sample size is relatively small, the requirements of each model used in the study were fulfilled. Moreover, the results could be compared to similar studies in construction management area. As this thesis is the first systematic study focusing on TPPP, the analysis results based on limited samples remain significant to the research field and practitioners.

The second major limitation is that the real life case was only adopted in the risk evaluation and allocation models but not applied to validate all the models proposed by this study. This limitation is due to time constrains and the difficulty to invite enough experts from one TPPP project. The case study should be applied in the critical success factor, sustainability model and the TPPP project excellence models to verify the research results.

The third limitation is that this study failed to discuss the 'risk mitigation' stage in the TPPP risk management process model due to time constraints. In future research, TPPP risk mitigation should be explored to help government and foreign investors prevent and respond to TPPP project risks.

The fourth limitation is that the current study discussed the key issues affecting TPPP project excellence, including risk, critical success and sustainability factors. The selection of key issues might not be comprehensive or perfect. Other potential factors influencing TPPP project excellence could consider conflict resolution

mechanisms and stakeholder relationship. More aspects should be considered in the future study to contribute to the TPPP project excellence model.

The fifth limitation is that this research failed to discuss how TPPP project managers can respond or manage these key factors due to time constraints. The methodologies provided by this study (such as IFAHP, BGT, FSE) are complicated and difficult to be directly adopted in industry. Future research should be conducted from this perspective to explore the management strategies in the TPPP life cycle management and develop a platform to assist TPPP practitioners manage TPPP projects.

8.7 RECOMMENDATIONS FOR FUTURE RESEARCH

Although, the outcome of the current study would be useful to researchers and practitioners, avenues for future research into this topic are numerous.

Firstly, this research established the risk management process model by providing the risk evaluation IFAHP and risk allocation game theory models. The following stage of risk allocation in PPP project should be risk responses to provide strategies on how to mitigate these risks. A risk mitigation method could be considered and focused on in future study. The results indicated that systematic risk management model (including risk identification, evaluation, allocation and mitigation) could be established to support the risk management for TPPP projects in the B&R countries.

Secondly, although the findings and implications of this study may be useful for policy makers and practitioners, a more practical, systematic and comprehensive framework could be established to combine all the results from the study. The key issues and strategies (including risk factors and management, success factors and

management, sustainability factors and management) should be placed in different stages of the TPPP project life cycle and actions corresponding to each stage could be provided to establish a best practice model for TPPP project stakeholders. A platform (a software or an application) can be built to put all important key issues and culcation methodology inside, so practitioner can show their perceptions on each key factor and get the results directly from the platform.

Thirdly, the current study focused on TPPP projects in B&R countries, particularly for the Chinese investors participating in TPPP projects in other B&R countries. Over 60 countries are involved in the B&R initiative, and the situations are different from country to country. Future studies may consider focusing on a specific country or area to establish the project management model.

Lastly, future research must target a large sample size. The present study analysed opinions from experts of professionals from academic, public and private sectors. Future studies could explore ideas from more experts. Additionally, interviews could be considered to obtain direct opinions from experienced TPPP experts.

8.8 CHAPTER SUMMARY

This chapter presented the validation of the TPPP project excellence model. The validation survey process and results were discussed in detail in this section. The results showed that most experts are confident in the results of this study and presented the entire study is appropriate and reasonable.

This chapter summarised the conclusions, significance, limitations and future studies of this research. The major conclusions of the four objectives were presented, followed by the significance of this study. Lastly, the limitations of this study and

the recommendations for future study were highlighted and discussed. This chapter closes this research study. The following pages contain the appendices and references for this study.

Appendices

Appendices list:

Appendix A

QUESTIONNAIRE FOR GENERAL SURVEY

Survey on key issues and influencing on the Transnational Public-Private Partnership projects Excellence

Letter to participants

Dear Expert,

I write to kindly invite you to participate in this questionnaire for research into "**key issues and influencing on the Transnational Public-Private Partnership projects Excellence**". This survey forms part of an ongoing PhD research under a "Joint Supervision Scheme" by the Department of Building and Real Estate of The Hong Kong Polytechnic University and Business School of Sichuan University.

In this study, TPPP is defined as *"a cooperative venture between the host public sectors and foreign private companies in infrastructure projects, built upon the fairness and expertise between each partner to share the resources, risks and benefits"*. For example, China Harbour Engineering Company Ltd. Has invested in the Jamaica North-South Expressway BOT project, which is a typical TPPP project due to different countries of public sector and private sector. This survey aims at requesting your experience to evaluate the critical risk factors and critical success factors for TPPP.

I will be very grateful if you could please spare part of your valuable time to review the questionnaire and return to the researcher within **FOUR WEEKS**. Thank you in anticipation of your kind contribution to the success of this research. For any enquiries, please contact the researcher on the email stated below.

Sincerely,
YU Yao,
Research Assistant
Department of Building and Real Estate. The Hong Kong Polytechnic University
PhD candidate
Business School, Sichuan University
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Telephone: +852 5570
Ir Professor Albert P.C. Chan, Head of Department of Building and Real Estate. The Hong Kong Polytechnic University.
Professor Chuan Chen, Business school, Sichuan University

Section A: Information of Participants

Q1. Please indicate the nature of your TPPP experience (multiple answers allowed).

☐Academic/research institute
☐Consulting firm
☐Public sector agency/department
☐Private investor
☐Contractor
☐Other(s) (please specify): Click here to enter text.

Q2. Please indicate your years of TPPP working or research experience.

Click here to enter text.

Q3. Please indicate the number of TPPP projects you have been involved in (if any).

Click here to enter text.

Q4. Please indicate your position in your current or recent organization?

☐Director/CEO
☐Senior manager
☐General staff
☐Other(s) (please specify): Click here to enter text.

Q5. Please indicate the sector of TPPP projects you have been involved in (multiple answers allowed):

☐Energy
☐Information and communication technology
☐Transport
☐Water and sewerage
☐Other(s) (please specify): Click here to enter text.

Q6. Please indicate the type of TPPP projects you have been involved in (multiple answers allowed):

☐Operation-Maintenance (OM)
☐Build-Operate-Transfer (BOT)
☐Build-Own-Operate (BOO)
☐Transfer-Operate-Transfer (TOT)
☐Rehabilitate-Operate-Transfer (ROT)
☐Other(s) (please specify): Click here to enter text.

Q7. Have you heard of "the Belt and Road Initiative" (One Belt One Road)?

☐Yes
☐No

Q8. If you answered 'Yes' in Q7, do you think "the Belt and Road Initiative" would affect the TPPP projects?

☐Yes
☐No

Section B: Evaluation of risk factors for TPPP projects

Q9. Evaluation the risk factors of TPPP projects

(A) Please, indicate an estimated probability (likelihood) of occurrence of each risk factor based on the following scale: 1——5 = extremely low——extremely high.

(B) Please, indicate an estimated severity of each risk factor based on the following scale: 1——5 = extremely low——extremely high;

(C) Please, you may also select the option "N/A" (under the last column to the right) if the factor is not applicable in your opinion.

No.	Risk factor	Possibility of occurrence	Severity of risk factors	N/A
		Low----------High	Low----------High	
R1	Tariff risk	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐
R2	Financing risk	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐
R3	Currency risk	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐
R4	Demand and revenue risk	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐
R5	Tax risk	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐

R6	Payment risk	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐
R7	Legal risk	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐
R8	Corruption risk	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐
R9	Political risk	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐
R10	Administrative risk	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐
R11	Lack of government support	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐
R12	Technology risk	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐
R13	Construction risk	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐
R14	Operation risk	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐
R15	Force majeure	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐
R16	Natural environment risk	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐
R17	Cooperation risk	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐
R18	Credit risk	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐
R19	Worker risk	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐
R20	Competitiveness risk	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐
R21	Cultural impediments	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐
R22	Language differences	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	☐
Please indicate other risk factors (if any)				
RA1		☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	
RA2		☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	
RA3		☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5	

Section C: Evaluation of success factors for TPPP projects

Q10. Evaluation the importance level of success factors for TPPP projects

Please, indicate an estimated level of importance for each success factor based on the following scale: 1——5 = extremely low——extremely high.

Please, you may also select the option "N/A" (under the last column to the right) if the factor is not applicable in your opinion.

No.	Critical Success Factors	Importance	N/A
		Low ----------High	
S1	Political support	☐1; ☐2; ☐3; ☐4; ☐5	☐
S2	Transparent procurement	☐1; ☐2; ☐3; ☐4; ☐5	☐
S3	Favorable legal framework	☐1; ☐2; ☐3; ☐4; ☐5	☐
S4	Government providing guarantees	☐1; ☐2; ☐3; ☐4; ☐5	☐
S5	Political stability	☐1; ☐2; ☐3; ☐4; ☐5	☐
S6	Streamline approval process	☐1; ☐2; ☐3; ☐4; ☐5	☐
S7	Well organized and committed public agency	☐1; ☐2; ☐3; ☐4; ☐5	☐
S8	State relationship	☐1; ☐2; ☐3; ☐4; ☐5	☐
S9	Stable macroeconomic condition	☐1; ☐2; ☐3; ☐4; ☐5	☐
S10	Acceptable level of tariff	☐1; ☐2; ☐3; ☐4; ☐5	☐
S11	Mature and available financial market	☐1; ☐2; ☐3; ☐4; ☐5	☐
S12	Sound economic policy	☐1; ☐2; ☐3; ☐4; ☐5	☐
S13	Competitive procurement	☐1; ☐2; ☐3; ☐4; ☐5	☐
S14	Detailed project planning	☐1; ☐2; ☐3; ☐4; ☐5	☐
S15	Technology innovation	☐1; ☐2; ☐3; ☐4; ☐5	☐
S16	Selecting the right project	☐1; ☐2; ☐3; ☐4; ☐5	☐
S17	Clear project brief and design development	☐1; ☐2; ☐3; ☐4; ☐5	☐
S18	Reliable service delivery	☐1; ☐2; ☐3; ☐4; ☐5	☐
S19	Clear goals and objectives	☐1; ☐2; ☐3; ☐4; ☐5	☐
S20	Consistent performance standard	☐1; ☐2; ☐3; ☐4; ☐5	☐
S21	Appropriate risk allocation and sharing	☐1; ☐2; ☐3; ☐4; ☐5	☐
S22	Strong private consortium	☐1; ☐2; ☐3; ☐4; ☐5	☐
S23	Strong commitment by both parties	☐1; ☐2; ☐3; ☐4; ☐5	☐
S24	Clarity of roles and responsibilities among parties	☐1; ☐2; ☐3; ☐4; ☐5	☐
S25	Open and constant communication	☐1; ☐2; ☐3; ☐4; ☐5	☐

S26	Choosing the right partner	☐1; ☐2; ☐3; ☐4; ☐5	☐
S27	Public/community support	☐1; ☐2; ☐3; ☐4; ☐5	☐
S28	Long term demand for the project	☐1; ☐2; ☐3; ☐4; ☐5	☐
S29	Suitable environment	☐1; ☐2; ☐3; ☐4; ☐5	☐
Please indicate other success factors (if any)			
SA1		☐1; ☐2; ☐3; ☐4; ☐5	
SA2		☐1; ☐2; ☐3; ☐4; ☐5	
SA3		☐1; ☐2; ☐3; ☐4; ☐5	

Section D: Evaluation of sustainability factors for TPPP projects

Q11. Evaluation the importance level of sustainability factors for TPPP projects

Please, indicate an estimated level of importance for each social responsibility factor based on the following scale: 1——5 = extremely low——extremely high.

Please, you may also select the option "N/A" (under the last column to the right) if the factor is not applicable in your opinion.

No.	Sustainability Factors	Importance	N/A
		Low ----------High	
SR1	Establish an environment management system	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR2	Ensure accountability, legitimacy, and transparency	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR3	Innovation	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR4	Cost reduction	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR5	Improve resource performance and efficiency	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR6	Profitability	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR7	Establish a waste emission management system	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR8	Keep close partnership between stakeholders	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR9	Improve project quality	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR10	Proper contract	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR11	Water protection	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR12	Serve community and benefit residents	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR13	Efficient maintenance	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR14	Provide jobs	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR15	Use sustainable design and materials	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR16	Proper payment	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR17	Improve service standard	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR18	Ensure projects running on time and budgets	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR19	Meet demands and provide great service	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR20	Reduce users cost	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR21	Improve climate resilient and air quality	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR22	Ensure worker health and safety	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR23	Improve environmental policy	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR24	Soil protection	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR25	Landfill protection	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR26	Reduce carbon emissions	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR27	Protect human rights	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR28	Effective communication with users	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR29	Support local business	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR30	Influence wider market	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR31	Noise prevention	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR32	Biodiversity protection	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR33	Working altruistically for the public good	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR34	Promote integrity, honesty, and impartiality	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR35	Improve local policy	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR36	Protect cultural heritage	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR37	Appropriate resettling, rehabilitation, and compensation	☐1; ☐2; ☐3; ☐4; ☐5	☐
SR38	Forest protection	☐1; ☐2; ☐3; ☐4; ☐5	☐

Please indicate other Social responsibility factors (if any)			
SRA1		☐1; ☐2; ☐3; ☐4; ☐5	
SRA2		☐1; ☐2; ☐3; ☐4; ☐5	
SRA3		☐1; ☐2; ☐3; ☐4; ☐5	

Section E: General statements about TPPP projects Excellence

Q12. Please indicate your level of agreement with the following statements about TPPP project excellence. Use the following scale: 1= strongly disagree; 2= disagree; 3= neutral; 4= agree; 5= strongly agree.

No.	Statements	Level of agreement Low ----------High	N/A
S1	Project Results: The TPPP project satisfies the KPIs.	☐1; ☐2; ☐3; ☐4; ☐5	☐
S2	Appreciation by the public sector: The public sector initiates the project to fulfil a specific need. What aspects and factors do the public sector value in judging the success of the project.	☐1; ☐2; ☐3; ☐4; ☐5	☐
S3	Appreciation by project personnel: The workers of the project will be concerned with reaching their personal goals as well as a good working atmosphere.	☐1; ☐2; ☐3; ☐4; ☐5	☐
S4	Appreciation by users: Users are concerned with their overall influence in the project and the functionality of the end product.	☐1; ☐2; ☐3; ☐4; ☐5	☐
S5	Appreciation by private sector: Private sectors try to make a profit at the project. They are also concerned with getting new orders and learning possibilities.	☐1; ☐2; ☐3; ☑4; ☐5	☐
S6	Appreciation by stakeholders: Those parties that are not directly involved in the project but have a large influence. The local macro level impacts brought from the project.	☐1; ☐2; ☐3; ☐4; ☐5	☐

Q13. Please provide your e-mail address if you would like to receive a summary of the research findings. Click here to enter text.

-This is the end of the survey

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