Risk Identification and Allocation in Public-Private Partnerships: A New Zealand Perspective

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Copyright Statement

Abstract

Public-Private Partnerships (PPPs) have become a prevalent solution for funding infrastructure projects amid declining public reserves. Despite their widespread adoption, not all PPP projects prove successful, often due to inadequate risk management. Recognizing the expertise of the private sector, including the New Zealand government, PPPs are increasingly utilized. However, there is a scarcity of specific research on PPPs in the local context, particularly in social infrastructure using the Design-Build-Finance-Maintain-Operate (DBFMO) delivery method. This thesis aims to address this gap by establishing a framework for improving risk management outcomes in New Zealand's PPP infrastructure projects, focusing on critical success factors, empirical investigations into risk identification, and the development and validation of a Fuzzy based risk allocation model to inform stakeholders' decisions.

This research employed two distinct questionnaire surveys targeting industry experts from both public and private sectors, all possessing relevant experience in the local industry and PPP procurement. Given the absence of a precise population, a combination of convenience and judgment sampling, was utilized. A total of 43 and 58 PPP experts provided valid responses to two questionnaires. The sample size was considered appropriate, especially considering the relatively recent adoption of PPP in New Zealand. Additionally, comparisons were made with similar studies that employed questionnaire surveys to ensure validity. The collected data underwent various statistical analyses, including mean score analysis, Cronbach's alpha reliability analysis, independent sample t-test, and factor analysis. Subsequently, the fuzzy synthetic evaluation (FSE) method was applied to model risk allocation. In addition, the study included a set of semi-structured interviews to provide a practical and policy-making context for the research.

Critical success factor rankings established through mean scores revealed approval and negotiation process, innovation and project complexity, client's brief, project's technical feasibility and strong private consortium to be five top ranked factors out of the 27 identified. Similarly, the top three risk allocation criteria (RAC) having very high importance (mean score greater than 4 on a scale of 5) were risk foresight, response to risk and minimise risk loss. Furthermore, factor analysis showed that the 9 identified RAC can be classified into three component groups namely risk management expertise, core risk management capability and risk management strategy.

Recognizing the importance of principle of risk allocation, the proposed fuzzy based risk allocation model took into account the risk management capability of public and private sector. FSE was chosen for its adeptness in handling intricate multi-faceted challenges, particularly in the context of risk distribution decisions that involve the inherent vagueness within human cognitive processes. Due to their contentious nature in literature and different PPP projects, 16 risk were carefully chosen to be allocated via the model from a list of 35 risks initially identified. The findings indicate that for 12 of the risks, the distribution proportions between the government and the private sector are comparable. Risks associated with land acquisition and public opposition are predominantly assigned to the public sector, while risks linked to unforeseen geotechnical conditions and financing are predominantly allotted to the private sector. The results were validated using six interviews with highly experienced professionals within the New Zealand PPP scene.

The outcomes of this study are anticipated to guide policymakers in formulating effective strategies for assigning risks and devising well-balanced risk sharing arrangements within PPP contracts, to achieve outcomes mutually agreeable to both the public and private sectors, ultimately enhancing the uptake of PPP projects.

Dedication

This thesis is dedicated to the memory of my father, whose unwavering support, love, and wisdom have been my guiding light throughout my life. His presence may have left this world, but his spirit and influence remain deeply embedded within the pages of this work.

To my ever-supportive and unwavering family members, who consistently offer their support and prayers.

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Table of Content

List of Figures

List of Tables

Abbreviations and Acronyms

AHP	Analytical Hierarchy Process
ANP	Analytical Network Process
BOO	Build-Own-Operate
BOOT	Build-Own-Operate-Transfer
BOT	Build-Operate-Transfer
CSFs	Critical Success Factors
CSFGs	Critical Success Factor Groups
CRFs	Critical Risk Factors
DBFM	Design-Build-Finance-Maintain
DBFM	Design-Build-Finance-Maintain-Operate
FA	Factor Analysis
FSE	Fuzzy Synthetic Evaluation
FST	Fuzzy Set Theory
KMO	Kaiser-Meyer-Olken
MCDM	Multi Criteria Decision Making
MF	Membership Function
MS	Mean Score
NZ	New Zealand
OCED	Organization Co-operation of Economic Development
PFI	Private Finance Initiative
PPP	Public-Private Partnership
RA	Risk Allocation
RAC	Risk Allocation Criteria
RMC	Risk Management Capability
RMCI	Risk Management Capability Index
SPSS	Statistical Package for Social Science
SPV	Special Purpose Vehicle
UK	United Kingdom
VfM	Value for Money

List of Peer-reviewed Publications

Journal Articles - (Published, Under review, Ready)

Article 1 in Chapter 3. Rasheed, N., Shahzad, W., Khalfan, M., & Rotimi, J. (2022). Risk Identification, Assessment, and Allocation in PPP Projects: A Systematic Review. *Buildings*, 12(8), 1109. MDPI AG. Retrieved from http://dx.doi.org/10.3390/buildings12081109

Article 2 in Chapter 4. Rasheed, N., Shahzad, W. M. & Rotimi, J. O. B. (2023). Factor analysis of risk allocation criteria (RAC) in public-private partnership (PPP) projects: A case of New Zealand. *Construction Economics and Building* (accepted). Manuscript ID: 9021.

Article 3 in Chapter 5. Rasheed, N., Shahzad, W. M. & Rotimi, J. O. B. (2023). Risk management capability for risk allocation in social infrastructure public-private partnerships: A New Zealand perspective. *Journal of Engineering, Project, and Production Management.* Special issue for *13th International Conference on Engineering, Project, and Production Management (EPPM2023),* Auckland, New Zealand. (accepted). **Best paper in management stream winner.**

Article 4 in Chapter 6. Rasheed, N., Shahzad, W. M. & Rotimi, J. O. B. (2023). Risk allocation in social infrastructure public-private partnership projects in New Zealand: A fuzzy method. *Journal of Engineering, Construction and Architectural Management* (under review). Manuscript ID: ECAM-09-2023-0943.

Conference Papers - (Published, Accepted)

Article 5 in Chapter 2. Rasheed, N., Jr, C. A. T., Shahzad, W., & Rotimi, J. O. (2019). Critical success factors of public-private partnerships (PPPs) in New Zealand. *Proceedings of* *the 43rd Australasian Universities Building Education Association (AUBEA) Conference*, November 2019, QLD, Australia, p. 223.

Article 6 in Chapter 2. Rasheed, N., Wahid, I., Shahzad, W., & Rotimi, J. O. B. (2020). Understanding the Factors Critical to Success of PPPs in New Zealand: Public and Private Sector Standpoint. *In Proceedings–New Zealand Built Environment Research Symposium* (p. 13). **Best presentation award winner.**

1 Introduction

1.1 Introduction

Development of social and economic infrastructure plays a significant role in the economic well-being of a country (Yescombe, 2011). Recent studies predicted an investment of 97 trillion US Dollars to be made in the next ten years to fill infrastructure development gap across the globe (Batra, 2022; Global Infrastructure Hub, 2017). The governments are struggling to keep up with such huge demands of investments globally and are looking for innovative ways to tackle this problem.

Over the last few decades, public sector has been actively involving private sector in the establishment of public infrastructure (Morrison, 2016). Consequently, various methods and techniques of procurement have been developed which bring these two sectors together to provide infrastructure projects. These methods can be categorized based on the extent of private sector involvement and the amount of risk transfer from public sector to private entity. Systems such as design and build, alliance and partnering, privatization and public-private partnerships (PPPs) are some of the examples of such procurement schemes.

An important reason for involving private sector for infrastructure development is the public sector's inability to achieve good performance in most of the projects realized through traditional project delivery systems (Liu et al., 2015; Raisbeck et al., 2010). Private sector involvement also helps align interest of both parties in a strategic manner which ultimately leads to better performance outcomes for the projects. These considerations combined with other factors urge governments to invite private sector to participate in infrastructure provision. Therefore, PPP has emerged as a well-recognized project delivery system worldwide for delivering infrastructure (Hodge & Greve, 2007).

World bank's PPP reference guide mentions that there is no single agreed upon definition of PPP internationally (World Bank Group, 2017). Due to the varying nature of the projects and differences in governmental policies worldwide, researchers and governments alike, have defined this term in many ways. However, a common characteristic among all PPP definitions is risk sharing among public and private parties. PPP allows risks to be allocated to the party which is best suited to manage it (Wibowo & Kochendoerfer, 2010; Xu et al., 2010).

Many developed nations such as the United Kingdom, Australia, Canada and United States have implemented PPP projects successfully over last few decades (Cheung et al., 2012). Following this, Government of New Zealand also showed its interest in using PPPs for provision of infrastructure where appropriate through publication of National Infrastructure Plan (Liu, 2013). Project proposal exceeding life cycle cost of 25 million NZD are required to consider PPP as an option if suitable (Treasury New Zealand, 2015).

There is plenty of evidence available in favour of PPP to deliver better performance as compared to traditional procurement systems (Liu et al., 2015; Raisbeck et al., 2010). However, the other facet of PPPs suggests that it's not a panacea due to complexity of financial arrangements, investor's expectancy of high returns, longer contract periods and risk heavy nature of projects (Blanc-Brude & Makovsek, 2013). Moreover, improper risk allocation and tendency of public sector to transfer almost all the risk to private sector impact project objectives negatively (Mazher, 2019). Therefore, efficient project risk management is crucial for successful implementation of PPP.

PPP projects are considered risky in nature and risk management is considered an important part of the planning process to deal with these risks (PMI, 2013). Risk management not only helps reducing the negative effect(s) of certain risks but it can also result in increasing the likelihood of positive effects. Due to the longer contract periods of PPPs traditional risk management approach has proven to be more challenging and expensive (Xiong et al., 2017). Therefore, increasing the effectiveness of risk management is crucial for success of PPP schemes.

PPPs have been used to deliver different types of infrastructure projects such as transport, power, water, telecommunication, and social infrastructure. New Zealand PPP experience to date has been focused on delivery of social infrastructure projects. Social infrastructure projects, which encompass essential facilities like schools, hospitals, and community centers, play a crucial role in enhancing public well-being and societal development.

This thesis follows a publication approach derived from Massey University's thesis by publication guidelines and publications are used in lieu of chapters. As each chapter was prepared with intention of publishing in a peer review journal, there exists some repetition of information particularly in the introduction and literature review section of each chapter.

1.2 Research Background

1.2.1 Procurement systems

In general, procurement means to acquire goods or services from a party, at a feasible price in a suitable manner (Opuwari, 2024; Walker & Rowlinson, 2007). The concept of procurement systems in construction has evolved over times and many researchers have defined it from their perspective. Some academics believe that it is an organizational system which defines and allocates responsibilities to people to execute the construction of a specific project (Naoum & Egbu, 2015). While some on the other hand argue that it also involves other components of project life cycle such as, financing and operation (Masterman, 2013).

A variety of procurement systems are available to choose from when executing a construction project. These can be categorized based on certain factors such as, amount of information available at initiation phase, level of risk involved and method of reimbursement. Based on these factors, two major types of procurement systems are; 'separate' and 'integrated' procurement system.

An overview of these system is shown in Table 1.1. In separate procurement system, which is also known as traditional procurement, there are two separate contracts for designing and construction of the facility. Generally, they involve separate organization for each stage. Integrated procurement system on the other hand, involves a single organization for design and construction of the facility. Another distinguishing feature of these procurement system is their financing arrangements. Separate systems are funded by one party, either government or private. Whereas, integrated systems can involve a combination of different financing sources.

Table 1.1 Separate and integrated procurement comparison (synthesis of several sources)

Type	**Separate**	**Integrated**
Characteristics	Design, construction and operation are assigned to different parties	Design, construction and operation are assigned to same party
Examples	Traditional methods Design-Bid-Build	Design-Build Public-private partnerships
Advantages	Competitive Client has more control Fixed price Well-recognized and tested method	Cost and time benefits Easier to execute due to one organization involved Overlap of design, construction
Disadvantages	Costly as compared to integrated Sequential processes take time Contractor not involved in design	Requires extensive initial planning Client has lesser control over design
Financing	Either private or public financing	Can be a mix of financing methods

1.2.2 Public-private partnership

In general, PPP is defined as a long-term co-operative venture involving public and private sector parties, typically resulting in provision of infrastructure. However, in literature a consensus between researchers on a single definition does not exist (Hodge & Greve, 2007). Some view PPP as a tool for infrastructure expansion, others think of it as a tool for governing and contracting. Many believe that definition of PPP varies from country to country due to objectives PPP is set out to achieve in the context of the specific needs of the country (Mazher, 2019).

Table 1.2 draws a comparison between main features of PPPs based on some of the definitions used worldwide. Payment mechanism and ownerships are two criteria where significant differences in these definitions are observed. In a performance-based mechanism of payment the ownership is shared between both the parties involved. Some of the common features among all these definitions are involvement of private sector, sharing of risks, long-term contracts and provision of assets or services. This study adopts the definition provided by National Infrastructure Unit (NIU) in New Zealand.

> *"A long-term contract for the delivery of a service, where the provision of the service requires the construction of a new asset, or the enhancement of an existing asset, that is financed from external (private) sources on a non-recourse basis and where full legal ownership of the asset is retained by the Crown."*

Infrastructure Australia (2008) has defined PPP as:

> *"A service contract between the public and private sectors where the Australian Government pays the private sector (typically a consortium) to deliver infrastructure and related services over the long term. The private provider will*

build the facility and operate or maintain it to specified standards over a long period. The private provider usually finances the project."

World Bank (2017) 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."

Table 1.2 PPP definitions comparison

Organization	**Nature of Contract**	**Payment Mechanism**	**Ownership**
World Bank	Long-term	Performance based	Shared
Canadian Council of PPP	Not specified	Performance based	Shared
Infrastructure Austrailia	Long-term	Fixed payments	Government
Infrastructure Transactions Unit New Zealand	Long-term	Fixed payments	Government

1.2.3 Structure of PPP

PPPs have complex organizational structure involving several key players. To deal with this complexity, a separate entity, usually referred to as Special Purpose Vehicle (SPV), is established. SPV, sometimes also referred as project company, acts as a legal entity dealing with all the contractual and financial obligations of the project (Akbiyikli et al., 2006). Establishment of SPV as a separate entity also enables the project to be of limited or non-recourse nature. This means that in case of default, there are little to no financial obligations on the government or sponsors of the project (Yescombe, 2011). Figure 1.1 shows a typical arrangement of key stakeholder in a PPP.

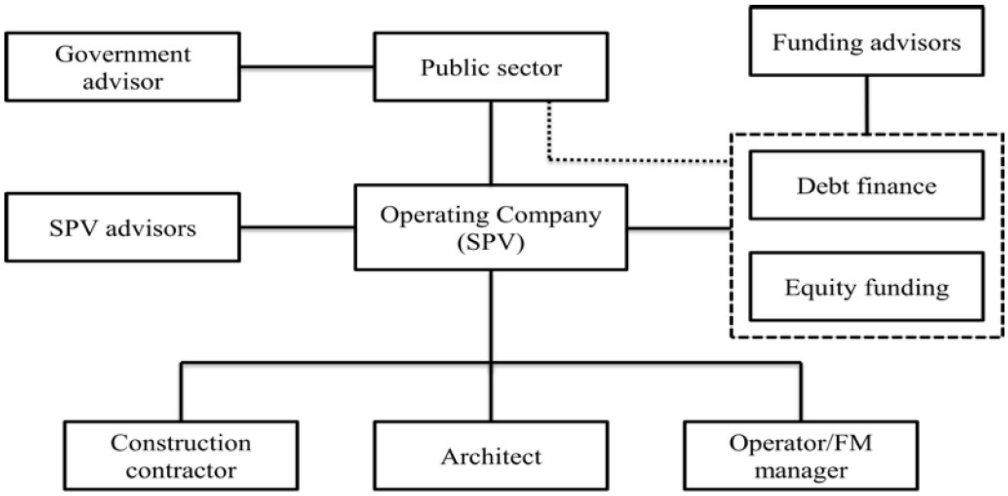

Figure 1.1 Structure of public-private partnerships (Grimsey & Lewis, 2007)

The public sector involvement can be at central or local government levels in form of departments, ministries and entities of the Crown (Delmon, 2017). The role of the Government is significantly different in PPPs when compared to traditional methods of project delivery. In traditional form of procurement, Government involvement is extensive in all phases of the project. However, in PPP, roles and responsibilities of public sector entity vary across different stages of project.

Project development and procurement stage is the most critical for public sector in terms of its involvement. As the contract is signed and significant risks of construction and operation are transferred to private sector, role of public sector is reduced significantly. Moreover, the element of reduced involvement does not affect the public sector's ability to own and exercise its control of project assets unlike some other forms of private sector involvement such as, privatization. Many researchers agree that public sector should focus on providing appropriate macroeconomic conditions for PPP to be successful during construction and operation stages (Kwak et al., 2009).

Private consortium typically consists of equity investors and debt providers who pool their finances to execute the project (Yescombe, 2011). Equity investors are normally the project sponsors. there can be more than one equity provider in this kind of arrangement. Financial institutions, contractors, suppliers and investment banks are usually the source for additional investment funds. However, major portion of project funds is acquired from debt financiers (Liu, 2013).

Project financing is the usual means for acquiring long term debt given the longer contract periods of PPP schemes. Lenders evaluate the projected future cashflows of the project and the level of risks involved to make their decision (Yescombe, 2011). PPP and project financing have a number of similar features, which is another important reason for arranging debt via project finance. Just like PPP, project finance also observes limited recourse to project stakeholders, makes use of SPV and used for establishing new facilities (Esty, 2004).

Other prominent sources for raising debt for project execution include bank loans and issuing bonds (Yescombe, 2011). Debt providers expect periodical repayments based on principle debt amount and an agreed upon interest rate. Project company's ability to manage and control project risks play an important role in lender's decision in favour of issuing debt. Moreover, future revenue generation expectations are also taken into account for evaluating SPV's borrowing capacity (Firmenich & Jefferies, 2016).

PPPs can be classified into different types based on the private sector involvement. Level of risk transfer to the private parties usually increases as it is engaged in more stages of project life cycle. A widely agreed upon categorization employed by Canadian Council for PPPs is shown in Figure 1.2 below.

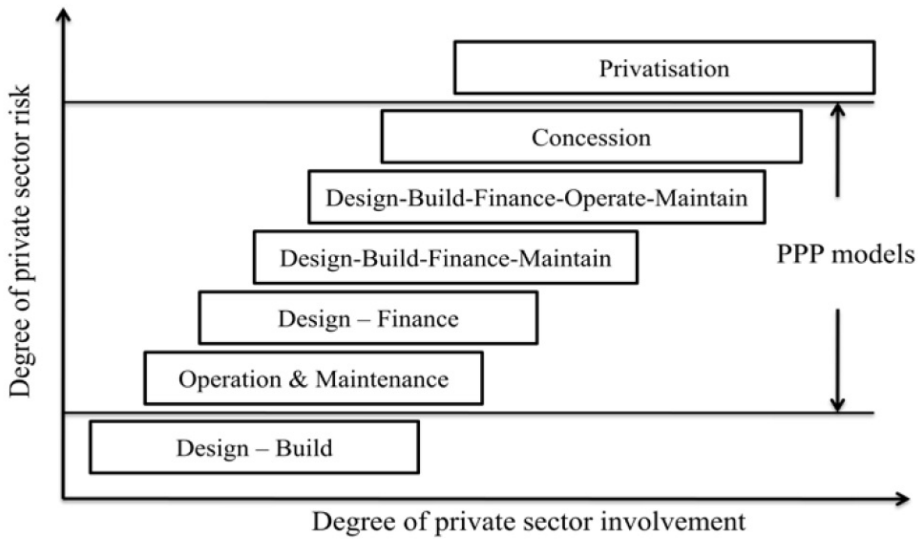

Figure 1.2 Different modes of private sector involvement

Source: Canadian Council for Public-Private Partnerships (CCPPP, 2019)

In an operation and maintenance PPP model, private sector is only involved for operating and maintaining the facility. Level of risks involved in this model is significantly less as compared to other PPP models. A concession PPP model involves private sector in all stages of the project (design, construction, operation, maintenance and financing). Hence, bearing most of the project risks. In turn, private sector is given full charge of the facility for a pre-determined period of time (concession period), typically 25 years, to recover its investment (Ullah et al., 2016; Esty, 2004).

1.2.4 PPPs in international practice

Private sector has been active in providing public services for many centuries. However, researchers assert that concession contracts similar to that of PPP have been in use since 18th century in countries like France and UK (Yescombe, 2011). These contracts allowed the private sector to charge general public directly in order to recover their investments. After the Second World War, a significant decline was observed in such type of contracting practices. During the early 1980's private involvement in state owned enterprises started to grow again through privatization schemes (Owen & Merna, 1997).

Project Finance Initiative (PFI) introduced by UK government in 1992 reinvented the concession contracts. Since then, many other governments have developed their own PPP models based on UK's PFI. There is a varying level of maturity across PPP markets in the world. Countries with developed economies such as UK and Australia have been more successful in harvesting the benefits of PPP as compared to developing countries (Galilea & Medda, 2010).

In 2012, UK government upgraded its PFI programme to PF2 (Zawawi et al., 2013). This decision came after PFI received widespread criticism for providing huge investment return to the private sector. New policies required project stakeholders to submit information on return to the governing body. Moreover, PFI schemes were aimed at removing cost of public assets from government's balance sheet. Whereas, PF2 schemes are aiming for greater value for money. According to a recent summary of PFI and PF2 schemes by Infrastructure and Projects Authority UK, 700 projects are in operation phase with a capital value of £57 billion (Infrastructure and Projects Authority, 2019).

Among other developed countries, France, Australia and US have used different PPP models to develop their infrastructure network. France has extensively used PPP since 2002 for social infrastructure projects such as hospitals, schools and prisons (Grimsey & Lewis, 2007). In the US, the use of PPP has been dominant in the water infrastructure projects (Yescombe, 2011). Australia has also actively pursued PPP since 2000 with the establishment of Partnership Victoria delivering projects such as Peninsula Link (27 KM four lane motorway) and East Link (largest urban road project constructed in Victoria consisting of a 39 KM fully-electronic tollway) (Jefferies & McGeorge, 2009).

Following the success of PPP schemes in developed countries, many developing countries have also committed their efforts in taking benefit from private sector involvement through this mechanism (Bovis, 2013). This only makes sense as developing countries have greater infrastructure investment requirement when compared to developed countries. A survey by World Bank showed that in 2012, private sector made an investment of more than 200 billion US dollars in developing countries alone (World Bank, 2015). Among developing countries, China leads the PPPs with most projects executed followed by Malaysia (Liang & Wang, 2019). India, Philippines and South Africa are some other prominent developing countries employing PPP practices for development of their infrastructure.

1.2.5 PPPs in New Zealand

In New Zealand, private sector has been involved at various stages of infrastructure provision in the past (Liu, 2013). However, these projects did not follow all the characteristics of PPP, such as the financing mechanism used and PPP concession agreement. Private sector involvement had been limited to providing either construction or operation services only in most of projects. In cases where they were allowed to construct and operate, private financing aspect of PPP was not present in such instances. One such example is the execution of Wellington's Clear Water project, where government bore all the construction costs. Moreover, these apparent PPP schemes of the past did not get any attention from the central government. Most of these projects were executed under local government which showed hesitation of central government towards adoption of PPP (Liu & Wilkinson, 2011).

Outsourcing, design-build and privatization have been predominant methods of private sector involvement in the past. In 2009, government expressed its interest to adopt formal PPP arrangements for infrastructure development (Liu, 2013). National Infrastructure Unit (NIU) was also established in the same year to restructure government's infrastructure priorities. PPP policy and guidelines stressed usage of PPP over traditional methods where appropriate. Infrastructure Transaction Unit (ITU) within Treasury provides assistance in delivery of PPP infrastructure projects (Treasury New Zealand, 2018).

Social infrastructure projects have received more attention since the introduction of PPPs in New Zealand. Six such projects have been executed till date, which include eleven schools in total and two prisons, co-ordinated by Ministry of Education and Department of Correction respectively. Most of these projects are in their operational phase. Moreover, two road infrastructure projects, 27 km long Transmission Gully expressway and 18 km long Pūhoi to Warkworth state highway have recently finished their construction phase under PPP schemes and started operation in 2023 (Treasury New Zealand, 2018). Most social PPP projects have been concentrated in the North Island, specifically in and around the Auckland area and two transport infrastructure projects are in Auckland and Wellington (Figure 1.3). Auckland receives a significant focus on infrastructure development due to its role as the country's economic and transportation hub, high population density, rapid urbanization, and strategic importance (Insch, 2018).

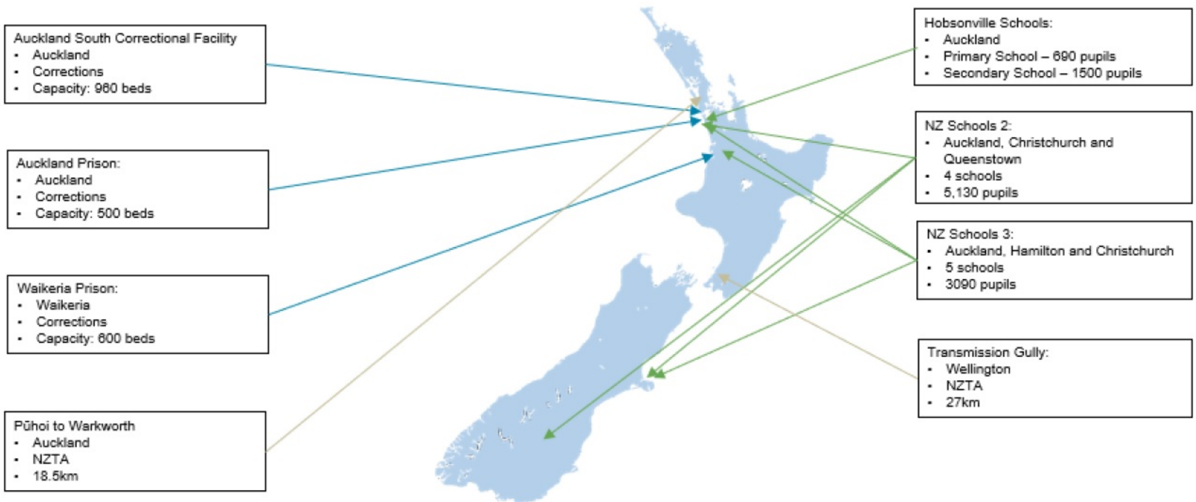

Figure 1.3 New Zealand's PPP portfolio

Source: (New Zealand Infrastructure Commission, 2021)

In New Zealand's PPP Model, the government and its private sector collaborator establish a predetermined cost for the asset's design, construction, maintenance, and long-term upkeep, including any operational services if necessary. This arrangement is referred as Design-Build-Finance-Maintain-Operate (DBFMO), has a specified timeframe, usually around 25 years. In case where the public sector remains accountable for providing operational services utilizing the asset, the preferred mode is DBFM. The government doesn't make any payments until the construction is finished and the asset is ready for service. Throughout the operational phase, deductions are made from payments if the asset is inaccessible or if the services don't meet the agreed-upon standards (New Zealand Infrastructure Commission, 2021).

1.3 Research Problem

Existing body of research highlights that PPPs are characterized by complex contractual and financial structures with limited or nonrecourse, along with negotiations that can stretch over extended periods and concession agreements that span long durations, as highlighted by (Kwak et al., 2009). Furthermore, it sheds light on the multifaceted challenges that often obstruct the successful implementation of PPP projects. These impediments include high transaction costs, prolonged waiting times before project initiation, deficiencies in the legal and regulatory environment, limited institutional capacity within public agencies, shortcomings in the private sector's performance, and inefficiencies in the procurement process, as illuminated by Chan et al., (2010) and Solino & Santos (2010).

To overcome the possible challenges associated with the utilization of PPPs and enhance the prospects of achieving favourable outcomes, a substantial body of international research has been dedicated to exploring various facets. This research encompasses an extensive investigation into performance evaluations, economic feasibility, value for money assessments, contract administration, governance and regulatory aspects, critical determinants of success, and risk management strategies (Zhang et al., 2016). Simultaneously, alongside these scholarly endeavors, there has been a proliferation of policy and guideline documents aimed at offering practical guidance to PPP practitioners. These documents outline policy objectives, fundamental principles, and intricate procedural mandates for effectively leveraging PPPs in diverse contexts. This dual approach, involving rigorous academic inquiry and practical policy development, underscores the global commitment to harnessing PPPs as a powerful tool for fostering collaboration between public and private sectors while ensuring accountability and value for money in various projects and initiatives.

A comprehensive analysis undertaken by Cui et al. (2018) reveals that the utilization of PPPs in projects related to transportation, water, and energy has a longer history compared to their application in health and network projects. In simpler terms, economic infrastructure projects, which encompass facilities and services that promote economic development objectives such as roads, tunnels, and bridges, are considered more well-established in the realm of PPPs when contrasted with social infrastructure projects. The latter category pertains to facilities and services that contribute to the attainment of social goals, including hospitals, schools, and prisons, and has a comparatively shorter track record in PPP implementation (Jefferies & McGeorge, 2009). Cui et al. (2018) report that out of 379 studies investigated in their review, only 55 were related to social infrastructure. Moreover, Build-Operate & Transfer (BOT) was the most common type of PPP employed in their review.

In the global discourse on PPPs, New Zealand's approach stands out as a relatively uncharted territory, with little attention paid to its specific challenges and opportunities. The nation's modest economic scale, in particular, poses distinctive challenges for PPP initiatives. Additionally, the absence of a sophisticated capital market underscores the need for creative financing mechanisms and strategies to facilitate successful PPP projects. Furthermore, public sentiment in New Zealand tends to be cautious when it comes to involving the private sector in critical infrastructure endeavors. Recognizing and addressing these concerns is pivotal in shaping a PPP framework that aligns with the values and expectations of the New Zealand populace.

Before the NZ government made the decision to actively pursue PPPs in 2010, a handful of academic studies delved into the use of PPPs within the country. Heiler (2002), for instance, revealed that the underdeveloped business environment for PPPs and the relatively limited understanding of these partnerships within the industry were likely to act as barriers to the adoption and successful implementation of PPP projects. Similarly, Riberio and Dants (2011), focused on the potential of utilizing PPPs for land transport projects. They pointed out that challenges arose from existing legislation and the public sector's approach, both of which created hurdles in the adoption of PPPs. This highlighted the need for legal and regulatory adjustments and a shift in the public sector's mindset to facilitate PPP utilization in the transportation sector. Furthermore, Austin (2008) emphasized the significance of management expertise and the commitment of the public sector. His research indicated that deficiencies in these areas posed limitations on the effective use of PPPs to achieve desired project outcomes.

Post 2010, the most notable academic work on PPPs in NZ has come from Liu and Wilkinson (2015). They conducted an in-depth examination of key factors that play a pivotal role in determining the feasibility of employing PPPs for prison development utilizing a combination of semi-structured interviews and focus groups to gather data for their investigation. The research findings underscore that the success of prison PPPs hinges on various critical factors. These encompass the development of a sound business case, efficient project development, effective contract administration and governance, strong private consortium, and balanced allocation of risks. Recognizing and proactively addressing these factors can significantly enhance the prospects of successful PPP ventures in the domain of prison development. Furthermore, Liu (2013)'s exploratory study conducted general interviews with practitioners and pinpointed a dozen crucial factors that influence the successful execution of PPPs in New Zealand. Nevertheless, when juxtaposed with international studies on critical success factors (CSFs), it becomes evident that the number of CSFs identified in Liu (2013)'s research are notably fewer. They also highlight the need to explore PPP research in NZ in specific sectors using quantitative data as their research is limited in these areas. They also recommended that future research should explore domains such as the risk allocation, payment methods, financial structures, and the tendering procedure.

Considering the current state of research internationally and within NZ the following observations are derived:

1- Research area related to CSFs and risk allocation has received less attention in literature when compared to other areas of PPP research such as economic viability, value for money decisions, procurement and contract management, performance management, governance and regulation.

2- Social infrastructure PPP projects, particularly schools and prisons, have received very little attention from researchers in PPP. Moreover, BOT is the main focus areas in terms of PPP delivery models. New Zealand has a very unique PPP program focusing on delivery of social infrastructure projects through DBFMO mode of PPP.

3- In New Zealand PPPs are relatively new and the current research is either before the start of PPP program or limited to research area of CSF and qualitative methods. Existing academic literature and policy documents recommend to investigate areas of risk allocation.

1.4 Research Aim, Questions and Objectives

To overcome the PPP knowledge gap in New Zealand context, the main aim of this research is to propose an efficient risk allocation model in New Zealand's PPP social infrastructure projects. In order to effectively achieve this aim, the following research questions and objectives are established.

Table 1.3 Research questions and objectives

	Research objective (RO)	**Research question (RQ)**	**Covered in**
1	To identify and evaluate CSFs for PPP infrastructure projects.	What are the critical success factors (CSFs) in PPP infrastructure projects?	Chapter 2
2	To identify and group risks related to PPP infrastructure projects.	What are the risks present in PPP infrastructure projects? How can these risks be grouped to understand them better?	Chapter 3
3	To determine the optimal risk allocation criteria (RAC) and their ranking.	What criteria can be used to better allocate risks to public or private party?	Chapter 4 and 5
4	To develop a decision support framework for risk allocation in PPP social infrastructure projects.	How to determine the risk allocation proportions to be borne by public sector and private sector in social infrastructure PPPs?	Chapter 6 and 7

1.5 Research Methodology

1.5.1 Philosophical underpinnings

Selecting an appropriate research design depends on researcher's philosophy of research. Research philosophy help researchers to highlight and convey their perspective of research. A suitable research philosophy results in smooth research development and well-grounded research findings. Ontology and epistemology are philosophical perspectives of research, which form the basis of research process.

Ontology is concerned with answer the questions of existence and its nature (Bryman & Bell, 2015). The focus of ontological perspective is identifying the relation between actions of people and social reality. Based on the answer to this question, ontological perspective can be separated into objectivism and constructionism. Objectivist ontological position means that social reality is not affected by perception of individual i.e. there's a s single social reality. Constructivist ontological position however, suggests that reality is not singular, it depends on the mind of the observer. Hence, it is constructed based on individual's experiences (Bryman & Bell, 2015). Philosophical ontology is important in order to comprehend the challenges associated in research when developing new theories or testing existing ones.

Epistemological perspective is concerned with answering the question that what should be considered acceptable knowledge in a field of study. This perspective helps the readers understand the relation between research and researcher. Two extremes of epistemological positions taken by research are positivism and interpretivism.

Positivism is the approach to research in which researcher believes that reality already exists independent of researcher and can only be measured in an objective manner using scientific methods. Deductive theory is heavily favoured in this approach. Positivist adhere strictly to principles of reasoning in approaching their questions and heavily rely on observations and experiments for obtaining data. Therefore, testing and refinement of current models and theories is quite common for researchers adopting this approach (Easterby-Smith et al., 2012). Quantitate research methods are considered appropriate for researchers following positivist approach (Saunders et al., 2016).

In opposition to this, interpretivism focuses on subjectiveness and take the stance that reality is dependent on social constructs (Bryman & Bell, 2015). Sometimes also referred to as 'Phenomenology', it suggests that people and world are interdependent. Experience of people and views in different settings yield different results. Unlike positivism, interpretivism heavily relies on inductive theory. Qualitative research methods are mostly preferred in this perspective. A comparison between the two perspectives drawn from Bryman & Bell, (2015) and Saunders et al., (2016) is presented in Table 1.4.

Table 1.4 Comparison between positivism and interpretivism

	Positivism	**Interpretivism**
Area of study	Natural Science	Human Interactions
Approach to study	Objective	Subjective
Subject Matter	Nature	Social reality
Beliefs	Reality is external	Reality is constructed
Focus of study	Fact finding	Interpretation of meaning
Theory	Deduction heavy	Induction heavy
Sampling	Large	Small but in depth

1.5.2 Research approach

A research plan is very helpful tool for a researcher to conduct research in an orderly way. While designing the research plan a relationship between research objectives, data collection methods and analysis techniques must be established. As mentioned earlier, each school of epistemological approaches has its favourite methodologies. Qualitative, quantitative and a mix of these termed as mixed methods, are three different approaches for data collection and analysis. A comparison between two main approaches is drawn in Table 1.5.

Table 1.5 Qualitative and quantitative comparison

	Qualitative	**Quantitative**
Approach	Inductive	Deductive
Theory	Tested	Generated
Ontology	Constructionism	Objectivism
Epistemology	Interpretivism	Positivism
Social reality	Constantly shifting	External and objective
Analysis	Descriptive	Statistical
Sampling	Small	Large

Quantitative research stresses on data collection and analysis to be quantified (Bryman & Bell, 2015). Deductive measures are taken to test existing theories using well established scientific methods. Furthermore, decisions are justified by performing mathematical and statistical analysis. Quantitative research method doesn't allow the participants to solicit their own experiences.

In contrast, qualitative research focuses more on the meaning of words rather their numerical values. Social reality is viewed as a constantly changing phenomenon associated with individual perceptions and theories are generated (Bryman & Bell, 2015). Qualitative research methods include interviews and questionnaires asking open ended questions giving them the freedom to express their opinions.

Mixed methods approach has some of the qualities from both qualitative and quantitative methods. Some have recognized this method as a solution to the weaknesses of aforementioned methods (Amaratunga et al., 2002). This method allows collection of qualitative and quantitative data at the same time using mixed approaches. Also, most commonly used research methods in the field of PPP are questionnaire survey, interviews and case studies (Zhang et al., 2016). Keeping this in mind, I am inclined to adopt this method for the objectives set forth in this study. In my opinion, the state of risk management in PPP arrangement can be better understood through subjective opinions of practitioners. Moreover, the objective of RAC and risk allocation can be well achieved by using quantitative approach.

1.5.3 Research design

Research design is a coherent framework that helps in achieving research objectives by connecting the research questions to research data (Yin, 2017). It is like a map, which links the research questions with the data to be collected and provides insight into data analysis methods. Research objectives, research philosophy, time and resources available for research play an important role in governing the research design (Saunders et al., 2016). However, others researchers suggest that experience of participants and researcher should also be considered relevant in developing a research design (Creswell & Clark, 2017).

This research is designed to be conducted in three stages as shown in Figure 1.4. In the first stage preliminary literature review and some informal discussion with academic expert regarding PPP were conducted to formulate the objectives of this research. Based on this an extensive literature review was carried out to refine the research agenda and formulate a suitable methodology for research. This stage also helped in identifying some key risks relevant to PPP project and RAC from literature. Stage two is aimed at collecting and analysing the data, while in stage three risk allocation model was developed and thesis report drafted.

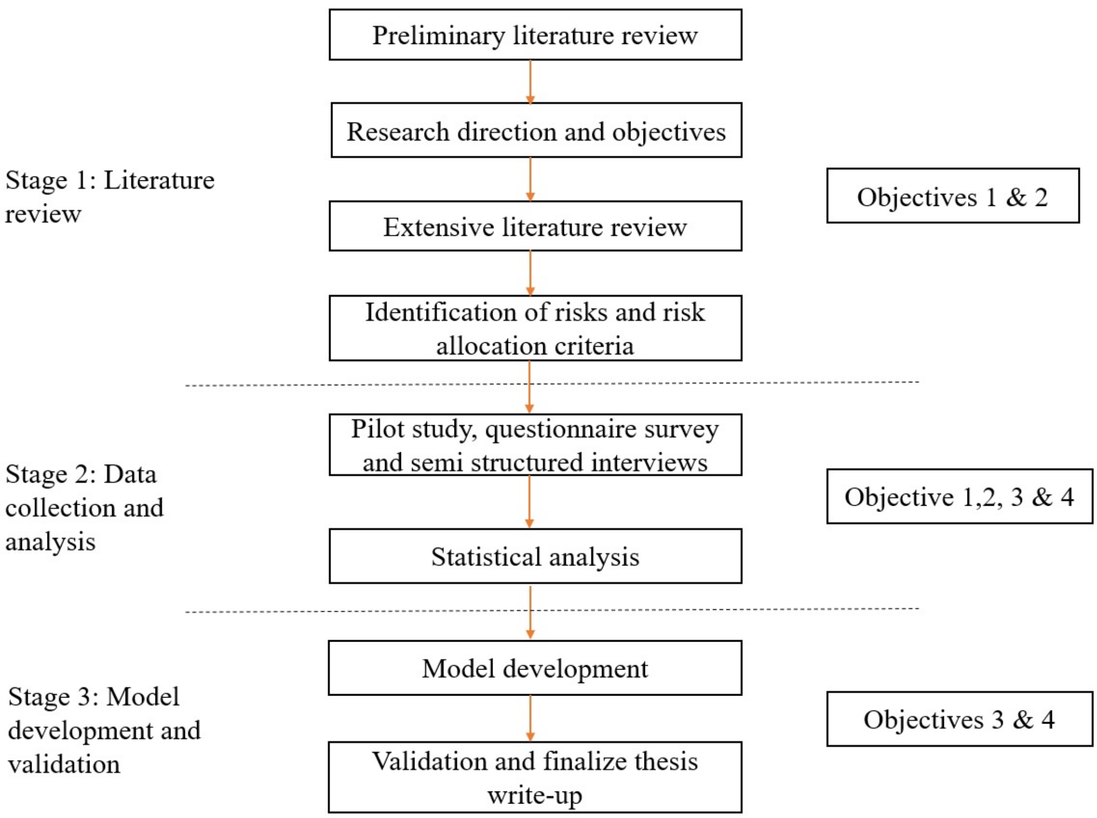

Figure 1.4 Research design

1.5.4 Data collection

This research is aimed at identifying, evaluating and allocating risks present in PPP infrastructure projects in New Zealand. Given the philosophical orientation of the study and use of mix methods approach, the research aim is divided into four objectives. Table 1.6

provides an overview of the research process in light of research objectives and research methods to be adopted. Furthermore, analytical tools to be adopted have also been listed. Following section provide a brief discussion of the data collection and analysis methods. Literature review, pilot study, questionnaire survey and interviews were used for data collection and validation.

Table 1.6 Research methods and analysis techniques

Objective	Methods	Analysis
1- To identify and evaluate CSFs for PPP infrastructure projects.	Literature review Pilot study Questionnaire survey	Content analysis Mean score ranking Cronbach's coefficient
2- To identify and group risks related to PPP projects in New Zealand.	Literature review	Systematic literature review (SLR) Content analysis
3- To determine the optimal RAC and their ranking.	Literature review Pilot study Questionnaire survey	Content analysis Mean value analysis Spearman's correlation Factor analysis
4- To develop a decision support framework for risk allocation in PPP projects.	Questionnaire survey Semi-structure interviews	Mean value analysis Fuzzy evaluation

1.5.4.1 Literature review

The theoretical foundation of every research is laid by a conducting a comprehensive literature review (Bryman & Bell, 2015). Literature reviews not only helps in solidifying the theoretical basis of the research, but also leads the researcher towards the problem identification. For this research work, the literature review engrossed the relevant sources of information related to PPP. These sources academic and institutional literature such as journal articles, doctoral thesis, text books, reports and guidelines.

The objectives of the literature review were to; (i) understand the current situation of PPP research in international practice as well as in New Zealand; (ii) formulate a framework for this research; (iii) identity relevant risks in PPP; and (iv) to develop an understanding of the risk management methods currently employed by different researchers in conducting research.

1.5.4.2 Questionnaire survey

For collecting large amounts of quantitative data, questionnaire survey is a preferred tool for many researchers in the field of construction management (Osei-Kyei & Chan, 2015). It allows for a large sample size from a population for collection of primary data. It is considered a suitable method for conducting qualitative and quantitative research as open and close ended questions can be incorporated in a questionnaire survey. This method has its limitations in terms of data accuracy and trustworthiness due to the absence of direct contact between the researcher and participant, especially if the survey is online (Gosling et al., 2004). Hence, a careful design of questionnaire is very important in this type of data collection.

For the purpose of this study, data on CSF (RQ1), risks (RQ2) and RAC (RQ3) identified from literature was gathered through the use of questionnaire survey from PPP practitioners within New Zealand. For CSF, an online questionnaire survey tool SurveyMonkey was used. For risks and RAC, another online survey tool Qualtrics was utilized. The decision to use online questionnaire was made due to ease of approaching participants and distribution which proved helpful in acquiring responses during the COVID pandemic of 2019/2020. Invalid responses were identified and removed to improve the authenticity of the data gathered. More information on survey development, number of responses collected and sampling methods is presented in the methodology sections of corresponding chapters of each research question. The questionnaire surveys are annexed in appendices B and D.

1.5.4.3 Pilot study

Pilot study in research can either be used to check the feasibility of the research or pre-test the selected instrument for carrying out the research (Ng et al., 2012). It helps in identifying the problems associated with a certain research method. Interview focus groups and pilot questionnaires are some of the options available for conducting pilot studies. One of the major limitations of pilot study is the possibility of researcher being affected by the results of pilot study which can affect the actual findings of the research. Also, inclusion of pilot study participant in the main study may contaminate the results.

For the purpose of this research, a pilot study was conducted in order to strengthen the data collected from questionnaire. A pilot involving two scholars and two industry experts was carried out to assess the effectiveness and applicability of the risks and RAC, drawing on their substantial expertise. Based on the review and comments of pilot study participants, issues regarding clarity and content of the questionnaire form were resolved.

1.5.4.4 Semi-structured interviews

An interview is a means to have a focused discussion on a certain topic between two or more people. It is widely used for qualitative research although it can also be used to obtain quantitative data (Hansen, 2021). It can be a telephonic or a face to face discussion for in-depth examination of a problem. Based on the nature of interaction and level of formality involved interviews can be categorized into structured, unstructured and semi structured (Saunders et al., 2016). Structured interviews offer higher level of reliability and they can be repeated. Hence, the question in a structured interview are identical and pre-planned for all the respondents. Unstructured interviews on the other hand, do not follow pre-planned questions and allow more freedom to the interviewee to express thoughts on an issue. Semi-structured interviews, as the name indicates lie somewhere between structured and unstructured interviews. Interviewer follows a theme and a set of some prepared questions (Naz et al., 2022). However, all the questions may not be answered or their order may be changed and some additional questions may be asked from the interviewee, hence offering some flexibility (Fellows & Liu, 2015). For validation of this research, semi-structured interviews approach was utilized given the nature of risk management in which opinions of experts can vary. This also enabled the researcher in understanding the current practices of risk management in PPP projects in New Zealand.

1.5.5 Sampling method

The need for sampling arises when it is impractical to collect data from an entire population. Assessing correct population, budget and time constraints are also important factors which need to considered when choosing sampling as an alternative to census. Data organization and analysis is easily manageable, apart from time and cost saving advantages achieved by opting for sampling. Quality of data is also increased when a representative sampling technique is adopted (Saunders et al., 2016).

Surveys utilize sampling techniques to collect data from a population in order to infer about the population to a specific level of confidence (Fellows & Liu, 2015). In this research, a combination of purposive and snowball sampling was adopted to collect data. Purposive sampling ensured that the respondents have sufficient working experience in PPP to participate in the survey. Snowball approach helped in acquiring responses from other PPP professionals who meet the criteria of minimum working experience. Given the developing nature of PPPs in New Zealand, finding a sufficient sample size of respondents was challenging. Hence, the combined sampling approach helped overcome this challenge. The resulting sample obtained using this approach was considered to be an elite sample because the size of sample and experience of respondents was comparable to other international studies having adopted PPP earlier than New Zealand.

1.5.6 Data analysis

The data collected through questionnaire survey and other data collection methods was analysed using software such as Microsoft Excel and Statistical Package for the Social Sciences (SPSS). A brief description of the data analysis techniques employed is provided in the sections below.

1.5.6.1 Content analysis

Content analysis is a systematic and objective way to analyse qualitative data collected in written, visual or verbal forms (Hashemnezhad, 2015). This technique is employed by researchers to analyse literature, case studies and semi-structured interview. It can help in deriving themes from qualitative data which can then be grouped into different categories for ease of interpretation. In this research, content analysis was mainly used in Chapter 2 and during the Systematic Literature Review (SLR) in Chapter 3, which helped identify CSFs, risks and RAC.

1.5.6.2 Mean score analysis

Mean score analysis has been widely used in construction management research in the past (Cheung et al., 2012). Ameyaw and Chan (2015) used this technique to rank risk factors in their study. The following formula was used in this study to establish mean scores of the identified factors and survey response.

$$Mean\ score = \frac{\sum a\ x\ b}{N} \qquad (1)$$

In this equation, ‘a’ is the rating given by each respondent to individual risks; ‘b’ is the frequency of this rating and ‘N’ is the total number of responses. In this research, mean scores were used to establish the importance rankings of CSFs and RACs.

1.5.6.3 Factor analysis

Factor analysis (FA) is a technique to reduce a large number of variables to a smaller number by identifying the underlying pattern of observed variables (Brown, 2015). It has been adopted by many construction management researchers in the recent past to group large number of variables such as risk factors and critical success factors (Osei-Kyei & Chan, 2015).

Kasier-Meyer-Olkin (KMO) and Barlett’s test of sphericity is used to determine the suitability of using factor analysis. KMO is determinant of adequacy of sample and its value ranges between 0 and 1. Higher value of KMO is associated with better correlation between samples resulting in better factor grouping. Correlation matrix should be equal to identify matrix for factor analysis to be used. This is determined by applying Barlett’s test of sphericity (Yelin Xu et al., 2010). In this research, FA is used in Chapter 4 to group RAC into three main groups.

1.5.6.4 Fuzzy set theory

Fuzzy set theory is the basis of modelling techniques such as fuzzy synthetic evaluation (FSE) and fuzzy additive weighting (FAW). These techniques have been employed in construction management research to deal with decision making under multi-criterion (Mazher et al., 2019; Oni et al., 2023; Osei-Kyei et al., 2017). It uses linguistic terms to represents variables such as low, medium and high to describe fuzzy sets. In project risk management, risk experts normally use such linguistic variables to assess risks. FSE is a method for modelling multi criteria decision making problems (Wei et al., 2014). This research employed this method to develop risk allocation model based on multi-criteria of risk allocation and linguistic variables of very low, low, medium, high and very high for assessing these criteria.

1.5.7 Reliability and Validity

For a research finding to be utilized in practice, its quality must be evaluated (Noble & Smith, 2015). Reliability and validity are two important measures for determining the success of research. Validity can be defined as the degree of accurateness of research findings. Whereas, reliability is the measure of accuracy of instrument used for research findings to provide same results under same settings (Heale & Twycross, 2015).

Saunders et al. (2016), argued that there are three aspects of validity, namely, measurement validity, internal validity and external validity. If research findings of a study can be generalized to other relevant settings, they are externally valid (Saunders et al., 2016). Whereas, if the research instrument is measuring what it is anticipated to measure then its internally valid. All of these aspects are aimed towards achieving quality and certainty in the research outcomes.

For the purpose of this research, research problem was investigated through literature review, questionnaire survey and semi-structured interviews. The questions for survey were prepared with the help of supervisors to ensure the validity of outcomes. External validity of research was ensured by selection of representative samples from existing PPP projects in New Zealand. Furthermore, where necessary appropriate statistical techniques were employed for selection of a fitting sample size. Internal validity of the research was ensured by covering the contents of the research in depth through literature review. Also, pilot study approach was adopted to address problems related to questionnaire survey validity. To check the reliability of research findings, Cronbach's Alpha test for internal reliability was used. Validity of this research is covered in more detail in Chapter 7.

1.6 Research Ethics

Issues related to ethics have become a major concern for researchers when conducting their research. There is a pressing need to carefully think about conducting research in an ethical way, especially during the data collection phase. Ethics in research are the behavioural standards towards the research participants that guide the process of data gathering (Saunders et al., 2016). These standards are guide by social norms of behaviour and philosophical basis of research ethics. There exists a variation in people's behaviours in different situations and philosophical approaches which lead to difference in views when it comes to adopting an ethical approach. This has resulted in development of code of ethics based on these factors.

For the purpose of this research, code of ethics developed by Massey University Human Ethics Committee (MUHEC) was followed. The research observed the principles of ethics from start to finish. As the data collection phase involved human participation, an application requesting permission for data collection was launched and later approved by MUHEC. Approval was granted for a period of three years under low risk category and ethics notification number for application is 4000021396.

Ethical principles of MUHEC have been tabulated in Table 1.7. Actions required to address any issues arising in light of these principles have been proposed also. Participation Information Sheet and Consent Form was presented to the participant in order to address the ethical principle of informed consent. Furthermore, all the study participant were treated with due respect. Collected data was stored in a safe drive at Massey University which was only accessible by the researcher and supervisors.

Table 1.7 Ethical considerations

Ethics Principle	Mitigation Measures
Integrity and objectivity of the researcher	Be truthful, act openly. Avoid deception, dishonesty and misrepresentation.
Respect for others	Respect others rights.
Avoidance of harm	Consider emotional well-being and avoid undue stress.
Privacy of the participants	Safeguard personal information of participants.
Voluntary nature of participation and right to withdraw	Participants will be informed of their rights to decline or withdraw from research.
Informed consent of those taking part	Provide Participation Information Sheet and seek for signed consent through Consent Form.
Avoidance of falsifying data and findings	Store data safely in encrypted form for future reference.
Ensuring the safety of the researcher	Follow safety rules and regulation when visiting construction sites.

1.7 Research Scope and Limitations

This research aims to identify CSFs, risks and RAC related to PPP projects and allocate risks associated with PPP using the identified RAC. Identification method used in this research is document analysis and expert opinions based on survey. Risk allocation was based on the opinions of the industry experts in light of identified RAC from existing literature. As the participant were selected from PPP projects in New Zealand, therefore the scope of this research is limited to PPP experience in New Zealand. Other limitation of the research related to methodology, data analysis and results, are addressed at the end of this research in Chapter 8 section 8.4.

1.8 Research Significance

This research aims to improve the state of risk management research in the area of PPP by introducing RAC as a means of allocation of risks. In doing so, first, the importance of risk sharing and transfer was established through study of CSFs, consequently, risks related to PPP infrastructure projects were identified through literature and risk groupings were established. Different RAC used to allocate risk to public or private sector were identified and assessed. Finally, this research attempted to make useful contribution to the existing body of knowledge by developing a decision support framework for risk allocation. This is particularly useful in the context of New Zealand PPP projects, where a significant knowledge gap exists in the PPP risk management.

Due to the distinctive characteristics of PPPs in New Zealand, the insights from this research continue to hold significance in directing future research endeavors and influencing global policy approaches. The study's outcomes establish a fundamental structure that governments and private entities can utilize to achieve fair risk distribution grounded in the principle of risk allocation for greater effectiveness. Furthermore, these discoveries empower researchers to conduct further practical studies on the theme of capability-driven risk allocation.

1.9 Thesis Outline

This doctoral thesis comprises a compilation of six journal and conference papers, five of which have been submitted, accepted, or published in international conferences and journal proceedings as of the time this thesis was written and sixth paper is ready for submission. Each paper within this thesis is organized as a chapter, with each chapter dedicated to addressing a specific research objective. Additionally, the title of each paper serves as the chapter heading. This dissertation adheres to Massey University's guidelines for thesis by publication. A brief outline of each chapter, including the introduction, validation and conclusion, is provided as follows:

In Chapter 1, the research study is introduced with a basic overview of PPP. It presents a brief overview of the current state of knowledge in the field and outlines the goals to be achieved. Additionally, a brief outline of the research methodology employed in this study is provided.

Chapter 2 introduces critical success factors of PPPs and presets 27 CSFs identified from previous studies. Perception of public and private participants obtained through a questionnaire survey are used to develop rank order of CSFs and further analysis is carried out to draw comparison between the public and private sector respondents. Top 5 most critical factors are discussed. Risk sharing and risk allocation are further selected to be looked into in detail in the next stage of research.

Chapter 3 presents a systematic literature review of PPP risk management research using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) research methodology. Risk identification and risk allocation literature is analysed and useful conclusions drawn. Several risks and RAC are identified from previous research studies.

Chapter 4 explores the RAC in detail and establishes rank order of importance of RAC using data collected from survey. Factor analysis techniques is further employed to show that the identified RAC can be classified into three component groups namely risk management expertise, core risk management capability and risk management strategy.

Chapter 5 examines the risk management capability of public and private sectors based on RAC in social infrastructure projects in New Zealand.

Chapter 6 develops a capability-based risk allocation model using FSE and data collected through questionnaire.

Chapter 7 delves into the process of validating the risk allocation model of risks in PPP social infrastructure projects.

In Chapter 8, this research is brought to a conclusion with a summary of the findings, an exploration of the study's limitations, and consideration of potential avenues for future research.

2 Critical success factors (CSFs) of public-private partnerships (PPPs) in New Zealand

This chapter was developed from Publication 5 and Publication 6. Publication 5 was developed from initial survey results of 33 responses focusing on ranking of CSFs and published in final form in the Proceedings of the 43rd Australasian Universities Building Education Association (AUBEA) Conference, November 2019, QLD, Australia, p. 223. Publication 6, an extension of Publication 5, was developed from final 58 survey responses focused on comparison of public and private viewpoints of CSFs and has been published in final form in the Proceedings of the 6th New Zealand Built Environment Research Symposium (NZBERS), February 2020, Massey University, Auckland, New Zealand, p. 13. This paper was very well received by the symposium delegates and won an award.

Abstract

Funding modern day projects in the face of declining public reserve pools has influenced the scale of infrastructure provision. Public-Private partnership (PPP) emerged as an effective solution for delivering infrastructure in many countries. However, not all projects have been reported successful. Literature suggests that an understanding of critical success factors (CSFs) is imperative to achieving project goals/successes, hence CSFs for PPPs has generated research interests worldwide. However, there is little to no research in this area in New Zealand. To address this gap, this study established a rank-order of CSFs, which could improve the delivery of future PPP projects in New Zealand. 27 CSFs were identified from the review of literature and presented to PPP practitioners, to capture their perceptions in New Zealand. The questionnaire survey was essentially Likert scaled. Findings revealed that "approval and negotiation process", "innovation and project complexity", "client's brief", "project's technical

feasibility" and "strong private consortium" are five top ranked factors. In future, as more responses are collected, factor analysis technique will be used to explore the grouping of these factors to enable valuable deductions. The results of the study can assist stakeholders in policy formulation and investment related decision-making.

2.1 Introduction

Infrastructure demand is on the rise with the ever-growing urban population worldwide (McNichol et al., 2015). Governments are struggling to keep up with such high level of investments in infrastructure. Hence, innovative procurement methods, which involve the private sector, have become a necessity to remedy this situation. One such method is PPP, which helps public sector to achieve its goal of infrastructure provision by tapping into resources of private sector. Moreover, it provides private sector an opportunity to capitalize on its investment. PPP is a popular choice for project delivery and has grown in the recent years with a key reason being the unprecedented lack of economic growth all over the world (Kleimeier & Versteeg, 2010).

PPP has been utilized to deliver transport, telecommunication and energy sector projects for infrastructure expansion in numerous cases (Carnis & Yuliawati, 2013). A key reason behind increasing popularity of PPPs worldwide is the execution of numerous successful projects (Hodge & Greve, 2007). It has been used to achieve value for money with the help of private sector involvement in countries like China, UK, Malaysia and Australia (Chou & Pramudawardhani, 2015).

In past, provision, improvement and operation of general infrastructure was achieved using public finances. However, after the rise of PPP more recently, public sector is using private sector's expertise to provide infrastructure (Bwanali & Rwelamila, 2017; Iossa &

Martimort, 2015). Private sector is normally engaged through the use of concession contracts for a pre-determined period of time (Ross & Yan, 2015).

The incentive for application of PPP lies primarily in its ability to allocate different risks to the project parties (Sastoque et al., 2016). However, if not managed properly, these risks can result in project failure as well. For this reason, PPP is not considered suitable for projects having high amounts of uncertainty and insecurity of cash flows (Blanc-Brude & Makovsek, 2013). It is rarely used for research and development activities, product launching and other possible risk heavy endeavours. So, projects having manageable risks and well-established operating methodologies are ideal candidates for PPP application (Grimsey & Lewis, 2007). These risks can be related to different project stages such as conception, planning, construction and operation.

New Zealand government showed its interest in pursuing PPP option for infrastructure development in 2009. Infrastructure Transaction Unit (ITU) was established to streamline the process for PPP implementation (Liu & Wilkinson, 2011). PPP policy published by the government highlighted its intentions to prefer PPP over traditional methods of delivery provided they deliver value for money (Treasury New Zealand, 2015). National Infrastructure Plan issued in 2010, stressed Government's priorities for infrastructure and its willingness to use PPPs across sectors. Mayoral position paper on PPPs, published in 2013, identified PPPs as a viable procurement strategy in New Zealand.

Hobsonville schools project was the first project procured through DBFM modality of PPP under a concession contract of 25 years in 2012. Since then, five new social infrastructure projects, including schools and prisons, have been launched and executed, most of which are in operation stage. Furthermore, two road infrastructure projects are in their construction stage (Treasury New Zealand, 2018).

With the increasing popularity of PPPs internationally, a number of areas related to PPP have been researched upon. A considerable attention has been paid to research domains relevant to relationship management, government regulation and guarantees, procurement and legal issues within PPPs (Osei-Kyei & Chan, 2015). A research trend established by Zhang et al. (2016) by systematically reviewing PPP literature in Chinese and international journals revealed PPP success factors as a promising area for research. Ke et al. (2009) also stressed the importance of this area in his study, which established seven major areas for PPP research. It is evident from such indicators that research interest in this area will only grow, as PPPs are continuously being applied in other markets around the world.

Al-Saadi and Abdou (2016) suggests that critical success factors are considered vital for successful implementation of PPP projects. Various research methods such as interviews, questionnaires and case studies have been used in the past to investigate these CSFs in numerous countries. However, there is little known about these CSFs in countries such as New Zealand which have just began to adopt PPPs. This study aims to address this gap by conducting an investigation into the factors critical for success of PPP projects in New Zealand perspective.

To achieve this goal, the study followed a three-step approach. In the first step, 27 CSFs were identified by reviewing relevant PPP literature. A 5-point Likert scale questionnaire survey was conducted in the second step, which gathered the opinions of PPP practitioners having experience and involvement in New Zealand PPP projects concerning the importance of the identified factors. In the last step, statistical tests of factors were used to rank 27 CSFs to establish their relative importance. The top five factors were selected for discussion.

2.2 Literature Review

According to Sehgal and Dubey (2019) CSFs are those particular features and activities of a project, which result in its favourable result when followed in execution of the project. The concept of CSFs has been around since the 1970s (Osei-Kyei & Chan, 2015). Its application in numerous areas such as information systems, business services and manufacturing industry has been observed as a managerial tool (Li et al., 2005). Jefferies (2006) argued that these factors have a positive influence on the outcome of the project if managed periodically.

Since the early 1990s, several researchers have applied this idea of CSFs to formulate and understand PPP policy and guidelines (Zhang et al., 2016). A lot of research has been undertaken to identify CSFs in countries such as UK, Australia, China, Singapore, Malaysia, Nigeria and Ghana (Chan et al., 2010; Hwang et al., 2013; Ismail, 2013; Jefferies, 2006; Jefferies et al., 2002; Li et al., 2005; Olusola Babatunde et al., 2012; Qiao et al., 2001). A range of areas of PPPs from different sectors consisting of various project models within PPP have been explored in these studies. Some of these sectors for which CSFs have been explored by researchers include transportation, power, telecommunication, and housing.

Qiao et al. (2001) identified and analysed 27 CSFs of BOT projects in China against different stages of the project. They argued that "stable political and economic situation" needs to be given importance in the evaluation phase of the project. Moreover, factors such as "technical solutions" for tendering stage, "reasonable risk allocation" for award phase, "competent project team" for construction phase and "management control" for operation phase of the project were identified to be important. Similarly, Zhao et al. (2010) investigated 31 success factors for Chinese PPP power projects that were delivered using the "build own transfer (BOT)" mode by reviewing relevant literature and carrying out interview with experts.

A recent study by Yang et al. (2017), followed a similar approach in exploring the CSFs for BOT projects in China. Their findings reveal that "reasonable risk allocation", "government support and guarantee", "strong project consortium" and "project technical feasibility" are top ranked important CSFs for BOT project in China.

On the other hand, despite the unique characteristics of PPP projects several studies have also engaged this concept of CSFs for PPP infrastructure projects in general, without specifying sector or project type (Chan et al., 2010; Ismail, 2013).

Li et al. (2005) identified 18 CSFs for PPP/PFI projects in the UK construction industry and examined their relative importance using a questionnaire survey. Mean analysis of these factors found "appropriate risk allocation", "strong private consortium" and "available financial market" to be the most crucial factors. Similarly, for an Australian sports stadium project, Jefferies et al. (2002) identified and examined 15 CSFs, which was delivered using the "build operate own transfer (BOOT)" mode of PPP. "Technical innovation", "efficient approval process", "solid consortium" and "good resource management" were found to be the most significant CSFs. The findings suggest that the negotiation process plays a key role in project success.

Following the 18-CSF list by Li et al. (2005), Chan et al. (2010) explored this concept in People's Republic of China. An empirical questionnaire survey instrument was employed to solicit the views of Chinese PPP experts. They employed factor analysis technique to group these factors into clusters which are, "macroeconomic stability", "shared responsibility between public and private sectors", "transparency in procurement", "stability in political and social atmosphere" and "informed government". They further concluded that the factor group "stable macroeconomic environment" is very critical due to rapidly changing global financial situation. Ismail (2013) also adopted the same methodology to study these CSFs in Malaysian PPP projects.

Following the New Zealand government's decision to pursue PPP as a procurement model, Liu and Wilkinson (2011) investigated the barriers and drivers for its adaptation in New Zealand's perspective. They used semi-structured interviews with PPP experts to investigate these issues. Some of the drivers in their findings are also the key critical success factors highlighted in a number of international critical success factors studies, namely, better risk allocation and whole of life cost savings.

Asquith et al. (2015) studied the effect of political influence on PPP health sector project in New Zealand. They conducted an exploratory study to identify the critical success factors for partnerships contracts in the health sector. Their findings suggest that clear contractual relationships, commitment and trust play key roles in determining the success of these partnerships. Furthermore, private sector respondents showed their concern about reforms in the political process, which dictates their decisions about entering into these partnerships.

Although several previous studies address CSFs related to PPP in international literature, studies focusing this area in New Zealand's context remain sparse. Moreover, due to distinctive characteristics of PPP to a country require a study on CSFs specifically for PPP in that country. Hence, this present study fills the gap by investigating the CSFs for implementation of PPP in New Zealand. The factors noted above from the most prominent studies have been extracted into 27 CSFs, as shown in Table 2.1.

Table 2.1 List of CSFs identified from literature

Critical Success Factors	References								Total
	1	2	3	4	5	6	7	8	
Appropriate risk allocation	*	*	*	*	*	*	*	*	8
Strong private consortium	*	*	*	*	*	*	*	*	8
Favourable legal framework	*	*		*	*	*	*	*	7
Transparency in procurement	*	*	*	*	*	*		*	7
Political support	*	*	*	*		*	*		6
Strong and committed public authority	*			*	*	*	*	*	6
Risk sharing	*			*	*	*	*		5
Adequate financial market	*		*	*		*	*		5
Stable macroeconomic conditions	*			*		*	*	*	5
Credible cost benefit analysis	*			*		*	*	*	5
Social support	*		*	*		*		*	5
Government guarantees	*		*	*		*		*	5
Commitment and responsibility	*	*		*		*			4
Sound economic policy	*			*		*		*	4
Shared authority	*				*	*		*	4
Sound governance	*		*			*		*	4
Multipurpose project targets	*			*		*		*	4
Competitive procurement	*		*			*			3
Project's technical feasibility	*		*					*	3
Client's brief		*	*						2
Innovation/Project complexity							*		2
Approval and negotiation process		*							1
Environmental impact		*							1
Community support		*							1
Business diversification			*						1
Credit rating of investors		*							1
Availability of suitable financier		*							1

References: 1 = (Li et al. 2005); 2 = (Jefferies 2006); 3 = (Chan et al. 2010); 4 = (Ismail 2013); 5 = (Hwang et al. 2013); 6 = (Chou and Pramudawardhani 2015); 7 = (Al-Saadi and Abdou 2016); 8 = (Yang et al. 2017)

2.3 Methodology

This study followed a three-step approach. In the first step, 27 CSFs were identified by reviewing PPP literature. A 5-point Likert scale questionnaire survey was conducted in the second step, which gathered the opinions of PPP practitioners working in New Zealand concerning the importance of the identified factors. In the last step, mean score of factors was used to ranked them which indicated their relevant importance and draw a comparison between the perceptions of public and private sector individuals. The top five factors were selected for discussion.

As stated above, the 27 critical success factors identified from existing literature (table 2.1) have received recognition from several researchers. These factors were examined using a five-point Likert scale questionnaire survey. Many other studies have utilized similar kind of scale in the area of construction management (Li et al., 2005; Chan et al., 2010; Ismail, 2013; Yang et al., 2017.

The survey measured the opinions of PPP professionals from public and private sectors in New Zealand regarding CSFs for PPPs. The complete questionnaire comprised two parts. The first part contained questions about the respondents' individual profiles and the second part surveyed the respondent's level of agreement against each of the identified CSFs. Questionnaire was pre-tested with the help of three academic and PPP professionals, before the start of data collection. Their proposed changes were incorporated in the questionnaire to improve the clarity and to help the respondents understand questions better.

The questionnaire survey was administered through Survey Monkey in July, August and September 2019 among New Zealand practitioners with involvement in PPP projects. Convenience sampling method was adopted to gather responses. Initial set of respondents were approached from an on-going PPP project. Considering the level of experience of these individuals in PPP scene, it was expected that they had connections with other potential respondents also, hence, some of the them were asked to distribute the survey form link to their peers as well.

The data was analysed using mean value analysis (MVA) and based on calculated mean scores, ranking of CSFs was generated. This method has been used by several studies in the past to analyse similar kind of data (Ismail 2013; Hwang et al., 2013). MVA is considered an acceptable method for ranking factors (Chou & Pramudawardhani, 2015). Cronbach's alpha using SPSS was calculated to check the reliability of the data. Cronbach's Alpha value was 0.916 suggesting high reliability of the data.

2.4 Findings and Discussion

A total of 58 responses were received through Survey Monkey. It was anticipated that some respondents might not be familiar with all the success factors identified from literature. To remove any bias from the data obtained from the survey respondents, an additional 'no idea' option for each question was included. Moreover, to safeguard the quality of the data, 12 responses were excluded from the analysis for their incompleteness.

Basic information gathered from the first section of questionnaire is presented in Table 2.2. Most of the respondents belong to the private sector. Out of the total 46 valid responses, 32 belong to the private sector and 7 from public sector. About half of the private sector respondents have gained their PPP experience working with the main contractor. Low response rate from public sector is consistent with previous studies in similar area (Chan et al., 2010; Ismail, 2013). Moreover, PPP tends to involve more private sector individuals as the public sector's role is mostly limited to serve as a facilitator in these kinds of partnerships.

Table 2.2 Background information of survey participants

Item	Type	N	(%)
Public	Central government	5	11
	Local government	2	4
Private	Main contractor	19	42
	Consultant	5	11
	Subcontractor	8	17
Others		7	15
			100
Role/ Position	Project Director	4	9
	Construction Manager	3	7
	Project Manager	11	24
	Project Engineer	5	11
	Quantity Surveyor	4	9
	Planning Engineer	3	7
	Others (Supervisor, Contract administrator, Area manager etc.)	16	35
			100
Experience	upto 5 years	24	52
	5-10 years	10	22
	11-15 years	5	11
	Over 15 years	7	15
			100
Country of Experience	New Zealand	26	57
	Australia	7	15
	UK	4	9
	Ireland	2	4
	Others	7	15
			100

Only 15% of the respondents have PPP work experience of more than 15 years. This could be due to the relatively new nature of PPPs in New Zealand. However, almost half of the respondents have experience of more than 5 years. In addition, 43% of the respondents have also worked on PPP project outside New Zealand.

2.4.1 Ranking of Critical Success Factors (CSFs)

Mean value analysis of the survey responses for the identified CSFs is used to rank factors in order of their importance. Overall mean scores for these factors range from 3.50 to 4.13 as shown in Table 2.3. There isn't much difference in the range of mean values of public and private sector respondents from the overall mean score. The results indicate that all the factors identified are deemed important by the survey respondents. However, 14 out of 27 factors are above the mean score of 4 which are considered more important than others.

The top five important factors based on respondent's perception are client's brief, sound economic policy, approval and negotiation process, project's technical feasibility and competitive procurement process. A brief discussion of some of these factors is provided in the following paragraphs.

Table 2.3 Mean scores of CSFs

Critical Success Factors	Mean Score			Rank		
	Overall	Private	Public	Overall	Private	Public
Client's Brief	4.137	4.146	4.182	1	1	12
Sound Economic Policy	4.10	4.102	4.092	2	2	14
Approval and Negotiation Process	4.096	4.097	4.091	3	3	15
Project's Technical Feasibility	4.096	4.073	4.08	3	7	9
Competitive Procurement	4.08	4.077	4.091	5	4	17
Availability of Financier	4.08	4.051	4.182	5	8	11
Strong Public Agency	4.078	4.075	4.091	7	5	18

Realistic Cost-Benefit Analysis	4.076	4.024	4.273	8	10	6
Multi-purpose Objectives	4.04	4.0	4.20	9	11	7
Committed Public and Private Sectors	4.039	4.024	4.10	10	9	13
Good Governance	4.019	4.075	3.818	11	6	23
Innovation/Project Complexity	4.00	3.902	4.364	12	15	2
Appropriate Risk Allocation	4.00	3.90	4.364	12	16	3
Transparent Procurement Process	4.00	3.951	4.181	12	12	10
Favourable Legal Framework	3.98	3.923	4.182	15	14	8
Environmental Impact	3.91	3.925	4.091	16	13	16
Government Guarantees	3.967	3.838	3.81	17	18	22
Risk Sharing	3.923	3.829	4.272	18	19	5
Strong Private Consortium	3.885	3.902	4.40	19	17	1
Shared Authority	3.843	3.732	4.363	20	22	4
Community Support	3.807	3.781	3.91	21	20	20
Political Support	3.788	3.78	3.82	22	21	21
Social Support	3.72	3.70	3.8	23	24	22
Adequate Financial Market	3.714	3.717	3.7	24	23	25
Credit Rating of Investors	3.557	3.43	4	25	27	19
Stable Macroeconomic Conditions	3.54	3.53	3.54	26	25	26
Business Diversification	3.50	3.43	3.4	27	26	27

Client’s brief, with an overall mean value of 4.137 is the most important CSF in New Zealand’s perspective. A client’s brief helps in clear communication of public sector requirements which play a vital role in the success of PPPs (Cheung et al., 2012). A well-crafted Client's Brief is essential for the success of PPP projects because it sets the foundation for effective project planning, execution, and governance. It helps manage risks, attract private sector investment, and ensures that the project aligns with the public sector's goals and the community's needs.

Sound economic policy was rated as the second most important factor for successful implementation of PPPs in New Zealand by the survey participants. It ensures stability and predictability in the economic environment, which is vital for attracting private sector investments. With clear and consistent policies, private partners gain confidence in the project's long-term viability. This, in turn, reduces risks, attracts more investors, and fosters an environment conducive to successful PPP project implementation.

Approval and negotiation process and project’s technical feasibility are both identified as the third most important factor for success of PPP projects in New Zealand. These factors have received considerable attention from PPP practitioners in other countries as well. Li et al. (2005) in his study for PPP CSFs for UK construction industry ranked project’s technical feasibility at sixth position. PPP tend to have a complex approval and negotiation process (Li et al., 2005). Jefferies (2006) identified this factor to be crucial for success in his case study of Australian Super Dome project. He argued that it can help identify key issues to be resolved at the early stage. Project company’s ability to effectively handle the technical aspects play an important role in winning the contract (Chan et al. 2010).

Competitive procurement process is ranked fifth by the participating respondents with an overall mean value of 4.08. Li et al., 2005, identified this factor as the most important factor in opinion of the public sector respondents. A competitive procurement process in PPP projects promotes transparency, innovation, cost-effectiveness, favourable terms, and accountability, contributing significantly to their overall success.

Surprisingly, the success factor ‘macroeconomic stability’ has not gotten much attention from the respondents and ranks last in the table above. In Chan et al. (2010) ranking of CSFs it was ranked fourth. Li et al. (2005) also emphasized the importance of favourable economic condition for successful execution of PPP projects. New Zealand enjoys a stable economy

(OECD, 2019), which is one of the potential reasons for this factor’s low importance in respondents’ point of view. Implementing suitable economic policies could result in a steady and expanding economic climate, enabling the private sector to function confidently. Additionally, the presence of a stable economic atmosphere would create a sense of predictability in the market, ultimately lowering risk for private sector participants (Li et al., 2005).

Client’s brief, sound economic policy and approval and negotiation process are also considered the top three most important factors in private sector’s opinion. Innovation and project complexity, strong private consortium and appropriate risk allocation are perceived as top three most important CSF by the public sector participants in this study. Solving complex project issues using innovative methods is one of the strong suits of private sector. It is one of the key reasons for private sector involvement in provision of public infrastructure as public sector often lacks the use of inventive techniques (Cheung & Chan, 2010). As public sector is considered to be reluctant in adopting to innovation, from their perspective the second rank of this factor is somewhat justified. Strong private consortium has also been identified as the top ranked factor in some previous studies (Li et al., 2005; Chan et al., 2010). Osei-key and Chan, 2015 argue in their study that a strong and well-structured consortium is vital in PPPs. These projects are often too complex for a single construction company to handle, leading to the formation of consortiums. However, the success of the project depends on the consortium's effectiveness. A poorly managed consortium can lead to difficulties and project failure.

Appropriate risk allocation has also been identified as a crucial success factor in PPP projects in many previous studies (Ismail, 2013; Osei-Kyei & Chan, 2015). It helps distribute responsibilities effectively between the public and private sectors. By assigning risks to the party best equipped to manage them, PPP projects can achieve several key benefits. Risk allocation encompasses the identification of potential risks and their equitable distribution among the involved parties, which can include both the public and private sectors (Y. Ke et al., 2010; Osei-Kyei & Chan, 2015). In the negotiation phase, risks are distinctly outlined and assigned to the party with more effective mitigation strategies for handling them. Osei-key and Chan, (2015) also note that governments should avoid the notion of completely shifting all project risks onto the private sector, as doing so could impact the advancement of PPP projects and discourage future involvement of private investors.

2.5 Conclusion

PPP has emerged as an innovative way of procuring public infrastructure projects. Private sector expertise and finances are used for provision of a project or service under long term contracts. These long-term contracts and complex arrangements can cause many issues during this process. Success of the project is dependent on many factors which if managed properly can lead to positive results.

This study examined the relevant critical success factors of PPP in New Zealand and ranked them in order of their importance. The findings show that all factors have a mean score of more than 3 which indicate that they were somewhat significant in PPP practitioners' views. Some of the top ranked factors are client's brief, sound economic policy and approval, negotiation process, innovation and project complexity, strong private consortium and appropriate risk allocation. In future, as more responses are collected from public and private sector participants, factor analysis technique will yield useful factor groupings.

There are some limitations to this study. Firstly, the CSFs are collected from the literature in general and from international PPP experience in other countries, some of which might not reflect a true representation of New Zealand. Secondly, all of the identified CSFs may not apply to all the PPP projects due to their generic nature. A project specific context, such as PPPs in social or road infrastructure, may be investigated in future. Lastly, similar studies can be conducted using a different research instrument such as case study or interviews to highlight the opinions of the practitioners.

3 Risk identification, assessment, and allocation in PPP projects: A systematic review

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Abstract

PPPs have gained widespread adoption as an innovative way of procuring public infrastructure projects over the last two decades. Risk identification, assessment, and allocation have received considerable attention from researchers due to the risk heavy nature of PPP projects. Adoption of PPPs has triggered a sudden increase in research interest in the area in recent years. This study attempts to provide an updated systematic review of literature related to risks in PPPs using PRISMA flowchart. The results of the study offer some valuable insights into the future and current state of research. The study found that focus of research on PPPs have shifted from an overall risk identification and assessment approach to individual risk analysis. Moreover, research trend is on the rise in developing countries, and that quantitative methods for risk management in PPP research and qualitative methods in practice are preferred. In developed economies, due to negative public sentiments, transparency concerns, and arguments of value for money not being achieved, PPPs are becoming less popular. For these reasons a shift to availability-based payment mechanisms such as in DBFM from traditional revenue-based mechanisms as in Build-Operate-Transfer (BOT) is observed. These shifts in research trends and practice offer researchers future opportunities to investigate these relatively newer approaches.

3.1 Introduction

Infrastructure development has always been seen as a driver for economic growth of a country (Cui et al., 2018). With the increasing urban population worldwide, the need to develop social and economic infrastructure has become even greater in the recent years. Previous research in infrastructure development suggests that there is a need to invest more in this area to cover the infrastructure gap (Garvin & Bosso, 2008; Jokar et al., 2021; Li & Wang, 2019; Selim et al., 2019). A study by Iyer and Purkayastha (2017) reported an infrastructure investment of approximately 50 trillion USD is required in the next ten years across the globe. However, governments all over the world are facing problems to keep up with such huge investments. Therefore, seeking help from the private sector in terms of finances and the extent of private sector involvement resulted in innovative project delivery schemes, one of them being PPPs (Morrison, 2016). PPPs among these methods have particularly caught public sector's attention worldwide, especially after the global economic recession (Osei-Kyei & Chan, 2015).

Involving the private sector in procurement of public infrastructure has led to improved levels of project performance (Liu et al., 2015). The ultimate reason for achieving better performance in such schemes is that interests of both public and private parties are aligned in these kinds of ventures. These factors, combined with others, incite the public sector to involve private sector in the delivery of infrastructure projects. Therefore, PPP has surfaced as a favourable and effective method of infrastructure provision particularly when a large investment is required such as road infrastructure projects (Sastoque et al., 2016).

There is plenty of evidence available in favour of PPPs to deliver better performance than traditional procurement systems where public sector is solely responsible for delivering the project (Raisbeck et al., 2010; Xiong et al., 2017). However, the other facet of PPPs suggests that it is not a panacea due to complexity of financial arrangements, investor's expectancy of high returns, more extended contract periods, and risk heavy nature of projects (Blanc-Brude & Makovsek, 2013). Moreover, improper risk allocation and the tendency of the public sector to transfer most of the project risks to the private sector impact project objectives negatively (Ahmadabadi & Heravi, 2019). Therefore, efficient project risk management is crucial for the successful implementation of PPP projects. Previous PPP studies had focused mainly on risk identification and assessment. Risk allocation received some attention but mainly in the area of preferred risk allocation. In the current study, there is particular interest in risk allocation in PPP based on the principle of allocating risk to the best party that is in the position to manage it. Therefore, this study reviews extant literature on risk identification, assessment, and allocation to provide further insights to management theory and practice. The study pursues the following objectives:

1. To undertake a systematic review of related literature on PPPs, including but not limited to the identification of publication trends from 1996 to 2021, leading authors, countries, and institutions in PPP risk management research.

2. To establish through the review findings the primacy of risks identification, assessment and allocation. It is anticipated that the findings will add to the risk management knowledge base and expound on the management of risk on PPP projects.

3.2 Theoretical Background

3.2.1 Primacy of risk identification, assessment, and allocation

The research interest in PPP has grown significantly over the last decade, given the governments' increasing adoption of PPPs (Lima et al., 2021). Researchers have explored areas of financial modelling, economic feasibilities, procurement, risk management, governance, and success criteria within PPPs (Cui et al., 2018). Given the extensive amount of literature available in the domain of PPP, many researchers have conducted systematic literature review (SLR) studies on existing PPP research (Chang, 2013; Le et al., 2019; Osei-Kyei & Chan, 2015; Yu, Chan, et al., 2018; Yuan et al., 2015). Most of these studies have incorporated PPP literature as a whole in their review. For example, Osei-Kyei and Chan (2015) conducted their systematic review of literature on critical success factors for PPP. Very few have paid attention to aspects relating to the operationalization of PPPs. A key aspect of PPP successes is in the way and manner that risks are managed on those projects.

Risk management involves systematical identification, response planning, monitoring, and controlling of project risks (Schieg, 2006). The process starts with establishing the overall strategy and defining the roles and responsibilities of key stakeholders followed by identification of potential project risks. Identifying all the relevant risks is an important step as the subsequent risk management processes are performed on the identified risks. In the next steps, risks are analysed for their relative importance through qualitative, quantitative, or a combination of both. Further analysis can also be carried out on key project risks, which also help in forecasting the costs of managing these risks. This process is followed by risk response planning in which risks are either accepted, transferred, avoided, or reduced through different techniques. A significant aspect of response planning is ensuring that identified risks are appropriately allocated. A common phraseology in response planning is ensuring that the party most appropriate to bear certain risks is allocated such risks (Karim & Alkaf, 2011). Lastly, risks and monitored and controlled to see the behaviour of risks as forecasted in previous steps.

PPP projects are considered risky in nature and risk management is considered an important part of the planning process to deal with these risks (Project Management Institute, 2013). Risk management not only helps reduce the negative effect(s) of certain risks but can also increase the likelihood of positive effects. Due to the extended contract periods of PPP projects, traditional risk management approach, where the focus on risk management is before the start of the project, has proven to be more challenging and expensive (Xiong et al., 2017). Therefore, increasing the effectiveness of risk management is crucial for success of PPP schemes. For this reason, an increasing interest can be observed in the risk management research specifically identification, assessment, and allocation in the recent years (Ameyaw & Chan, 2015b; Hartono et al., 2021; Liu et al., 2018; Osei–Kyei et al., 2021; Savrukov et al., 2020; Zhang, Zhao, et al., 2019). Although previous studies provide a review of PPP research, a more recent study reviewing these key aspects of risks in PPP is lacking.

This article will be helpful for other academics to understand the present state of studies on PPP risk management. In addition, project managers, core PPP project partners, and decision-makers will gain insights to expand their knowledge of PPP risk management. The remainder of the article covers three sections: research methodology used to select and examine the relevant literature for this study, results and discussion, and study conclusion.

3.3 Methodology

A research technique is the foundation of any study since it acts as a plan for guiding the investigation from beginning to conclusion (Akomea-Frimpong et al., 2020). A literature review is an effective approach to acquire insight into a study topic and understanding the current body of knowledge on the subject (Yu, Darko, et al., 2018). Thus, Systematic Literature Review (SLR) is employed to fulfill the current research's objectives, which is supported by many previous researchers in the area of PPPs (Eshun et al., 2020; Ke et al., 2009; Osei-Kyei & Chan, 2015; Sastoque et al., 2016). SLR is a more principled and unbiased approach of choosing relevant prior research for a current study, followed by a comprehensive critical analysis (Wang et al., 2019). This study used the Preferred Reporting Items for Systematic

Reviews and Meta-Analyses (PRISMA) flowchart, as shown in Figure 3.1, to retrieve, select, accept, and assess target papers. Historically, this approach of conducting SLR was most commonly used in medical research (Moher et al., 2009), but over time it has gained popularity among construction management researchers (Le et al., 2019; Lima et al., 2021). In total, 87 papers published in peer-reviewed journals related to PPP risk management have been reported and systematically analysed to achieve these objectives.

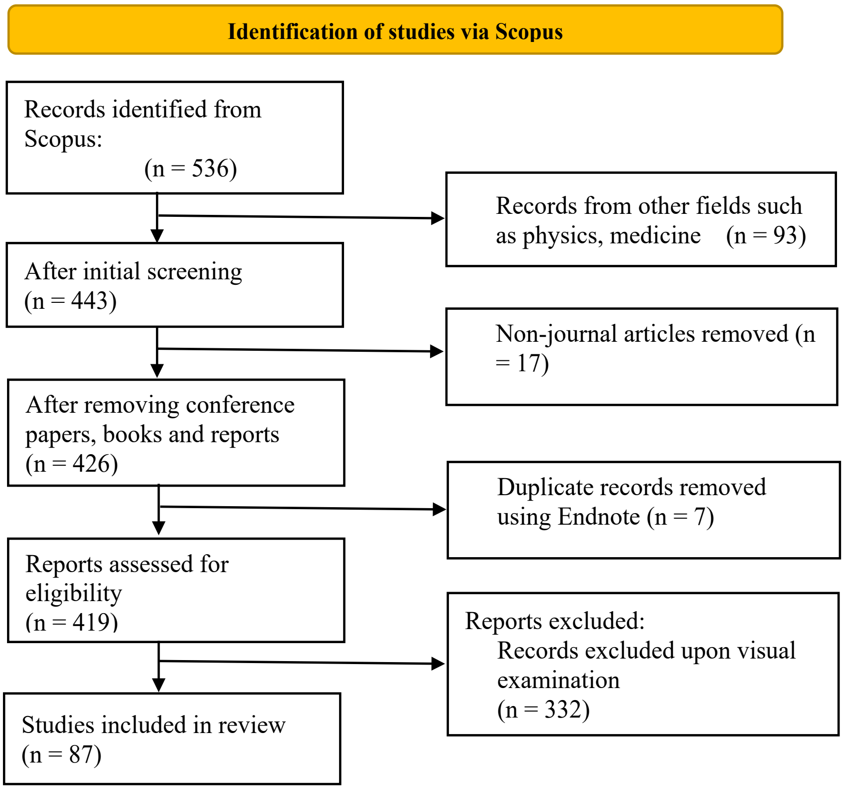

Figure 3.1 Research process

3.3.1 Retrieval of relevant papers

After establishing the clear objectives of this study, the study's next steps were to select a relevant database for obtaining the research articles and finalise the search string to be used to search the database. In the first step of this stage, a comprehensive desktop search related to risk management in the PPP was carried out using Scopus search engine. Scopus was selected for its widespread use by other researchers in this field (Lima et al., 2021; Sastoque et al., 2016) and for other reasons such as its ease of use, comprehensive coverage, effectiveness, and precision of the search results (Yu, Chan, et al., 2018). Moreover, Scopus is more popular among PPP risk management research circle than other search engines like Google Scholar and Web of Science because of its broad coverage and article search accuracy (Akomea-Frimpong et al., 2020).

Keywords for the Scopus search were carefully selected and finalised considering the research objectives and previous literature. Keywords included relevant terms such as critical risk factors, risk identification, risk assessment, risk allocation. This search was limited to subject area by using keywords like public-private partnership and PPP infrastructure. Papers that had these terms in the title, abstract or keywords were deemed to have satisfied the initial criteria for further investigation. Furthermore, the period of publication was limited to 25 years between 1996 and 2021. This search range was chosen to encompass all the relevant studies on this topic with the first one published in 1996. The authors consider the period appropriate since the advent of modern PPPs took place with the start of project finance initiative (PFI) in UK in 1992 (Bing et al., 2005). Search string used in Scopus is given below:

(TITLE-ABS-KEY("critical risk factors" OR "risk factors" OR "critical risks" OR "risk assessment" OR "risk identification" OR "risk allocation" OR "CRFs") AND TITLE-ABS-KEY("public-private partnership" OR "PPP" OR "public infrastructure")) AND DOCTYPE(ar OR re) AND PUBYEAR > 1995 AND PUBYEAR < 2022 AND (LIMIT-TO (SUBJAREA,"BUSI") OR LIMIT-TO (SUBJAREA,"ENGI") OR LIMIT-TO (SUBJAREA,"ENVI") OR LIMIT-TO (SUBJAREA,"DECI") OR LIMIT-TO (SUBJAREA,"ECON") OR LIMIT-TO (SUBJAREA,"ENER")) AND (LIMIT-TO (LANGUAGE,"English"))

The initial search using the above string yielded 536 papers. Some irrelevant papers still appeared in the search from other subject areas such as Medicine, Psychology, Physics, Agriculture, and Neuroscience. A potential reason for this could be that these papers were listed in more than one subject area due to their cross-disciplinary nature. These subject areas were manually removed from the search results as they did not meet the requirements of this study. Search results were further scrutinized by manually defining the source type of relevant papers in the search options to 'journal'. This reduced the number of papers to 426. These search results were then downloaded from Scopus in the form of an Excel spreadsheet which included author names, title of the articles, year of publication, source title/journal, location/affiliation, keywords, and paper abstracts. Further, seven papers were removed from the list due to being duplicates when imported in EndNote software, bringing the number of papers down to 419.

3.3.2 Identifying Relevant Papers

Not all the 419 papers initially selected were relevant to the objectives of this study; many of them were not related to PPP risk identification, assessment, and allocation. This was revealed after careful visual examination of the abstracts of these papers. Some of these papers were not filtered out in the initial screening process due to the terms' "risk", "PPP", and "infrastructure" being very common in some other fields as well. For example, PPP in medical sciences refers to plant protection products. Therefore, a thorough visual examination was carried out, and irrelevant papers were filtered out. A total of 87 papers were deemed valid after this last stage of filtration. The sample size of 87 papers was considered satisfactory for a review study. A previous well-established review study by Osei-Kyei and Chan (2015) considered 27 papers for a review study on critical success factors in PPP. The number of pertinent papers selected from various journals having 2 or more publications is summarized in Table 3.1 along with CiteScores of these journals obtained from Scopus. CiteScore is an important metric used by some researchers in the field to gauge the quality of research.

International Journal of Project Management has the highest CiteScore of 16.4 with 5 articles. Highest number of papers were published by the Journal of Construction Engineering and Management (11 papers), followed by Construction Management and Economics, Journal of Infrastructure Systems and Sustainability (MDPI) having published 7 papers each. The remaining papers were spread across various other journals. 24 out of the 38 journals had only one publication.

Table 3.1 Key journals in PPP risk management research

Source title	Number of papers Relevant	CiteScore
Journal of Construction Engineering and Management	11	6.4
Construction Management and Economics	7	5.6
Journal of Infrastructure Systems	7	4.8
Sustainability (Switzerland)	7	3.9
International Journal of Project Management	5	16.4
Engineering, Construction and Architectural Management	5	4.0
Advances in Civil Engineering	4	1.7
Journal of Cleaner Production	3	13.1
International Journal of Construction Management	3	4.7
Journal of Civil Engineering and Management	3	5.4
Expert Systems with Applications	2	12.7
Journal of Facilities Management	2	3.1
International Journal of Critical Infrastructures	2	0.9
Journal of Engineering, Project, and Production Management	2	N/A

3.3.3 Assessing target papers

For assessing the author scores of target papers, formula proposed by Howard et al. (1987) was used as shown in equation 1. This formula was adopted due to its extensive use by similar studies in the past for its reliability (Akomea-Frimpong et al., 2020; Yi & Chan, 2013).

$$Score = \frac{1.5^{n-i}}{\sum_{i=1}^{n} 1.5^{n-i}} \tag{3.1}$$

where n = total authors in paper;

and i = order of author in paper

The formula gives each author a score for their contribution based on total number of authors and position in the paper. The formula considers the sequence of authors to compute their contribution in paper by assuming that the first author has more contribution than the second and so on. Using this formula, Table 3.2 was developed for multiauthor papers. These scores were then used to calculate and rank different authors for their contribution in the field and establish the country ranking from their affiliation.

Table 3.2 Score matrix for assessing author contribution

No. of authors	**Order of authorship**					
	1	2	3	4	5	6
1	1					
2	0.6	0.4				
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	
6	0.36	0.24	0.16	0.105	0.075	0.05

3.4 Results

The following section presents the result of this study. The section is structured to present results relating to reviewed publications such as annual publication trend, author affiliations, and country of research. A similar approach of presenting similar results has also been observed in many previous review studies (Cui et al., 2018; Ke et al., 2009; Osei-Kyei & Chan, 2015; Tallaki & Bracci, 2021).

3.4.1 Publication analysis of selected papers

3.4.1.1 Annual publication trend

A yearly publication trend presented in Figure 3.2 was constructed during the study period to demonstrate how academics' interest has evolved in risks associated with PPP. No study was published in 1996, and just a handful of studies were carried out in the first half of the study period. Between the periods of 1996 and 2009, only two years saw the publication of more than one study related to the research topic of this study. However, this trend changed quickly after 2010. Almost 75% of the publications included in this literature review were conducted between the second half of the study period. The year 2020 saw the most number of studies conducted in a year reaching 20 papers.

Moreover, an upward trend during these years can be seen, showcasing an increasing research interest in this area. This trend is consistent with the increasing adoption of PPP to procure public infrastructure projects, especially in developing countries where the government balance sheets are strained (Tan & Zhao, 2019). This trend is expected to increase in the upcoming years as governments are ill-placed in their current situation due to the ongoing pandemic to spare budget for constantly increasing infrastructure demand (Jallow et al., 2020; Yoshino et al., 2019).

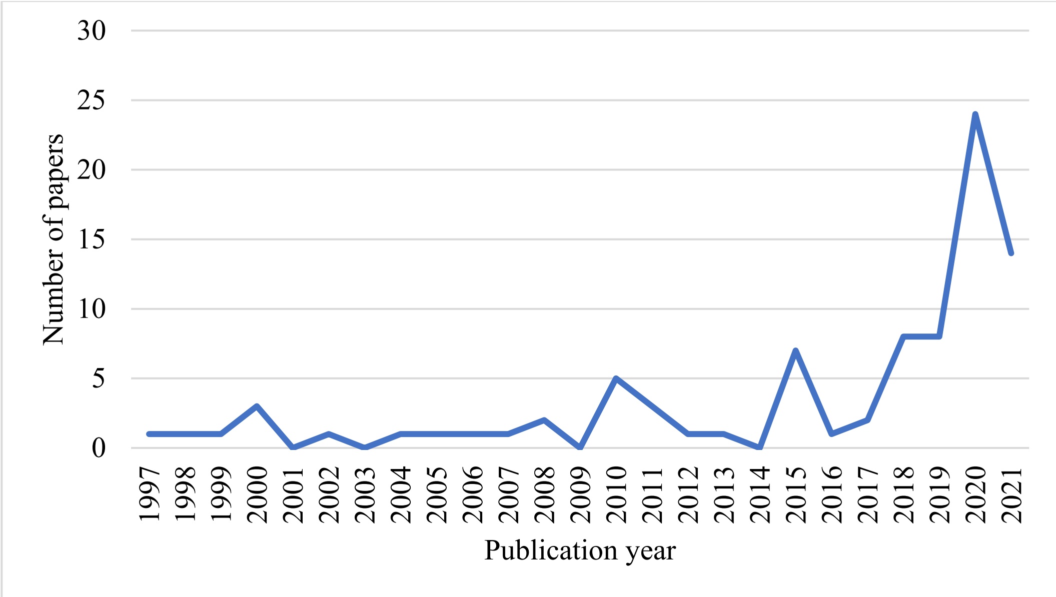

Figure 3.2 Annual publication trend

3.4.1.2 Authors and country of research

To understand the researcher's interest in different countries relative to the study title, the contribution score of each nation was computed based on the scoring matrix in Table 3.2. The ranking of these countries based on the scoring matrix is exhibited in Figure 3.3, which was developed using the Microsoft Excel tool 'Geographical Heat Map'. The nations that contributed to PPP risk management research along with the number of researchers from each nation during the period studied are identified. Research publications arranged by their origin on a certain issue may indicate the degree of industry practices and progress on the topic in specific places, the contributions of various nations to researching the risks in PPP projects must be examined. Therefore, it is of importance to find out the level of research being carried out in certain areas to gather helpful information into the scope of risk management activities on PPP projects in particular locations. The matrix of author scores in Table 3.2 was used to calculate each country's contribution score.

Country	Researchers	Score
China	47	22.61
Hong Kong	12	14.83
Australia	21	7.57
India	11	6.68
UK	13	5.49
Iran	8	4.28
Singapore	5	4.21
USA	7	2.92
Egypt	6	2.82
Italy	5	2.12
Nigeria	6	2
Turkey	3	2
Greece	3	1.68
Taiwan	2	1
Austria	1	1
Indonesia	3	1
Spain	2	1
Pakistan	3	0.73
Colombia	2	0.7
Saudi Arabia	3	0.595
South Africa	2	0.53
Vietnam	1	0.47
Lithuania	1	0.42
Norway	1	0.32
Chile	2	0.3
Ghana	2	0.25
Puerto Rico	1	0.21
Netherlands	1	0.11
Malaysia	1	0.105

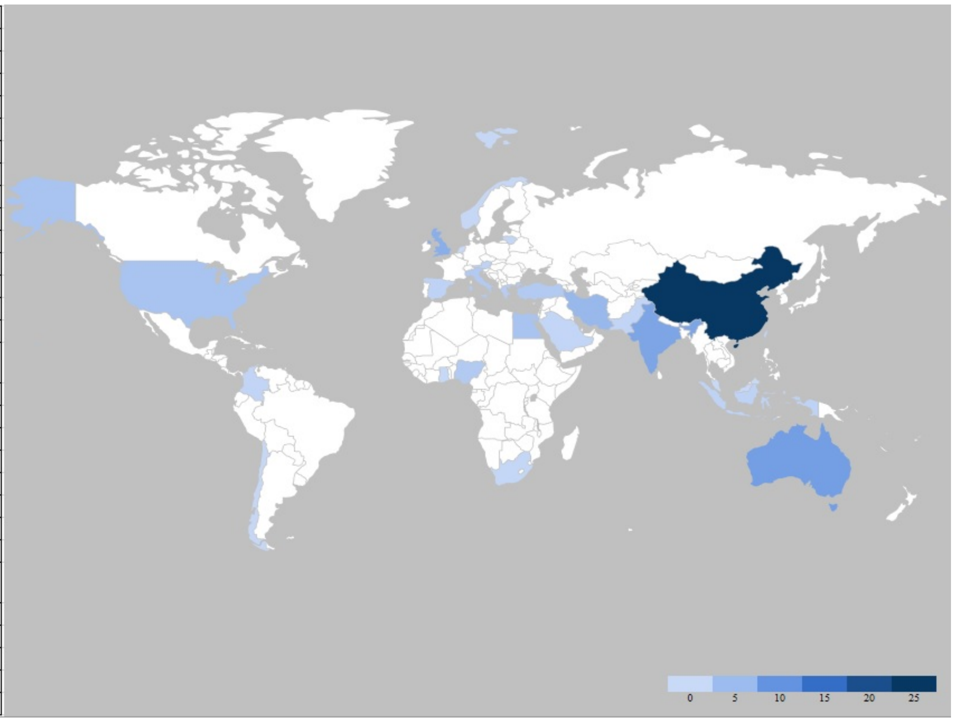

Figure 3.3 PPP researchers map by country

Figure 3.3 demonstrates that the risks in PPP projects have been investigated by both developed and developing nations, indicating that this is an issue of interest worldwide. China, Hong Kong, and Australia are the top three countries, with scores of 22.61, 14.83, and 7.57, respectively. In China, 47 researchers from several institutions published papers discussing risk factors in PPP projects, followed by 21 researchers from Australia and 12 from Hong Kong. (Ke et al.)'s study from 2009 on research trends in PPP research showed that PPP researchers were very active in developed economies such as the UK having 82 researchers from 42 different institutions compared to developing economies. However, result of this study show otherwise, indicating a shift in focus of PPP research from developed to developing nations. Heavy research interest in a developing country such as China can be explained because during the last decade, there has been an increase in PPP method of project delivery in the developing regions. Moreover, the data is consistent with the declining interest in a developed nation such as the UK for the use of PPP by showcasing a decrease in the research trend.

The most renowned and active researchers with multiple publications and securing a score of greater than 1 during the study period are shown in Table 3.3. Some key authors may have not made the list due to the limitations inherent in the formula used above to calculate author contributions. The formula considers the number of researchers and place of each researcher in a publication. Hence, if some key author collaborates with a number of other researchers and is placed later on the author list, they might not get a high score. The top 2 most active researchers scored 6.43 and 4.27 respectively, which happen to be from recent publications and have worked and collaborated on most of these publications are; A.P.C. Chan having 19 and E.E. Ameyaw having 11 publications. For most of these publications, their affiliation is with the Hong Kong Polytechnic University. Recognizing the leading contributors in research may offer other researchers some possible options for collaborations.

Table 3.3 Contribution of authors and ranking

Author	Number of papers	Affiliation	Country	Score
Chan A.P.C.	19	The Hong Kong Polytechnic University	Hong Kong	6.43
Ameyaw E.E.	11	The Hong Kong Polytechnic University, Coventry University	Hong Kong, UK	4.27
Wang S.Q.	9	National University of Singapore, Tsinghua University, Nanyang Technology University	Singapore, China	2.54
Xu Y.	4	Southeast University	China	1.57
Li Y.	4	China University of Mining and Technology	China	1.2
Tiong R.L.K.	4	National University of Singapore, Nanyang Technology University	Singapore	1.12
Ke Y.	4	Tsinghua University, University of Newcastle	China, Australia	1.07

3.4.2 PPP risk management findings

The findings relating to risk management in PPP are presented in this section. Findings on the risk management processes from this study have been presented in two sections.

3.4.2.1 Risk identification and assessment in PPPs

Risk management is a systematic process of identifying and managing risks to reduce losses by carefully examining potential future scenarios. Various professional and organizational standards for risk management can be found in Project Management Institutes' risk management guidelines having received widespread acclaim from industry professionals and researchers alike.

Construction projects are risky in nature, PPPs not only involve construction, but the operation, maintenance, and financing are also embedded into its system. Which, in turn, introduces additional risks. Ibrahim et al. (2006) suggested that all the parties involved in PPPs need to understand these risks to achieve project milestones. Therefore, risk identification and assessment were found to be a common theme in many of the papers studied in this review. The risk assessment process lets project stakeholders decide the areas of project management that need to be focused on to achieve optimal results. Therefore, the need for practical and objective risk assessment approaches has been stressed in existing literature on PPP (Li & Zou, 2011). Moreover, assessing the overall impact of various similar risks lets project managers plan remedial measures more effectively while saving time and cost (Ameyaw & Chan, 2015a).

Risks can be classified during the risk identification and assessment stage based on their inclination towards private or public sector. Mazher (2019) explored this type of categorization in which risks were classified into the country, market, and project level risks. Country level risks include risks related to the macro environment of a country and allocated to public sector. As the name indicates, project-level risks were related to project objectives of cost, time, and design, and allocated to the private sector. Market level risks included interest, inflation, and demand, and hence these are shared between both parties. Further classifications have also been proposed by other researchers based on the project life cycle phases. Akomea-Frimpong & Jin (2009) classified the PPP project risks into groups of pre-construction, construction, operation, maintenance, and market level risks.

Bing et al. (2005) identified the risks present in UK's private finance initiative (PFI) projects using a questionnaire survey. They categorized the risks based on certain aspects of project such as design, delays, cost and performance. Perception of lenders and contractors were sought based on these categories. Results showed that respondents had different perceptions from each other based on their own interests. Similarly, by reviewing PPP literature, Wu et al. (2018) identified 37 risks related to PPPs. They further proceeded to develop categories of these risks. These categories consist of risks related to construction, operation, maintenance, legal, and economic nature. Hwang et al. (2013) also studied 42 significant risks in Singapore's PPP projects by reviewing the literature comprehensively. Their analysis showed that "lack of governmental support" was the most significant risk suggesting inadequacy of government's experience.

Other studies adopted methods such as literature reviews, cause and effect analysis, brainstorming, and expert opinions to develop list of risks. This current study identified 35 key risks from nine most referred studies in this review, presented in Table 3.4. These studies were carefully chosen to extract these risks for their credibility among other researchers. Many of the pre 2015 studies among these are observed to act as a risk identification checklist/base for some of the newer studies in the area. On the other hand, a few studies included in this review identified as many as 50 risks making the process exhaustive and resulting in some of the risks identified to be very similar in nature to some other risks. For this reason, 35 risks were considered satisfactory for this study. Moreover, five risk groups (RG1 = Financial, RG2 = Political, RG3 = Project specific, RG4 = Social, RG5 =Uncontrollable), based on previous studies for each of the identified risk. A detailed account of these categories and definitions of identified risks is given in Appendix C.

Table 3.4 Risks related to PPP from Literature

Risks	Risk group	Risk Owner	Frequency	References
Interest rate changes	RG1	Private/Shared	9	1,2,3,4,5,6,7,8,9
Political interference	RG2	Public	8	1,2,4,5,6,7,8,9
Financial constraints	RG1	Private	8	1,3,4,5,6,7,8,9
Force majeure	RG5	Shared	8	1,2,4,5,6,7,8,9
Expropriation	RG2	Public	7	1,2,4,5,6,7,8
Asset risk	RG1	Shared	7	1,2,4,5,6,7,8,
Public disapproval	RG4	Public	7	1,3,4,6,7,8,9
Communication risk	RG3	Shared	7	1,2,4,5,7,8,9
Construction time overrun	RG3	Private	7	1,2,4,5,6,8,9
Approval issues	RG3	Public	7	1,2,4,5,7,8,9
Weather	RG5	Shared	7	1,2,4,5,6,8,9
Geological settings	RG3	Shared	7	1,2,4,5,6,8,9
Change in taxes	RG1/3	Public	6	1,2,4,5,7,8
Corruption	RG2	Public	6	1,3,4,5,7,8
Environment	RG3	Shared	6	1,4,5,7,8,9
Inflation	RG1	Shared	6	1,3,4,5,7,8
Construction cost overrun	RG3	Private	6	1,5,6,7,8,9
Legal problems	RG3	Private	6	1,2,4,7,8,9
Design flaws	RG3	Private	6	1,3,5,6,8,9
Unstable government	RG2	Public	6	1,3,5,7,8,9

Government support	RG2	Public	5	3,4,7,8,9
Low productivity	RG3	Private	4	1,5,7,8
Technical risk	RG3	Private	4	1,5,7,8
Demand risk	RG1	Shared	4	1,3,4,9
Material risk	RG3	Private	4	1,2,4,9
Testing new practices	RG3	Private	4	1,2,4,9
Lack of PPP experience	RG3	Private	4	1,6,8,9
Contractual changes	RG3	Shared	4	1,7,8,9
Site availability	RG3	Shared	3	1,4,9
Safety and security	RG3	Shared	3	1,3,9
Commitment issues	RG3	Unspecified	3	1,2,9
High finance cost	RG1	Private	2	1,9
Scope Changes	RG3	Shared	1	4
Insufficient authority	RG1/2	Unspecified	1	1
Poor workmanship	RG3	Private	1	1
References: 1 = (Bing et al., 2005); 2 = (Ng & Loosemore, 2007); 3 = (Li & Zou, 2008); 4 = (Yelin Xu et al., 2010); 5 = (Hwang et al., 2013); 6= (Ameyaw & Chan, 2015a); 7= (Chou & Pramudawardhani, 2015) [51]; 8 = (Wu et al., 2018); 9 = (Rybnicek et al., 2020)				

3.4.2.2 Risk allocation in PPPs

Many researchers have argued in favour of PPPs for offering value for money. The basis of this argument is PPP's ability to transfer most of the project risk to private parties who are better equipped and experienced to manage risks (Wibowo & Kochendoerfer, 2010). Failure to transfer and share reasonable amount of risk to private sector also goes against the principals of using PPP (Froud, 2003). Reasonable transfer of risk helps in achieving better performance which leads to overall project success.

However, some of the well-established studies have been tabulated below in Table 3.5 to showcase their focus of research. The term preferred risk allocation reflects the practice of allocating risks based on majority opinion to the party best able to manage it (Rafaat et al., 2020). These studies reinforce the importance of proper risk identification as that paves the way for a good risk allocation strategy.

Table 3.5 Main ideas in risk management research

Focus of Research	Main Ideas	Authors
Allocation	Developed risk categories for UK PFI project, conducted questionnaire survey to find out preferred allocation of risks	(Bing et al., 2005)
Identification and allocation	identified and studied risk allocation criteria and actual risk allocation in Sydney railway project	(Ng & Loosemore, 2007)
Identification, assessment, and allocation	Identified risk from literature, risk assessment and allocation achieved by survey in Chinese PPP projects	[56]
Identification, assessment, and allocation	Identified risks from literature review, Ranking and assessment generate by mean value analysis of survey responses, preferred risk allocation by respondent's views in Singapore	(Hwang et al., 2013)
Identification and assessment	Risk factors identified for PPP water projects, shortlisted significant risks by survey from Ghana, quantitative analysis of significant risks using fuzzy approach	(Ameyaw & Chan, 2015a)
Identification, comparison, and allocation	Identified, compared and categorized risk from literature, preferred risk allocation using mean value analysis of survey responses	(Chou & Pramudawardhani, 2015)
Identification and assessment	Risk identification from literature, risk assessment using probability impact values	(Wu et al., 2018)

Different modelling techniques have been employed by researchers to model the allocation of risks in PPP projects as of late instead of previously used method of preferred risk allocation where expert opinions were mainly used to determine which party is responsible for managing the risk (Ke et al., 2010). These include but are not limited to Analytical Hierarchy Process (AHP) (Khazaeni et al., 2012; Li & Zou, 2011), Fuzzy Set Theory (FST) (Mazher et al., 2018; Valipour et al., 2016), System Dynamics (SD) (Li et al., 2010), and Game Theory (Li et al., 2017; Wang et al., 2007). Ameyaw and Chan (2016) in their study about risk allocation argue in favour of such risk allocation decision making models as they take into account risk management capability of parties involved as opposed to preferred method of allocating risks which is based on decision maker's perception of the risks (Hwang et al., 2013).

3.5 Discussion

Table 4 presented most commonly identified risks in PPP risk management literature. Among these, risks of interest rate changes, inflation rate, and change in taxes have received considerable attention from researchers (Osei–Kyei et al., 2021; Rybnicek et al., 2020; Zhang, Sun, et al., 2019). These risks are related to macroeconomic environment of a country. Such risks are of special importance in the developing economies where PPPs are becoming increasingly popular (Osei-Kyei & Chan, 2017), developed countries however may not be affected by these adversely, as they have stable economy (OECD, 2019). Moreover, due to the long-term nature of PPPs, such kind of financial risks need to be managed in great detail as even very small changes in the probability of occurrence can pose major impacts on the project deliverables (Ameyaw et al., 2015a). An example of this would be higher cost of debt-servicing for project financing.

Another risk that has received considerable attention from researchers in the reviewed articles, especially in developing countries, is political interference (Ke et al., 2011; Yelin Xu et al., 2010). Political influence such as making design changes in the construction stage, changing subcontractors due to political motives, and renegotiating contracts by the newly elected government have been identified as factors leading to delays in the project and incurring additional money to the public balance sheet (Sachs et al., 2007). In most of the reviewed studies that have developed risk ranking, political interference is ranked in the top five risks (Ameyaw & Chan, 2015; Ke et al., 2011; Yu, Darko, et al., 2018; Zhang, Sun, et al., 2019). Some of the studies report this risk to be one of the reasons for failure of projects as well (Reside & Mendoza, 2010). Lack of professionals consulted during the planning stage, unnecessary pressure on private consortia to adjust user charges, and poor allocation of some key risks have been cited as reasons for increased public sector interference (Cheung et al., 2012). Another reason for this risk to have been given significant importance by researcher could be that it is also linked to other political risks such as expropriation, corruption, political opposition, and government instability.

Methods used to assess the risk involved in PPP projects are either qualitative or quantitative. Research indicates that the selection of the method depends on some factors such as; information available about risks, risk management capabilities of parties involved, and maturity of the PPP market (Mazher, 2019). A previous review by Zhang et al. (2016) shows that PPPs in developed countries prefer to use quantitative risk approaches, and qualitative risk assessment practices prevail in developing nations. However, the findings of this study indicate that this is not the case anymore. With the progression of PPP model with time, newer and more complex approaches to assess the risks of PPPs have been proposed by various researchers. Some of the qualitative methods employed in practice are expert judgement, risk urgency analysis, and risk categorization (Y. Xu et al., 2010). These methods have an element of subjectivity in them as they rely on individual opinions in assessing the risks (Zhang et al., 2021). Quantitative analyses which are less common in practice but more emphasized by researchers include but are not limited to sensitivity analysis, Monte Carlo simulation, risk probability and impact matrix, meta-network approach, and fuzzy logic (Zhang et al., 2021; Zhang et al., 2016).

Apart from risk identification and assessment, risk allocation in PPP has also received considerable attention from researchers in this area. The risk allocation process seeks to establish appropriate risk transfer and risk sharing practices between public and private sector parties. This study identified three main themes for discussion of risk allocation in PPP, which are presented in the following subsections.

3.5.1 Actual and preferred risk allocation in PPP

Appropriate risk transfer and sharing have been identified as key success factors by a handful of studies conducted in PPP research (Yang et al., 2017). Risks are allocated to parties based on their ability to identify, plan, and control them. That is why it is not feasible to transfer or allocate all the project risks to the private sector. However, assessing a prospective risk, owner's ability to manage a certain risk is subjective in nature, involving a high level of complexity. Which in turn, makes the whole process of risk allocation vague and results in misallocation of risks. Alonso-Conde et al. (2007) proposed that incentives offered by the public sector help counter this complexity and help achieve value for money.

To study the allocation of risks, many researchers have performed studied which compare the actual allocation of risks on PPP projects with the preferred allocation driven from expert opinion mostly through a questionnaire survey. Participants are provided with a number of risks and asked to allocate the risk to a certain party or choose a combination of sharing mechanism in which both parties share the risk equally or one party is given more share than the other. Ke et al. (2013) studied the preferred risk allocation in Chinese PPP projects and found that most of the risks were shared among public and private sector. They studied allocation of 37 risk, and only one of the risks was allocated solely to one party with the rest being shared. Results of such studies show that there is a considerable difference between the actual and preferred allocation of risks on PPP projects which have led to inefficiencies in risk allocation on PPP projects.

3.5.2 Misallocation of risks in PPP

Although the principle for allocating risk to the party best equipped to manage it is appropriate to say the least, implementing it in practice is very tricky. This argument is supplemented by various literature citing sub-optimal allocation of risks in practice (Ameyaw & Chan, 2016; Mazher, 2019). Some researchers have called this principle effective but also argue that it is vague in its nature (Mazher, 2019). Ng and Loosemore (2007) argue that determining the ability of a party to manage risk is not simple and depend on some external factors. These include bargaining power of the other party, requirement of various other stakeholders, and the complex capital structure associated with such projects.

Given the importance of risk transfer and risk sharing among public and private sectors in PPP projects, a few researchers have studied ineffective risk allocation and misallocation of risks in PPP projects. Ke et al. (2013) compared and evaluated the risk misallocation impact on project performance in Chinese PPP projects based on the preferred and actual allocation of risks. Their results showed that project performance decreases with higher misallocation of risks. Further investigation revealed that risks of corruption, government intervention, land acquisition, and approvals were the most significant risks which affected project performance. Similarly, Shrestha et al. (2018) conducted a similar study where they used questionnaire survey to determine the inefficiency in risk allocation by asking respondents the actual and preferred risk allocation in Chinese PPP water supply projects. Their findings revealed that the risks which were solely borne by private were inefficiently allocated. Furthermore, external risks such as political, social, environmental, and demand risk depicted inefficient allocation, which again are borne mostly by the private sector.

3.5.3 Capability based risk Allocation

To counter misallocation of risks, many researchers have come up with optimal risk allocation practices which assess each party's ability/capability to manage the identified risks (Ameyaw & Chan, 2016). Generally referred to as RAC, these practices guide 'what, which, and how' of risk allocation i.e., what risks to allocate, to which party, and how to go about it. These criteria adopted from reviewed literature for their widespread use in PPP research have been tabulated in Table 3.6. RAC assess the ability of risk-taking party to manage such risks effectively.

Due to unique characteristics of PPP, the focus of research is normally in the context of a specific country or sector. That is why it is difficult to generalize the allocation of these to a certain stakeholder involved in the project. There is a consensus among the researchers of articles reviewed that risk allocation achieved through their studies are in context of the country involved in the study and the type of PPP project. This argument is supplemented by some other studies in the field of PPP research, which have identified appropriate risk allocation as a critical success factor in different countries (Adetola et al., 2011; Osei-Kyei & Chan, 2015; Rasheed et al., 2019). Different models of PPP such as Build-Operate-Transfer (BOT), Build-Own-Operate-Transfer (BOOT) and DBFMO may have different risk allocation in the same country depending on the type of infrastructure project. For this reason, further analysis of allocation of risks identified in this review has not been undertaken but could be useful in future research.

Table 3.6 Risk allocation criteria identified from literature

RAC	Description of the criteria	Other examples in literature
Risk foresight	Ability of the party to identify and assess risk by predicting the probability of occurrence and the impact if that risk occurs.	(Ameyaw & Chan, 2016; Lam et al., 2007; Loosemore & McCarthy, 2008; Mazher, 2019; Thomas et al., 2003)
Response to risk	Ability of the party to minimise the probability and impact of risk before it takes place.	(Ameyaw & Chan, 2016; Lam et al., 2007; Loosemore & McCarthy, 2008; Mazher, 2019; Thomas et al., 2003)
Minimise risk loss	Ability of the party to minimise the loss/reduce the impact of the risk in case it occurs.	(Ameyaw & Chan, 2016; Lam et al., 2007; Loosemore & McCarthy, 2008; Mazher, 2019)
Absorb risk impact	The ability of the party to sustain the impact of the risk based on their experience.	(Ameyaw & Chan, 2016; Irwin, 2007; Lam et al., 2007; Mazher, 2019; Thomas et al., 2003)
Low risk cost	The ability of the party to manage risk in the least possible cost.	(Ameyaw & Chan, 2016; Irwin, 2007; Mazher, 2019)
Obtain risk premium	The ability to receive compensation of a loss borne as a result of risk occurrence.	(Ameyaw & Chan, 2016; Lam et al., 2007; Mazher, 2019)
Exploit risk	To take advantage of certain risks due to an organization's capability and experience of dealing with that risk exceptionally well.	(Ameyaw & Chan, 2016; Lam et al., 2007; Loosemore & McCarthy, 2008; Mazher, 2019)
Risk attitude	The attitude of a party towards risk management i.e. risk averse/seeker/neutral/transfer.	(Ameyaw & Chan, 2016; Chung et al., 2010; Mazher, 2019)

PPP arrangements involve multiple stakeholders, long contract periods and complex financial undertakings. All these factors result in additional risks which if not handled appropriately may result in failure of these schemes. Hence, uniqueness and complexity of PPP projects demand comprehensive risk management. Based on the findings of this study and literature reviewed, a conceptual RAC based risk management process is presented in Figure 3.4 which aims to achieve effective risk management by improving risk allocation. This coupled with other success factors increase the chances of project success.

Risk identification and assessment methods are well documented in literature. Document analysis/literature review and checklist are the preferred tools for risk identification. Risk categorization can help group large items of risks into smaller more manageable risk groups. Identified risks can be better assessed for their criticality based on their chance of occurrence and severity using probability impact matrix. These steps can therefore help in improving risk identification which further compliments other stages (allocation and response planning) of PPP risk management. Traditional practice of risk allocation is by negotiation between the public and private sector participants. Risk specialists from private and public sector negotiate an agreement for the allocation of risks. There is no neglecting the importance of negotiation in PPPs. However, it is not necessarily always considered the best tool for risk allocation practice. As, depending on the stage of the project, one or the other party has more control over the project. For example, at procurement stage the public sector has more authority than the private parties, hence, greater bargaining power. This has been exploited in the past to allocate more risks to the private sector, often more than its capacity. The allocation process proposed in this study allocates certain risks based on the risk management capability of a party which is assessed in light of identified RAC from the literature reviewed in this study (Ameyaw & Chan, 2016; Irwin, 2007; Loosemore & McCarthy, 2008; Mazher, 2019; Thomas et al., 2003). This is also embedded in the rule of risk sharing in PPP which states that risk should be allocated to the party best able to manage it. A better risk allocation can be achieved when each party’s risk management capabilities are taken into account, which will ultimately help in achieving efficient risk allocation.

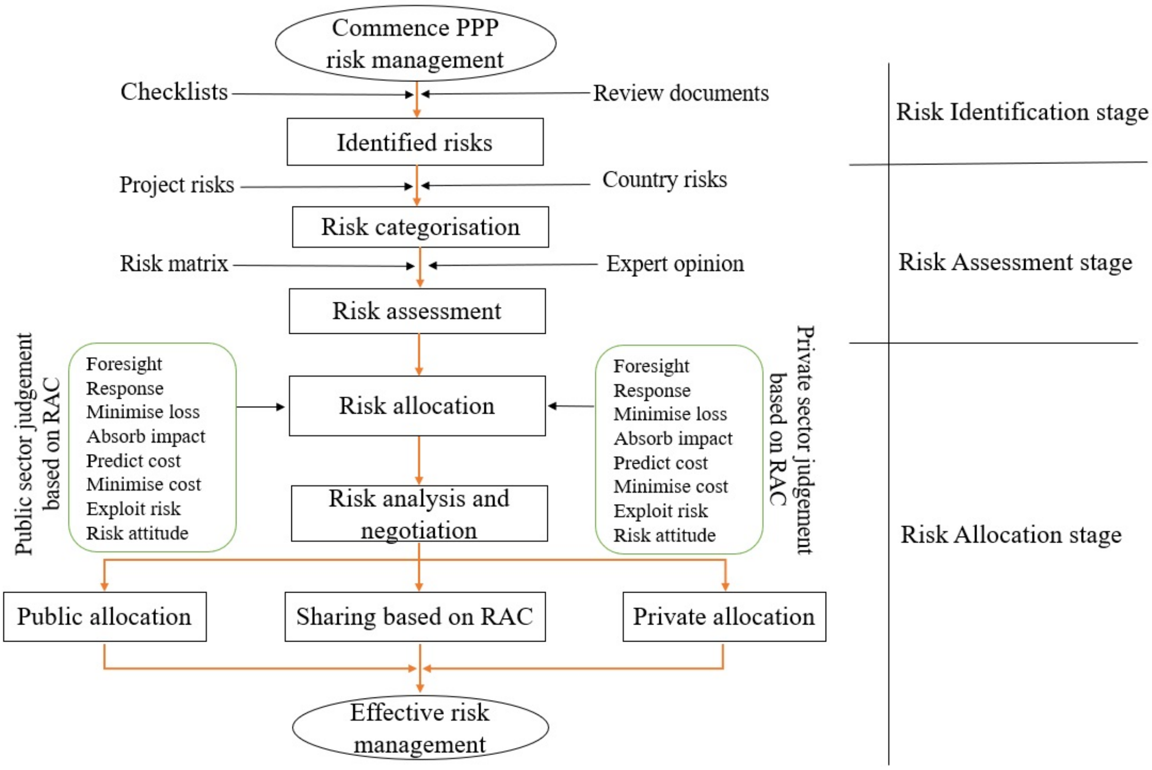

Figure 3.4 RAC based risk management process

3.6 Conclusion

PPPs have seen a resurgence in the last decade in implementation as well as have grown more popular among researchers. Such projects have longer than usual lifecycles and are inherently complex because many stakeholders involved are considered riskier than traditional methods of procurement. Moreover, risk-sharing being the primary incentive to adopt such technique of project delivery demand a more advanced understanding of the risks involved. This study performed a SLR using PRISMA flowchart to examine the current literature relevant to risk identification, assessment, and allocation in PPP projects internationally from 1996 till date. Following a structured approach 87 relevant papers were identified and studied. Initial findings revealed that Journal of Construction Engineering and Management is leading journal having published approximately 12% of the total papers in this area. The yearly trend of the publications showed that research interest has grown exponentially from just 1 publication in 1996 to 24 publications in 2021. The most recognised researcher in the area and university are

Chan A.P.C. and The Hong Kong Polytechnic University. China had the greatest number of researchers working in the risk management area of PPPs. Based on these findings it can be argued that previously stated research trend in literature of PPPs being more popular in developed countries than developing nations is reversing. Developing nations such as China, India, and Iran have seen massive growth in PPP projects and research interest in the last decade. Conversely, PPPs have become less popular in developed countries due to negative sentiments in public for not achieving value for money as claimed. Consequently, a shift from more established PPP models such as BOT towards relatively newer design, build, finance, maintain, and operate (DBFMO) models is observed, which offers the public sector to better control the financing to achieve transparency for public approval.

Risk identification, assessment, and allocation are the major areas studied in this review article. Interest rate changes, political interference, financial constraints, and force majeure are some of the most common risks identified in the reviewed literature. Although most studies have identified these risks, that does not mean they are the most critical. Different researchers have argued differently on the criticality of these risks. Further factors such as location, type, and mode of PPP employed need to be considered to determine critical risks. As the research trend has increased, the methods used for assessment of risk have become more objective with a focus on quantitative modelling. However, findings from the reviewed articles show that there is still a significant gap present in the practical implementation of such assessment techniques. Professional still rely on qualitative approaches that are more subjective. Risk allocation in PPP projects has also received considerable attention from the research community. Researchers have used various approaches to allocate the risk between the public and private sectors. The two most common approaches identified are preferred risk allocation and capability-based risk allocation. Again, a shift from one to the other can be seen as the literature has developed over the years. Capability-based risk allocation, which is more objective than preferred risk allocation, has gained popularity over the past decade.

This study has its limitations. The aim of the paper was to provide a general overview of the state of risk identification, assessment, and allocation research on PPPs. A more thorough understanding can be developed by separately reviewing aforementioned stages of risk management. Moreover, most of the reviewed research took a holistic approach to understand project risks, be it identification, assessment or allocation. Very few articles have approached an understanding of the most critical project risks individually. Future research can fill this gap by studying individual risk and their relation to other project risks. Further limitations of this research relate to the highly uneven distribution of publication over the study period. Since the last 5 years have seen more research undertaken in this area compared to the previous 20 years. By limiting the time span for future studies, a better judgment can be drawn for the current state of research. As mentioned previously, relatively newer financing arrangements in developed nations have come into practice to offer more transparency and achieve better value for money, such as the DBFMO mode of PPP employed by Infrastructure Commission New Zealand. This offers new opportunities for further research.

4 Factor analysis of risk allocation criteria (RAC) in public-private partnership (PPP) projects: A case of New Zealand

This chapter was developed from Publication 2, which has been accepted for publication in Construction Economics and Buildings.

Abstract

The utilization of PPPs has become widely prevalent as an innovative approach for procuring public infrastructure projects. Risk transfer/allocation is one of the main reasons for this widespread adoption and considered a critical success factor for a PPP. Given the importance of equitable risk allocation, this study identified and analysed 10 key RAC using factor analysis. Experts with experience in PPP projects in New Zealand were surveyed through an empirical questionnaire to obtain industry-wide data. Mean score analysis and factor analysis were then used to analyse the collected data. In order to ensure the validity of the analysis results, appropriate statistical tests such as Cronbach's Alpha, Kaiser-Meyer-Olkin (KMO) statistic and Bartlett's test of Sphericity were conducted. Result indicate that the most important criteria for risk allocation are "risk foresight", "minimise risk loss" and "response to risk". Furthermore, factor analysis showed that the identified RAC can be classified into three component groups namely "risk management expertise", "core risk management capability" and "risk management strategy". This study aims to provide PPP stakeholders with useful insights into the most effective measures for achieving equitable risk allocation. To achieve this, the study recommends to consider the risk management capabilities of both the public and private sectors in light of the identified RACs/groupings. The results of the study are expected to assist PPP stakeholders in developing strategies that can enhance risk management and achieve a fair distribution of risks.

4.1 Introduction

A country's economic growth is highly dependent on its infrastructure. Governments all over the world continue to struggle in the provision of infrastructure in face of rising urban populations (Kaluarachchi, 2022; OECD, 2012). Infrastructure provision requires huge sums of money as well as innovative ways of construction management. Public sector is often criticized for struggling to adopt innovation and achieve value for money (Ammons, 2019). For these reasons, private sector involvement in infrastructure projects has become normal over recent decades. One of the innovative ways private sector is involved in the provision of public infrastructure projects is public-private partnership (PPP/P3) (Bayliss & Van Waeyenberge, 2018; Rasheed et al., 2022).

There are many evidences that PPPs work better than conventional procurement, which depend predominantly on government entities to carry out the project (Raisbeck et al., 2010; Wang & Zhao, 2018). The other aspect of public-private partnerships, however, raises the possibility that they are not a panacea because of the intricate nature of financial structure, the expectation of high returns on investment, the lengthier contract terms, and the inherently risky projects procured through this delivery method (Carbonara et al., 2015; Rybnicek et al., 2020). Moreover, inadequate risk management and inefficient risk transfer among the public and private sectors negatively impact project objectives (Jin & Zhang, 2011; Shrestha et al., 2017). As a result, effective project risk management is essential for PPP project implementation success.

Researchers have examined the issue of risk transfer and sharing in PPP projects and have found that there is often inefficient risk allocation. Many studies have compared the actual risk proportions in PPP projects with allocations based on subject matter expert judgements, often using surveys. These studies have shown a significant mismatch between preferred and actual risk distribution, resulting in inefficiencies in risk allocation. For example, in Chinese PPP water supply projects, the private sector was found to bear risks in an inefficient manner (Shrestha et al., 2018). More recently, some scholars have proposed best practices that evaluate each party's capacity to manage identified risks and aim to prevent risk misallocation. These approaches often rely on principle of risk allocation in PPP i.e., “risks should be allocated to a party who is best able to manage it” (Ke et al., 2008).

While the concept of allocating risks to the party most capable of managing it is logical, implementing this principle can be challenging due to the subjective nature of assessing risk management capability. For this reason, researchers utilized criteria which can reflect risk management capability of participating parties. These criteria are termed as RAC. Previous PPP studies had a strong emphasis on identifying and evaluating risks. Moreover, some attention has been given to the area of risk allocation in PPP. However, focus of risk allocation research in PPP has mainly been on preferred risk allocation where risk allocation preferences of experts are sought; and its comparison with actual allocation of risk. Given that risk allocation principle necessitates considering the risk management abilities of all parties involved, it is crucial to conduct research focused on risk management capability-based risk allocation. There is a considerable gap in the field of risk allocation derived from risk management competence of public or private sector particularly in social infrastructure projects. Therefore, this paper aims to fill this gap in light of the identified RAC from literature (as listed in Table 1). This study sought to explore key components that could guide RAC based risk management in PPP projects. The insights gained could assist practitioners in both the public and private sectors in assessing their risk management capabilities for partnership projects. Empirical data through questionnaire from PPP projects in New Zealand was collected and analysed using factor analysis to develop factor groups of RAC for simplicity. The findings of this study are anticipated to support PPP stakeholders in formulating strategies that enhance risk management and promote an equitable allocation of risks.

4.2 Literature Review

4.2.1 An overview of risk management in PPP

Governments' increasing adoption of PPPs has spurred significant academic interest over the past decade (Lima et al., 2021). Researchers have focused on financing, economic viability, legal issues, risk management, regulations, and success factors relating to PPPs (Zhang et al., 2016; Cui et al., 2018). Risk management involves identifying, planning responses to, monitoring, and controlling project hazards (Schieg, 2006). The process starts with establishing strategy and stakeholder duties, followed by risk assessment, which must be preceded by thorough risk identification. Risks are evaluated based on their likelihood and impact using qualitative, quantitative, or mixed methods. Costs of managing key project risks are assessed, followed by planning for risk responses such as acceptance, transfer, avoidance, or reduction. Proper risk distribution is essential, with specific risks assigned to the most capable parties (Karim & Alkaf, 2011). Continuous monitoring and re-evaluation of risks are also necessary.

PPPs are inherently risky, making risk management crucial (PMI, 2013). Effective risk management not only reduces negative impacts but also enhances positive outcomes. Traditional risk management, focused before project commencement, is challenging and costly for long-term PPP projects (Xiong et al., 2017). Thus, improving risk management's efficacy is vital, leading to increased research on risk identification, evaluation, and allocation (Ameyaw & Chan, 2015b; Liu et al., 2018; Osei–Kyei et al., 2021; Savrukov et al., 2020; Zhang, Zhao, et al., 2019). Besides construction, PPPs face risks in funding, operation, and maintenance. Stakeholders should be well-informed about these risks to achieve project milestones (Ibrahim et al., 2006). Realistic and objective risk assessment methodologies are essential (Li & Zou, 2011), helping project managers plan corrective actions efficiently (Ameyaw & Chan, 2015a).

Risks can be classified by their impact on public or private sectors, divided into national, regional, and project levels (Mazher, 2019). Akomea-Frimpong et al. (2020) categorized PPP project risks into pre-construction, construction, operation, maintenance, and market level. Bing et al. (2005) highlighted UK PFI project risks, categorized by design, delays, costs, and performance. Wu et al. (2018) identified 37 risks in PPPs, categorized into construction, operating, maintenance, legal, and economic risks.

Risk management's importance in PPPs is evident from extensive research on risk identification, assessment, and measures. However, risk transfer and allocation has received less focus. Recent efforts aim to address this gap. PPPs are cost-effective by transferring most risks to private partners better equipped to handle them (Wibowo & Kochendoerfer, 2010). Fair risk transfer enhances performance and project success. Risks should be allocated to parties capable of managing them, but this is complex and prone to subjective judgment, leading to misallocation (Alonso-Conde et al., 2007).

Expert opinions have been used to determine preferred risk allocation in previous studies (Ke et al., 2010; Rafaat et al., 2020). In China’s PPP projects, most risks were shared between public and private sectors, revealing inconsistencies between preferred and actual risk distribution (Ke, Wang, and Chan, 2010). Implementing risk allocation in real projects is challenging, supported by literature documenting inadequate risk distribution (Ameyaw & Chan, 2016; Mazher et al., 2019). Evaluating a party's ability to handle risk depends on external factors, including bargaining power, stakeholder concerns, and financial arrangements (Ng & Loosemore, 2007).

Inefficient risk allocation has been examined in PPP projects. Ke et al. (2013) found that risk misallocation leads to poor project performance in Chinese PPP projects, particularly regarding government action, land acquisition, and approvals. Shrestha et al. (2018) found inefficiencies in risk allocation in Chinese PPP water supply projects, with external risks largely absorbed by the private sector despite limited capacity to manage them. Scholars have developed best practices to evaluate each party's capacity to manage identified risks, typically based on RAC (Ameyaw & Chan, 2016).

4.2.2 Risk Allocation Criteria

RAC are used to determine the "what, which, and how" of risk allocation, or what risks to assign to which parties and how to accomplish allocation. For their broad application in PPP research, these standards taken from the contemporary literature have been included in Table 4.1. RAC evaluates a party's capacity to successfully manage such risks. Risk allocation has traditionally been done through negotiations between players in the public and private sectors. Risk specialists from the public and commercial sectors form a risk allocation agreement. The value of negotiating in PPPs cannot be understated. It isn't generally thought of as the ideal instrument for risk allocation practise, though. As one side may have more influence over the project than the other depending on its stage. For instance, the public sector has more power than the private parties during the procurement stage, which gives it more negotiating leverage. In the past, there have been instances where the private sector has been burdened with risks beyond its capacity, indicating a misuse of this approach (Loosemore & McCarthy, 2008; Xu et al., 2011). Hence, to better reflect the PPP's risk-sharing principle, which specifies that responsibility for managing the risk should be placed with the party most qualified to do so, the ability of each party to handle risk may be taken into consideration to improve risk allocation, which will ultimately lead to effective risk allocation.

Table 4.1 Risk allocation criteria identified from literature

(Adopted with permission from: (Rasheed et al., 2022))

RAC	Description of the criteria	Other examples in literature
Risk foresight	Ability of the party to identify and assess risk by predicting the probability of occurrence and the impact if that risk occurs.	(Ameyaw & Chan, 2016; Lam et al., 2007; Loosemore & McCarthy, 2008; Mazher, 2019; Thomas et al., 2003)
Response to risk	Ability of the party to minimise the probability and impact of risk before it takes place.	(Ameyaw & Chan, 2016; Lam et al., 2007; Loosemore & McCarthy, 2008; Mazher, 2019; Thomas et al., 2003)
Minimise risk loss	Ability of the party to minimise the loss/reduce the impact of the risk in case it occurs.	(Ameyaw & Chan, 2016; Lam et al., 2007; Loosemore & McCarthy, 2008; Mazher, 2019)
Absorb risk impact	The ability of the party to sustain the impact of the risk based on their experience.	(Ameyaw & Chan, 2016; Irwin, 2007; Lam et al., 2007; Mazher, 2019; Thomas et al., 2003)
Low risk cost	The ability of the party to manage risk in the least possible cost.	(Ameyaw & Chan, 2016; Irwin, 2007; Mazher, 2019)
Obtain risk premium	The ability to receive compensation of a loss borne as a result of risk occurrence.	(Ameyaw & Chan, 2016; Mazher, 2019),(Lam et al., 2007)
Exploit risk	To take advantage of certain risks due to an organization's capability and experience of dealing with that risk exceptionally well.	(Ameyaw & Chan, 2016; Lam et al., 2007; Loosemore & McCarthy, 2008; Mazher, 2019)
Risk attitude	The attitude of a party towards risk management i.e. risk averse/seeker/neutral/transfer.	(Ameyaw & Chan, 2016; Chung et al., 2010; Mazher, 2019)
Bargaining power/ negotiation tactics	The relative strength or influence of party in negotiating and executing the terms of the partnership agreement.	(Arndt & Maguire, 1999; Thomas et al., 2003; Y. Xu et al., 2010)
Experience	The level of knowledge, skills, technical/financial capacity and track record of party in executing and managing PPP projects.	(Jin & Doloi, 2008; Y. Xu et al., 2010; Zhu et al., 2007)

4.3 Research Methodology

Any study needs a research technique since it serves as a map for directing the enquiry from start to finish (Akomea-Frimpong et al., 2020). This study utilizes deductive reasoning approach using quantitative data collected through a questionnaire survey and collected data was analysed through statistical means. An extensive literature review was used to identify and develop a list of 10 RAC. These criteria are shown in Table 4.1 together with the corresponding definitions. However, a pilot research was carried out among four experts (two industry professionals and two academics) to determine the applicability and usefulness of the resulting RAC. The relevance and usefulness of the set of criteria were validated and reinforced by the experts, with just a few minor phrasing changes proposed and suggestion of removing one criterion for lack of clarity and redundancy. A questionnaire for the study was created using the finalized set of criteria using an online data gathering tool Qualtrics. Questionnaire survey was adopted for its widespread use in the area of construction management research (Wahid et al., 2023). Questionnaire was divided into two parts. First part corresponded to the respondent's profile which was designed to assess whether they possessed appropriate experience and knowledge of PPP projects. Questions were asked about respondent's experience in PPP project, type of project they worked on, their sector of association and position in their organization. These questions were important as they established credibility of the collected data, given the scarcity of PPP projects in New Zealand. Second part of the questionnaire was designed to understand the importance of the identified RAC and perceived risk management capability of the respondent's organization for each RAC. A five-point Likert (1 = least important and 5 = most important) scale was adopted to assess the importance of RAC and ability of respondent's organization to deal with risks in terms of identified RAC. A no idea (NI) option was also provided to respondents in case they felt they were not experienced enough to answer any of the questions.

After refining the questionnaire with the help of pilot study, the primary data for this study was gathered through an industry wide survey in New Zealand. All decision-makers and professionals from public and private sector who have been involved in PPP initiatives in New Zealand were the survey's target audience. A combination of two non-probability sampling techniques, convenience and judgement, was used to approach respondents as opposed to random sampling as the exact population wasn’t available. An ongoing PPP initiative was approached for initial group of responders. Given their degree of PPP scene experience, it was anticipated that they would know other possible responders as well, therefore they were asked to share the survey form link with their network as well. However, this approach wasn’t fruitful and did not achieve the desired number of responses. Therefore, additional steps were taken to increase the survey responses. In doing so, all the relevant PPP projects in New Zealand were identified to obtain of list major stakeholders. These stakeholders were then contacted through academic connections to participate in the survey. Additionally, professionals from PPP organizations who worked on these projects were contacted individually through email and LinkedIn connections to distribute the survey. This resulted in obtaining an elite sample size of professionals from New Zealand’s PPP projects as the exact size of population could not be determined.

The collected data from questionnaire survey was subjected to various statistical analysis techniques such as mean score analysis, reliability analysis and exploratory factor analysis using latest versions of Microsoft Excel and Statistical Package for Social Sciences (SPSS). Mean score ranking was used to establish the importance of RAC along with standard deviation of each RAC. Factor analysis was performed in SPSS using principle component analysis with varimax rotation to obtain factor loadings of the 9 RAC. Suitability of these two analysis techniques was also considered through various tests and given their widespread use in other PPP studies involving factors, such as Critical Success Factors (Babatunde et al., 2016), Risk

Factors (Mazher et al., 2018), Critical Success Criteria (Osei-Kyei & Chan, 2021). The basic premise of factor analysis is that measurable variables can be reduced to a smaller set of latent variables that share common variance, a process known as dimensionality reduction (Yong & Pearce, 2013).

4.4 Results and discussion

A total of fifty-one responses were deemed valid, and based on the comparison with other similar studies that utilized questionnaire surveys, the sample size was deemed adequate for further analysis, (Osei-Kyei & Chan, 2021) collected 48 responses, Ameyaw and Chan (2015) obtained 35 responses and Jin et al. (2012) obtained 44 responses in their respective studies. Additionally, given the small number of PPP projects present in New Zealand and study area being somewhat advanced 51 responses were considered sufficient. Table 2 displays a comprehensive overview of the background information of the participants. As presented in Table 4.2, 63% of respondents have more than five years of experience related to PPP.

The mean scores of the nine RAC were used to identify RAC groups (RACGs) through the Factor Analysis (FA) technique. Typically, a recommended variable to sample size ratio of 1:5 is followed prior to conducting FA (Lingard & Rowlinson, 2006)). Given the sample size of 51 against nine RAC, the FA technique is deemed suitable and appropriate for the data set. However, to confirm the suitability of the technique for this study, various preliminary tests such as internal consistency reliability, correlation matrix, Kaiser-Meyer-Olkin (KMO), and Bartlett's test of Sphericity were also conducted (Norusis, 2008; Osei-Kyei & Chan, 2021).

Table 4.2 Background information of survey participants

Item	Type	Frequency	Percentage (%)
Public	Central government	5	10
	Local government	6	12
Private	Main contractor	19	37
	Consultant	4	8
	Subcontractor	8	15
	Others	9	18
			100
Position	Project Director	3	6
	Construction Manager	6	12
	Project Manager	9	18
	Project Engineer	5	10
	Quantity Surveyor	7	13
	Planning Engineer	4	8
	Others (Supervisor, Contract administrator, Area manager etc.)	17	33
			100
Experience	upto 5 years	19	37
	5-10 years	17	33
	11-15 years	9	18
	Over 15 years	6	12
			100

Initially, a reliability test was performed using the Cronbach's alpha model. The primary objective of the test is to verify if the factors and their corresponding Likert scale accurately measure the intended construct. The Cronbach's alpha coefficient, which can range from 0 to 1, is commonly used to assess internal consistency. As a general guideline, George and Mallery (2021) proposed that a score of at least 0.7 is the minimum threshold, while a score of 0.8 or higher is considered an excellent indicator of internal consistency. The overall alpha value for the nine RAC was found to be 0.721, which exceeds the recommended threshold, suggesting a good level of consistency in the survey responses.

In addition, the correlation matrix was used to evaluate the relationships among the factors by calculating the partial correlation coefficients. The resulting matrix showed strong correlations among the nine CSC, as their correlation coefficients exceeded 0.30 for more than one other variable (Li et al., 2005; Norusis, 2008; Osei-Kyei & Chan, 2021). Output rotated component matrix from SPSS is tabulated in Table 4.3 below. Furthermore, to check the adequacy of applying FA, KMO statistic and Bartlett's test of Sphericity were performed (Table 4.4).

Table 4.3 Rotated component matrix of RAC

Rotated Component Matrix			
	Component		
	1	2	3
RAC3	0.792		
RAC9	0.779		
RAC4	0.777		
RAC6	0.72		
RAC1		0.824	
RAC8		0.765	
RAC5		0.671	
RAC7			0.81
RAC2			0.75

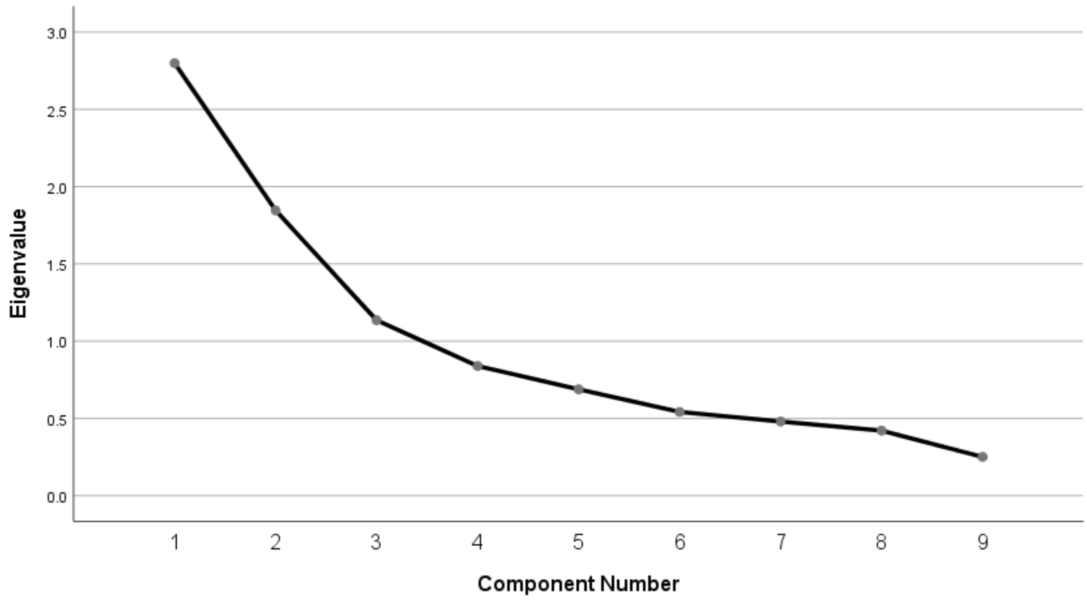

Figure 4.1 Scree plot from analysis

The KMO test is used to assess the degree of partial correlation among variables and its strength. A KMO value closer to 1.0 is considered to be ideal, while values below 0.5 are deemed unacceptable (Tang & Shen, 2013). However, many researchers have suggested value of greater than 0.7 to be desirable. Shrestha (2021) reported that for sample sizes below 100, a value exceeding 0.6 is considered acceptable. Results revealed a KMO value of 0.687, indicating a significant overlap of information among the variables or the presence of strong partial correlation. This suggests that conducting a factor analysis is a plausible approach.

The Bartlett's test of sphericity is a statistical tool used to examine the null hypothesis that the correlation matrix is an identity matrix, indicating that the variables are independent and not suitable for factor analysis (Norusis, 2008). If the statistical test produces a significant result, typically less than 0.05, it means that the correlation matrix is not an identity matrix and the null hypothesis can be rejected. The Bartlett's test of sphericity produced a large value (chi-square = 133.653) and a significance value of less than 0.05 (p = 0.00), suggesting that the population correlation matrix is not an identity matrix (ibid.).

Table 4.4 Results of reliability tests

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.687
Bartlett's Test of Sphericity	Approx. Chi-Square	93.063
	df	36
	Sig.	.000

Table 4.5 presents the analysis of the mean values 9 RAC along with factor loadings, Eigenvalues, percentage of variance explained and cumulative percentage of variance. The mean values, ranging from 4.34 (indicating high importance) to 3.52 (important), and the standard deviation values (SD) ranging from 0.53 to 0.94 are shown in the table. It is noteworthy that only three criteria are considered to be of very high importance in evaluating risk allocation decision in PPP projects. These criteria are “risk foresight” (ms = 4.34), “response to risk” (4.12) and “minimise risk loss” (ms = 4.08).

As mentioned earlier, to investigate the underlying relationships among 9 RAC, factor analysis was employed. This analysis is significant as it reduces the number of factors to smaller groupings, making it easier for practitioners to identify the best practices necessary for achieving the small groupings of criteria. Moreover, through factor analysis, practitioners can comprehend the relationships among several criteria within each smaller grouping.

A three-factor solution was obtained using principal factor extraction with varimax rotation, which had eigenvalues exceeding 1.0 (see Table 4.5). Varimax rotation was preferred because it simplifies the interpretation process by representing the principal component factor with a small number of easily interpretable variables (Osei-Kyei et al., 2017).

Table 4.5: Mean scores, S.D., factor groups and Eigen-values of RAC

No.	**RAC**	**Mean Score**	**Std. Dev.**	**Factor loading**	**Eigen-value**	**% of variance**	**Cum. % of var.**
RACG1	Risk management expertise	3.84			2.799	31.09	31.09
RAC3	Absorb risk impact	3.81	0.932	0.792			
RAC9	Experience	3.96	0.946	0.779			
RAC4	Obtain risk premium	3.74	0.813	0.777			
RAC6	Bargaining power/negotiation tactics	3.86	0.903	0.720			
RACG2	Core risk management capability	4.04			1.846	20.508	51.604
RAC1	Response to risk	4.12	0.606	0.824			
RAC8	Minimise risk loss	4.08	0.866	0.765			
RAC5	Low risk cost	3.92	0.868	0.671			
RACG3	Risk management strategy	3.93			1.135	12.612	64.215
RAC7	Risk attitude	3.52	0.640	0.810			
RAC2	Risk foresight	4.34	0.535	0.750			

All variables had factor loadings at or above 0.50, with seven of them exceeding 0.69, as shown in Table 4.5. This once again confirms the suitability of the survey data for factor analysis (Osei-Kyei et al., 2021). The relevance of factors is determined by their eigenvalues, with only factors having an eigenvalue higher or equivalent to 1 being considered in this analysis (Hsueh & Chang, 2017; Osei-Kyei & Chan, 2021). Table 4.5 presents the extracted factors, with their eigenvalues being greater than 1. Additionally, the three major factors account for 64.21% of the total cumulative variance, indicating the sufficiency of the three factors in representing the 10 RAC. These three major components are labelled as follows:

(1) RACG1 – Risk management expertise.

(2) RACG2 – Core risk management capability.

(3) RACG3 – Risk management strategy.

The three primary components were named according to the subfactors' loadings, meaning that subfactors with higher absolute loading values had a greater impact on the naming of their respective RAC. It's important to note, however, that this naming process can also be considered theoretical, subjective, as discussed in the literature (Osei-Kyei, Robert, et al., 2022).

4.4.1 RACG1: Risk management expertise

Explaining 31.09% of the variance the first group was called "Risk management expertise". This group consists of four RAC RAC3 "Absorb risk impact"; RAC9 "Experience"; RAC4 "Exploit risk" and RAC6 "Bargaining power/negotiation tactics" with factors loadings of 0.792, 0.779, 0.777 and 0.720, respectively. Importantly, these four subcriteria largely relate to the past experience of a party in PPP project to implement valuable lessons learned and insights that can be used to inform future risk management practices. The factor loading of the RAC3 has the highest value showing that the ability of a party to absorb the risk impact is one of the significant criteria to consider when allocating risks of the project. Shrestha et al. (2019) and Ameyaw and Chan (2016) also stress the importance of this in their studies that the party responsible for managing the risk should possess the ability to minimise the costs. It is important to note that bargaining power/negotiation tactics with a factor loading of 0.72 is an important criterion. Rasheed et al. (2022) stress the importance of understanding the negotiating power of each party at the time of allocating risks, as this can lead to unequitable allocation of risks at negotiation stage of the project.

Risk management expertise plays a critical role in the successful execution of public-private partnership (PPP) projects. It involves the knowledge, skills, and capabilities of the project stakeholders in identifying, assessing, mitigating, and managing risks throughout the project lifecycle. In PPP projects, several factors come into play when considering risk management expertise, including the experience of the partnering entities, their ability to absorb risk impacts, their capacity to exploit risks for mutual benefit, and their bargaining power.

Experience of a Partner: The experience of a partner, whether it is a public authority or a private company, greatly influences their risk management expertise. A partner with prior experience in PPP projects brings valuable knowledge of potential risks, effective risk mitigation strategies, and best practices. They are better equipped to anticipate and address project-specific risks, drawing from lessons learned in previous ventures. This experience enhances their ability to navigate complexities, make informed decisions, and effectively manage risks throughout the project lifecycle.

Absorbing Risk Impact: Risk management expertise in PPP projects includes the capacity to absorb and manage the impact of risks. Partners need to assess their financial strength, organizational resilience, and risk appetite to determine their ability to withstand the consequences of potential risks. A partner with robust financial resources and risk management systems is better positioned to absorb unexpected costs, delays, or other adverse events. This ability to absorb risk impacts reduces the potential negative consequences on the project's overall objectives and ensures its long-term viability.

Exploiting Risks: Risk management expertise in PPP projects extends beyond risk mitigation to also encompass the identification and exploitation of potential opportunities. Effective risk management involves recognizing risks that may present opportunities for value creation, innovation, or improved project outcomes. Partners with strong risk management expertise possess the capability to identify and assess these risks, develop strategies to exploit them, and derive mutual benefits from the project. This proactive approach to risk management can lead to enhanced project performance, increased efficiency, and better outcomes for both parties.

Bargaining Power of a Party: The bargaining power of a party in a PPP project can significantly influence risk management expertise. A partner with stronger bargaining power may have greater leverage to negotiate risk allocation, risk-sharing mechanisms, and contractual provisions that favour their risk management strategies. This includes negotiating favourable terms related to risk transfer, insurance coverage, dispute resolution mechanisms, and performance guarantees. The ability to assert bargaining power effectively can help optimize risk management arrangements and align them with the party's risk appetite and capabilities.

In summary, risk management expertise in PPP projects encompasses the experience of partners, their ability to absorb risk impacts, their capacity to exploit risks for mutual benefit, and their bargaining power. By leveraging their experience, partners can apply effective risk management practices, anticipate challenges, and implement mitigation strategies. The capacity to absorb risk impacts ensures the project's financial viability and resilience. Identifying and exploiting risks as opportunities can lead to improved project outcomes. Finally, effective bargaining power enables partners to negotiate risk allocation and contractual provisions that align with their risk management strategies. By considering these factors, partners can enhance their risk management expertise, increasing the likelihood of successful outcomes in PPP projects.

4.4.2 RACG2: Core risk management capability

Core risk management capability explained variance of 20.58% and combined with RACG1 explained 51.604% of cumulative variance. It consists of three RAC, namely, RAC1 “Response to risk”; RAC8 “Minimise risk loss” and RAC5 “Low risk cost”. The risk allocation criterion in this group mainly relate to the efficiency of risk response in PPP projects. Response to the risk should be such that not only does it minimise the impact of the risk, but also does it in a cost-effective way.

In the context of public-private partnerships (PPPs), risk response refers to the actions taken by project stakeholders to address and mitigate risks throughout the various phases of the project's lifecycle. The goal of risk response in PPPs is to either avoid risks altogether or minimise the likelihood and impact of their occurrence.

Risk response in PPPs involves proactive measures aimed at identifying potential risks and implementing strategies to prevent them from materializing or to mitigate their consequences. This proactive approach is crucial because PPP projects often span long periods, involve multiple stakeholders, and carry inherent complexities and uncertainties.

One aspect of risk response in PPPs is risk avoidance. This approach seeks to eliminate or bypass risks by making strategic adjustments to project plans, designs, or methodologies. For example, if a particular risk is identified during the planning phase of a road infrastructure project, the project stakeholders might choose to alter the route to avoid environmentally sensitive areas or to mitigate potential geological risks.

Risk mitigation is another key component of risk response in PPPs. It involves implementing measures to reduce the likelihood or impact of identified risks. This can include the use of advanced technology, robust safety protocols, contingency plans, or alternative construction methods. For instance, in a PPP project involving the construction of a high-rise building, the project team might employ state-of-the-art fire suppression systems and emergency evacuation procedures to mitigate the risk of fire incidents.

Furthermore, risk transfer is a strategy commonly utilized in PPPs. It involves the allocation of specific risks to the party best equipped to manage them. For example, the private sector partner in a PPP project may assume certain construction or operational risks based on their expertise, experience, and access to specialized resources. This transfer of risks allows each party to focus on areas where they have a comparative advantage, leading to more efficient risk management.

It is important to note that risk response in PPPs requires a collaborative approach and clear contractual agreements. The responsibilities and obligations of each party regarding risk management should be clearly defined and communicated. This ensures that risk response measures are properly implemented and that there is a shared understanding of risk allocation and mitigation strategies.

By focusing on risk response throughout the lifecycle of a PPP project, stakeholders can enhance the project's resilience, optimize performance, and safeguard the interests of all involved parties. Effective risk response contributes to a more sustainable and successful delivery of infrastructure projects under the PPP framework.

4.4.3 RACG3: Risk management strategy

"Risk management strategy" obtained 12.615% of the variance explained and consists of two subfactors, namely, RAC7 "Risk attitude"; and RAC2 "Risk foresight" with factors loadings of 0.810 and 0.750, respectively. These two criteria relate more with the approach and behaviour of risk management in an organization. Risk management approach can be traditional, agile, enterprise, resilience, collaborative or a combination of these. Similarly risk behaviour can be risk seeking, risk averse or risk neutral. Overall, these factors can greatly influence the way risk managers foresee and predict the risk probability and impact of a risk. The relevance of these items is also well-documented in literature (Akintoye et al., 2008; Jin et al., 2012; Nisar, 2007).

Risk management strategy in public-private partnership (PPP) projects involves the systematic approach adopted by parties to identify, assess, mitigate, and monitor risks throughout the project lifecycle. Several factors, including the risk attitude and risk foresight of a party, play a crucial role in shaping the risk management strategy in PPP projects.

Risk Attitude: Risk attitude refers to a party's willingness to take on risks and their approach to managing them. Different parties may have varying risk attitudes, ranging from risk-averse to risk-seeking. A risk-averse party is cautious and prefers conservative risk management strategies, aiming to minimise potential negative impacts. On the other hand, a risk-seeking party is more willing to accept higher levels of risk in pursuit of potential rewards. Understanding the risk attitude of each party involved in the PPP project is essential for developing a risk management strategy that aligns with their preferences and objectives.

The risk attitude of a party influences various aspects of risk management, including risk allocation, risk-sharing mechanisms, and the level of contingency planning. For example, a risk-averse public authority may seek to transfer significant construction risks to the private partner through a robust contractual framework, while a risk-seeking private partner may be more willing to accept such risks in exchange for potential financial gains. By considering the risk attitude of each party, the risk management strategy can be tailored to strike a balance between risk mitigation and risk-sharing, ensuring a mutually acceptable approach.

Risk Foresight: Risk foresight refers to the ability of a party to anticipate and identify potential risks that may arise during the course of the PPP project. It involves a proactive approach to risk management, whereby parties actively assess and analyse future uncertainties and emerging risks. Effective risk foresight requires a thorough understanding of the project's context, the industry, and the specific risks associated with the project's scope and objectives.

Parties with strong risk foresight capabilities engage in comprehensive risk assessments, scenario planning, and use predictive models to anticipate potential risks. By identifying risks in advance, parties can incorporate appropriate risk mitigation measures into the project's design, planning, and contractual arrangements. This proactive approach helps to minimise the potential negative impacts of risks and enhances the overall risk management strategy.

Risk foresight also enables parties to make informed decisions about risk allocation, contractual provisions, and the selection of risk management tools and techniques. For example, if a party identifies a potential risk related to environmental regulations, they may incorporate strict environmental standards into the project's requirements or engage in early stakeholder consultation to mitigate the risk of public opposition.

By considering both risk attitude and risk foresight, parties can develop a comprehensive risk management strategy in PPP projects. This strategy should encompass risk identification, risk assessment, risk allocation, risk mitigation measures, and ongoing monitoring and control. Effective risk management strategies align with the parties' risk preferences, anticipate future risks, and enable proactive measures to minimise negative impacts. Through a well-defined risk management strategy, parties can enhance the project's resilience, protect their interests, and improve the chances of successful project outcomes in PPP projects.

4.5 Conclusion

PPPs have been increasingly adopted by governments worldwide as a preferred procurement approach for public infrastructure projects. In such projects, private sectors are often required to take on many of the risks that have traditionally been borne by governments. Although risk transfer is a key factor in achieving value for money, its implementation has been criticized as contentious and challenging. As such, achieving the optimal allocation of risks is crucial to ensuring the success of PPP projects. The traditional approach of allocating risks through negotiation have been criticized for its lack of objectivity. This study investigated nine RAC identified from previous literature to determine capability-based risk management. Data was gathered thorough a questionnaire survey from PPP projects in New Zealand. Factor analysis was used to understand the underlying relation among the criteria and resulted in three factor groupings. Core risk management capability of a party was found to be the most significant of groups with the highest Eigenvalue and percentage of variance explained.

The research findings may be limited in their generalizability for several reasons. Firstly, the number of responses received was relatively low despite all efforts made to increase it. However, the sample size was considered adequate when compared to similar studies, and meaningful conclusions can still be drawn for future practice and reference. Secondly, the less common mode of PPPs in New Zealand, DBFMO, and the fact that survey participants were involved in various types of PPPs (such as transport, schools, and prisons) may limit the generalizability of the results to other regions of the world. Nevertheless, given the unique nature of PPPs in New Zealand, the research findings remain valuable for guiding future research and informing international policy practices. The results of this study provide a foundational framework that governments and private developers can employ to achieve more effective risk allocation. In addition, these findings will enable researchers to undertake additional empirical studies on the subject of capability-based risk allocation.

5 Risk management capability for risk allocation in social infrastructure public-private partnerships: A New Zealand perspective

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Abstract

The use of PPPs has become increasingly popular as an innovative way for procuring public infrastructure projects. One of the main reasons for this widespread adoption is the transfer and allocation of risks. Research has shown that fair allocation of risks is very crucial for the success of a PPP. This study recognized the significance of fair risk distribution and examined seven crucial RAC along with 16 risks that are often improperly assigned based on previous research. An online questionnaire through Qualtrics was administered to experts who had prior involvement in 3 schools and 2 prison PPP projects in New Zealand to obtain data on risk management capability. The data collected from 43 respondents was analysed using mean score analysis. Relevant statistical tests such as Cronbach's Alpha and independent sample t-test were performed to ensure the accuracy of the analysis results. The objective of this study is to offer valuable insights to PPP stakeholders on the most efficient measures to achieve fair risk allocation and the state of risk management capabilities of public and private sectors in New Zealand. To accomplish fair risk allocation, the study proposes considering the risk management capacities of both the public and private sectors in the context of the identified

RAC. The findings of the study are anticipated to aid PPP stakeholders in formulating strategies that can enhance risk management and establish a balanced distribution of risks.

5.1 Introduction

Governments worldwide are facing challenges with increasing infrastructure demand and investment requirements (Tirumala & Tiwari, 2023). Consequently, they have turned to the private sector for financial assistance and increased private sector participation, leading to the emergence of innovative project delivery approaches, including public-private partnerships (PPPs). Engaging the private sector has also resulted in enhanced project performance (Liu et al., 2015). The primary reason for achieving superior outcomes in such arrangements is the alignment of interests between the public and private entities involved. Therefore, public-private partnerships (PPPs) have emerged as a favourable and effective approach for infrastructure provision, particularly in large-scale investments like road infrastructure projects (Sastoque et al., 2016).

There is substantial evidence supporting the notion that PPPs yield better performance compared to traditional procurement systems, where the public sector bears sole responsibility for project delivery (Koppenjan et al., 2022; Xiong et al., 2017). However, it should be noted that PPPs are not without challenges, as they involve complex financial arrangements, high investor expectations of returns, extended contract durations, and inherently risky project environments (Kukah et al., 2022). Therefore, effective risk allocation and risk management strategies are critical to ensuring a successful risk transfer and achieving the desired outcomes in PPP projects. Risk transfer is a key benefit of PPPs, enabling the public and private sector to assume and manage specific project risks (Debela, 2022). This facilitates efficient risk allocation, enhances performance accountability, enables access to private financing, and promotes long-term asset management.

Previous research has explored the issue of risk transfer and sharing in PPP projects and has identified inefficient risk allocation as a common problem (Shrestha et al., 2018). Numerous studies have compared the actual distribution of risks in PPP projects with recommended allocations based on expert opinions, often using surveys (Rasheed et al., 2022). These studies have consistently revealed a significant mismatch between the preferred and actual risk distributions, resulting in inefficiencies in risk allocation. Recently, some scholars have proposed best practices aimed at evaluating each party's ability to manage identified risks (Ameyaw and Chan, 2016, Mazher et al., 2019). The goal is to prevent the misallocation of risks. This approach is based on the principle of risk allocation in PPP projects, which states that risks should be allocated to the party best equipped to handle them (Koppenjan et al., 2022).

There exists a knowledge gap in capability-based risk allocation research in social infrastructure PPP sector. This paper aims to fill this gap by assessing the risk management capabilities of the public and private sectors in New Zealand’s social infrastructure PPP projects by employing various RAC derived from existing literature. The research findings have implications for both practical applications and academic studies in the field of risk management for PPP projects. Additionally, the results offer valuable insights for international companies planning to invest in infrastructure construction projects in New Zealand.

5.2 Literature Review

The literature review of this chapter has been adopted and paraphrased from section 4.2, since the focus of this chapter is also RAC.

5.2.1 Risk management in PPP

Risk can be defined as an uncertain event or condition that can have either positive or negative impacts on project objectives, including scope, quality, cost, and schedule, as well as individual, group, or organizational objectives (Project Management Institute, 2013, Mazher et al., 2022). In the context of construction projects, risks are inherent and significant (Dey & Ogunlana, 2004; Vegas-Fernández & Rodríguez-López, 2018). However, when compared to traditional procurement methods, public-private partnership (PPP) projects tend to be riskier. This is primarily due to factors such as extended concession periods, substantial capital investments, complex contractual arrangements, diverse motives and interests of project participants, and nonrecourse financing arrangements (Zhang, 2005). Moreover, traditional risk management approaches encounter greater challenges when applied to long-term PPP projects that have considerably longer contract periods compared to short-term traditional projects (Xiong et al., 2017).

Effective project risk management entails identifying, assessing, allocating and mitigating risks throughout the project lifecycle (Jokar et al., 2023). It involves a comprehensive understanding of the potential risks involved, establishing appropriate risk allocation mechanisms, and fostering collaboration and communication between the public and private partners (Project Management Institute, 2013). By proactively managing risks, including financial, operational, and legal uncertainties, PPP projects can navigate challenges and increase the likelihood of achieving their intended objectives. Furthermore, robust governance frameworks, transparency, and accountability are vital elements in PPPs to ensure the equitable sharing of risks and benefits between the public and private sectors. Adequate oversight and monitoring mechanisms should be established to evaluate project progress, address potential issues, and make necessary adjustments when required.

The complexity and unique characteristics of PPP projects expose them to a broader range of risks. The extended concession periods associated with PPPs introduce uncertainties that may arise over time, such as changes in market conditions, regulatory frameworks, and stakeholder expectations. The large capital investments required for PPP projects also amplify financial risks, as they often involve long-term financing commitments and potential revenue fluctuations (Esty, 2004). Furthermore, the complexity of contractual arrangements, with multiple parties involved, creates additional risks related to coordination, communication, and potential conflicts of interest. The diverse motives and interests of various stakeholders participating in PPP projects, including the public sector, private companies, and the community, can introduce conflicting objectives and increase the overall project risk. Recognizing the significance of these risks, Ibrahim et al. (2006) emphasized the importance of all stakeholders involved in PPPs being fully aware of the potential risks.

Traditionally, risk management has been primarily emphasized before the initiation of projects, aiming to identify and address risks proactively. However, in the context of PPP projects, which often involve long contract durations, this conventional approach has been found to be more challenging and costly (Xiong et al., 2017). The extended duration of PPP contracts introduces complexities and uncertainties that require a more dynamic and comprehensive approach to risk management. As a result, there is a pressing need to enhance the efficacy of risk management practices specifically tailored to the unique characteristics of PPP initiatives. Recognizing this need, there has been a growing interest in research focusing on various aspects of risk management in recent years.

Equitable risk allocation is another focal point of research in the field of PPP risk management (Ke et al., 2011). Achieving a fair and balanced distribution of risks between the public and private sectors is essential to foster collaboration and ensure mutual accountability.

By identifying key RAC and defining clear roles and responsibilities, stakeholders can establish a framework that promotes transparency and enables effective risk sharing.

Recognizing the importance of risk sharing and transfer between the public and private sectors, several researchers have investigated the issue of ineffective risk allocation and misallocation. Comparing the actual and preferred risk allocation Ke et al. (2010) conducted a study evaluating the impact of risk misallocation on performance of PPP projects in China. Their findings revealed that higher levels of risk misallocation led to decreased project performance. The study further identified land acquisition, corrupt practices and approvals of permits as the most significant risks affecting project performance. Shrestha et al. (2018) performed a similar study focusing on risk allocation inefficiency utilizing a questionnaire survey to gather data on actual and preferred risk allocation from respondents in a water supply PPP in China. Their research uncovered risk allocation inefficiencies particularly in risks transfer to private sector. Furthermore, external risks such as environmental, social, political and demand risks were also found to be inadequately allocated, with the private sector bearing a disproportionate burden.

These studies highlight challenges and shortcomings in risk allocation for PPP projects, emphasizing the negative impact of misallocated risks on project performance. The identified risks, both project-specific and external, emphasize the need for more precise and equitable risk allocation strategies. Misallocated risks can result in financial burdens, delays, disputes, and project failures, necessitating a systematic and objective approach to risk allocation. Robust frameworks, methodologies, and decision-support tools are needed to evaluate risk management capabilities and guide the fair distribution of risks among stakeholders. Several other studies in PPP research have highlighted the significance of proper risk transfer and sharing as crucial factors for success (Osei-Kyei & Chan, 2015; Rasheed et al., 2019). Risks within PPP projects are allocated to various parties based on their capacity to identify, plan, and manage them effectively. It is important to note that not all project risks can be entirely transferred to private sector, as some risks are better handled by the public sector due to their nature or expertise.

Although the principle of allocating risks to the party best suited to manage them is theoretically sound, implementing it in practice poses significant challenges. Assessing the owner's ability to manage a particular risk is subjective and inherently complex. This subjectivity introduces challenges and complexities into the process of risk allocation. Consequently, the process becomes somewhat ambiguous, leading to the misallocation of risks. Various studies have highlighted the suboptimal allocation of risks observed in real-world scenarios (Ameyaw and Chan, 2016, Rasheed et al., 2022). Researchers have described this principle as effective but also criticized its vagueness (Mazher, 2019). Ng and Loosemore (2007) argue that assessing risk management capability of a party is complex and influenced by external factors such as complex financial arrangements, bargaining power of parties involved and requirements imposed by different stakeholders.

5.2.2 Risk allocation criteria

In response to the issue of misallocated risks and minimise subjectivity, some recent studies have introduced RAC to assess risk management capability of each party involved in PPP projects (Mazher, 2019). These criteria provide guidance on determining "what, which, and how" risks should be allocated to specific parties. In other words, they outline which risks should be allocated, to which party, and how the allocation process should be conducted. To capture the widely used RACs in PPP research, a comprehensive review of literature has been conducted, and the findings have been summarized in Table 5.1 with minor modification from Table 3.5. These criteria serve as benchmarks or standards for evaluating the ability of the party undertaking the risk to effectively manage it. The RACs offer a systematic approach to risk allocation by considering various factors that influence risk management capabilities. These factors may include financial strength, technical expertise, experience, operational efficiency, and risk appetite. By assessing capability of each party against these criteria, project stakeholders can make informed decisions regarding risk allocation, ensuring that risks are assigned to the parties best equipped to handle them.

Table 5.1 Risk allocation criteria

(modified with permission from (Rasheed et al., 2022))

Risk allocation criteria (RAC)	Description of the criteria
Risk foresight (RAC_1)	The capacity of the party to recognize and evaluate risk by foreseeing the likelihood of its occurrence and the potential consequences in occurrence.
Risk response (RAC_2)	The capability of the party to proactively reduce both the likelihood and consequences of risk prior to its occurrence.
Curtail risk loss (RAC_3)	The capacity of the party to mitigate losses or minimise the impact of the risk if it materializes.
Absorb risk impact (RAC_4)	The party's capacity to endure the impact of the risk based on their prior experience.
Reduce risk cost (RAC_5)	The party's capability to handle risk with the lowest feasible cost.
Acquire risk premium (RAC_6)	The capacity to obtain compensation for a loss incurred due to the occurrence of risk.
Risk exploitation (RAC_8)	To leverage specific risks based on an organization's exceptional capability and experience in handling those risks adeptly.
Risk attitude (RAC_7)	The stance of a party regarding risk management, such as being risk-averse, risk-seeking, risk-neutral, or risk-transfer.

The traditional approach to risk allocation in PPP projects involves negotiation among risk specialists from both sectors (Wan et al., 2022). Undoubtedly, negotiation plays a crucial role in PPPs, as it allows stakeholders to address their concerns and find mutually acceptable solutions. However, relying solely on negotiation may not always be the most effective tool for risk allocation practices. The suitability of negotiation for risk allocation depends on the project stage and the relative control that each party holds. For instance, during the procurement stage, the public sector typically has greater authority and bargaining power compared to the private parties. This power dynamic has been exploited in the past, resulting in the excess transfer of risks to the private sector, often exceeding its capability to effectively manage them.

To address the limitations of negotiation-based risk allocation, this study proposes an alternative allocation process that considers the risk management capabilities of each party for allocation of risk. This assessment is conducted in light of the identified RAC derived from the literature reviewed (Rasheed et al., 2022, Mazher, 2019, Ameyaw and Chan, 2016). This approach aligns with the risk sharing principle of PPP, which states that "risks should be allocated to the party best equipped to manage them". In addition to the RACs, a thorough examination of existing studies and research was conducted to identify a comprehensive list of risks associated with PPP projects. From this extensive list, 16 risks were identified that were not explicitly allocated to either the public or private sector or have been of contentious nature in reviewed literature. Presented in Table 5.2, these risks were considered for inclusion in the research to ensure a comprehensive analysis of risk allocation practices.

By taking into account each party's risk management capabilities, a more optimal and efficient risk allocation can be achieved. This approach acknowledges that different parties possess varying levels of expertise, resources, and experience in managing specific risks.

Consequently, risks can be allocated in a manner that leverages the strengths of each party and minimises potential vulnerabilities.

Considering risk management capabilities also helps prevent the overburdening of any one party with excessive risks. This proactive assessment ensures that risks are allocated within the capacity of each party, mitigating the potential for project delays, cost overruns, and other negative impacts. Implementing an approach that incorporates risk management capabilities and RACs enhances the objectivity and fairness of the risk allocation process. It reduces the reliance on power dynamics and subjective negotiations, promoting a more rational and informed allocation of risks. Ultimately, this approach contributes to more efficient risk management, improved project performance, and a higher likelihood of successful PPP outcomes. However, it is important to note that even capability-based risk allocation process should be tailored to the specific characteristics and context of each PPP project. Flexibility and adaptability are necessary to accommodate the unique circumstances and dynamics of individual projects. Regular reassessment and refinement of risk allocation strategies based on lessons learned and emerging best practices further enhance the effectiveness of the approach.

In summary, while negotiation has traditionally been employed for risk allocation in PPPs, its limitations and potential for imbalanced outcomes necessitate the adoption of alternative approaches. The risk allocation process should consider risk management capabilities of each party. By aligning risks with parties' capabilities, this approach has the potential to enhance the efficiency and effectiveness of risk allocation, contributing to the overall success of PPP projects.

5.3 Methodology

The research commenced with an extensive literature review, delving into the realm of risk allocation in PPPs. Through this literature review, a list of risks and relevant RAC were initially extracted and documented, providing a foundation for the subsequent research activities. To validate and reinforce the relevance and usefulness of the identified RACs and risks, the expertise of individuals well-versed in PPP projects was sought. Two academics and two industry professionals, recognized as experts in the field, were engaged in the study. The identified RACs and risks were presented to these experts, who evaluated their adequacy and usefulness based on their extensive knowledge and experience. The input and feedback provided by the experts played a crucial role in refining and validating the RACs and risks. Minor phrasing changes were proposed to improve the clarity of certain risks, and one criterion was suggested for removal due to its lack of clarity.

A two-part questionnaire survey was administered using Qualtrics to gather data. By employing a questionnaire survey, the study aimed to gather insights and perspectives from a diverse range of stakeholders with experience in 3 schools and 2 prison PPP projects in New Zealand. This data collection approach facilitated the examination of risk management capabilities within the context of identified RACs and provided valuable input for the analysis and findings of the study.

The first part focused on gathering information about the respondents' profiles to assess their relevant experience and knowledge of PPP projects. The second part of the questionnaire aimed to capture the perceived risk management capability of the respondents' organizations for each identified RAC in relation to the identified risks. To measure this, a five-point Likert scale was adopted, ranging from 1 (least important) to 5 (most important). This scale allowed respondents to rate the perceived ability of their organization to address risks associated with each RAC. In cases where respondents felt they did not have sufficient experience or knowledge to answer certain questions, a "no idea" (NI) option was provided. This option allowed respondents to indicate their lack of confidence in responding to specific questions, ensuring the data collection process accounted for varying levels of expertise among the participants.

The study used a combination of non-probability sampling methods, namely convenience sampling and judgment sampling, due to the lack of an exact population for random sampling. Convenience sampling was employed to select participants based on accessibility and willingness to take part. Professionals from PPP organizations experienced in New Zealand's social infrastructure PPP projects were targeted. Judgment sampling was also used, with researchers selecting participants based on their expertise and potential insights. The researchers made informed decisions using industry knowledge and personal networks. To gather enough survey responses, professionals were individually contacted via email and platforms like LinkedIn. It is important to acknowledge that the use of convenience and judgment sampling techniques may introduce certain limitations to the study. The sample obtained through these techniques may not be fully representative of the entire population of PPP stakeholders in New Zealand. However, given the specific context of the research and the scarcity of PPP projects in the country, these sampling techniques were considered appropriate and elite for gathering relevant and valuable insights from professionals with first-hand experience in the field.

The collected data from the questionnaire survey underwent several analysis techniques to gain insights and draw conclusions. These techniques included mean score analysis, reliability analysis, and independent sample t-test analysis. These analyses provide confidence in the accuracy and consistency of the data used in the study. The reference to previous studies (Mazher et al., 2018, Osei-Kyei and Chan, 2021) highlights the widespread use of Cronbach's Alpha in other PPP-related literature. The latest versions of Microsoft Excel and Statistical Package for Social Sciences (SPSS) were utilized for these analyses. Mean score analysis was employed to determine the risk management capability of both the public and private sectors concerning all the risks associated with the selected Risk Assessment Criteria (RAC). Overall, through these analyses, the researchers were able to assess risk management capabilities, establish rankings based on mean scores, and ensure the reliability of the collected data. These insights contribute to a comprehensive understanding of the research topic and support the conclusions drawn from the questionnaire survey.

5.4 Results

A total of 43 valid responses were obtained for the study. To assess the adequacy of the sample size, comparisons were made with similar studies that utilized questionnaire surveys. Osei-Kyei et al. (2021) collected 48 responses and Ameyaw and Chan (2015) obtained 35 responses in their respective studies. In light of these comparisons, the sample size in the current study was considered sufficient for further analysis. It should be noted that the number of PPP projects in New Zealand is relatively small, and considering the advanced nature of the study area, the collection of 43 responses was considered appropriate. For a comprehensive understanding of the participants, Figure 5.1 provides an overview of their background information. According to the figure, it is evident that 61% of the respondents possess more than five years of experience in the field of social infrastructure PPP projects.

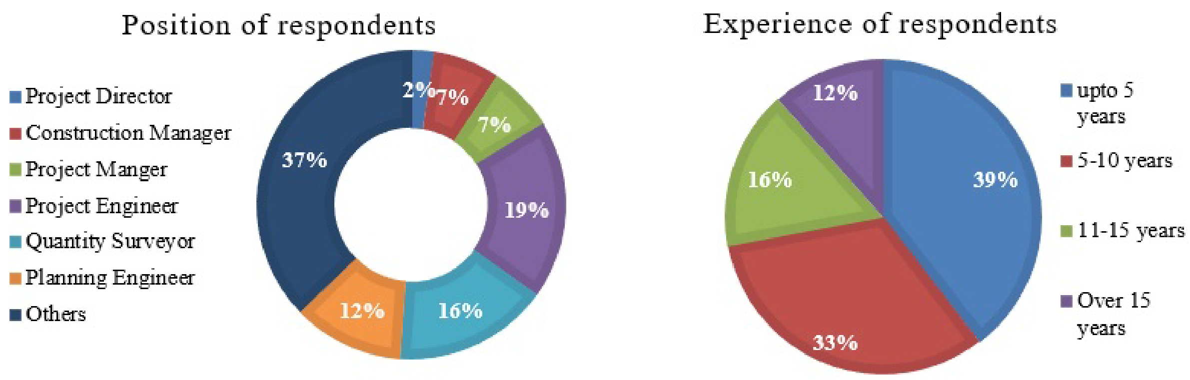

Figure 5.1 Background information of respondents

The first step in the analysis involved conducting a reliability test using Cronbach's alpha coefficient. The primary purpose of this test was to examine the internal consistency of the factors and their corresponding Likert scale in measuring the intended construct. The Cronbach's alpha coefficient, a widely used measure of internal consistency, was employed for this assessment, ranging from 0 to 1. According to George and Mallery (2019), a minimum threshold of 0.7 is recommended, while a score of 0.8 or higher is considered an excellent indicator of internal consistency. Upon analysing the data, it was found that the overall alpha value for the seven RAC was determined to be 0.721, surpassing the recommended threshold. This result suggests a good level of consistency in the survey responses. Thus, the reliability test confirmed that the factors and the Likert scale used in the study reliably measured the intended construct.

Additionally, an independent 2-sample t-test was conducted to investigate whether there existed a significant difference in the mean value responses between two distinct groups of respondents: the public sector and the private sector (Ross & Wilson, 2017). This analysis aimed to explore potential variations in perceptions regarding the 16 risks discussed in the study. The significance level of 0.05 was used as the threshold to determine if the observed differences were statistically significant. Out of the t-test outcomes for the allocation of these risks, seven risks yielded results below the significance level of 0.05 as shown in Table 5.2.

Table 5.2 Identified risk from literature and t-test results

Risk ID	Risk	F	t	sig.
RF_1	Inflation	1.042	2.587	0.016*
RF_2	Variation in foreign exchange rate	0.615	2.889	0.008*
RF_3	Interest rate fluctuation	0.511	2.641	0.015*
RF_4	Land acquisition	0.058	3.309	0.003*
RF_5	Public opposition to project	0.421	4.04	0.001*
RF_6	Change in law/regulation	0.065	2.936	0.007*
RF_7	Unexpected geotechnical conditions	31.194	-1.142	0.087
RF_8	Supply/resourcing risk	1.649	-0.868	0.212
RF_9	Delay in project approvals and permit	2.437	1.079	0.132
RF_10	Insurance risk	2.542	-1.019	0.125
RF_11	Unforeseen project characteristics	0.742	0.566	0.398
RF_12	Financing risk	5.009	-1.7	0.035*
RF_13	Lack of PPP experience	0.16	-0.193	0.693
RF_14	Weather risk	2.145	1.122	0.157
RF_15	Change in government	2.791	0.515	0.108
RF_16	Design changes	0.142	-0.628	0.51

F = equality of variance assumed (Levene's test), t = t-test value for equality of means, sig. = significance

Among the 16 risks examined, the t-test results indicated that for the majority of risks, there was no significant discrepancy in the mean value responses between the public and private sectors. This suggests a similarity in the way both groups perceive and evaluate 9 of the risks. However, for remaining risks, the mean responses differed significantly between the two sectors, as they fell below the designated significance level of 0.05. These divergent perceptions may indicate contrasting attitudes, priorities, or risk management approaches between the public and private sectors for those particular risks.

Table 5.3 presents detailed analysis of survey results. Mean scores of each RAC from public and private sector respondents are presented against the 16 risks. From private respondent's data across all RAC, RF_8 "Supply risk" scored highest with a score of 4 against RAC_1 "risk foresight" and RF_5 "Public opposition to project" scored lowest with a score of 1.5 against RAC_7 "Risk attitude". Similarly, from public sector respondent's data across all RAC, RF_9 "Delay in project approvals and permit" scores highest with a score of 3.82 against RAC_1 "Risk foresight" and RF_3 "Interest rate fluctuation" scored lowest with a score of 1.64 against RAC_7 "Risk attitude". Furthermore, an overall risk management capability score (WRMC) for both sectors obtained by weighted average of the 7 RAC for each risk is also presented. For simplicity each RAC is given equal weightage in calculation the overall RMC score. Top risk factors in terms of RMC from public and private sectors are discussed further.

Table 5.3 Mean score analysis results of risks against RAC

	RAC_1		RAC_2		RAC_3		RAC_4		RAC_5		RAC_6		RAC_7		WRMC	
	Pb	Pr	Pb	Pr	Pb	Pr	Pb	Pr	Pb	Pr	Pb	Pr	Pb	Pr	Pb	Pr
RF_1	3.27	2.64	2.18	1.93	3.18	2.57	3.36	2.93	3.00	2.33	2.40	1.75	1.82	1.38	2.75	2.22
RF_2	3.09	2.46	1.91	1.77	2.64	2.31	3.55	2.92	3.27	2.42	2.44	1.75	1.82	1.38	2.67	2.14
RF_3	3.18	2.69	2.40	1.92	2.73	2.38	3.36	3.15	3.27	2.33	2.60	2.00	**<u>1.64</u>**	1.62	2.74	2.30
RF_4	3.79	2.64	3.27	1.82	3.55	2.23	3.73	2.64	3.55	2.31	3.64	2.26	2.36	1.82	**<u>3.41</u>**	2.25
RF_5	3.73	2.57	3.55	2.07	3.27	2.36	3.55	2.46	3.71	2.31	3.18	2.15	2.18	**<u>1.50</u>**	**<u>3.31</u>**	2.20
RF_6	3.55	2.29	3.27	2.14	3.18	2.71	3.27	2.71	3.55	2.62	2.91	2.69	2.09	1.62	3.12	2.40
RF_7	2.27	3.07	2.00	2.91	2.55	3.36	2.73	3.14	2.67	3.08	2.40	2.92	1.73	2.18	2.34	2.95
RF_8	2.55	**<u>4.00</u>**	2.45	3.21	3.18	3.07	3.09	3.07	2.73	2.93	2.64	2.54	2.55	2.14	2.74	2.99
RF_9	**<u>3.82</u>**	3.07	3.73	3.21	3.36	3.57	3.45	3.21	3.36	3.08	3.45	3.00	2.18	2.31	**<u>3.34</u>**	3.06
RF_10	2.56	2.85	2.78	2.92	2.89	3.15	2.78	2.92	2.67	2.92	2.78	2.62	2.11	2.08	2.65	2.78
RF_11	2.82	2.79	2.55	2.86	3.09	2.86	3.18	2.93	2.82	2.93	2.91	2.62	1.91	1.69	2.75	2.67
RF_12	2.18	3.71	2.09	3.21	2.26	3.73	2.58	3.43	2.34	3.13	2.26	3.21	2.08	2.15	2.26	3.23
RF_13	3.18	3.43	3.09	3.55	3.09	3.38	3.18	3.43	2.73	3.36	3.18	2.58	2.09	2.46	2.93	**<u>3.17</u>**
RF_14	3.18	3.14	2.55	2.21	3.20	2.86	3.09	2.57	2.91	2.46	2.73	2.31	2.18	1.71	2.83	2.47
RF_15	3.10	2.57	2.50	1.93	2.40	2.29	2.80	2.64	3.00	2.31	2.30	2.15	1.90	1.71	2.57	2.23
RF_16	3.36	3.73	3.27	3.64	3.27	3.55	3.09	3.57	3.27	3.46	2.91	3.36	1.91	2.36	3.01	**<u>3.38</u>**

5.5 Discussion

5.5.1 Land acquisition (RF_4)

The risk of land acquisition in a public-private partnership (PPP) project refers to the challenges and uncertainties associated with acquiring the necessary land for the project's development or expansion. Land acquisition scored the highest among public sector respondents with a risk management capability score of 3.41. Literature shows that risk of land acquisition is mostly allocated to the public sector (Bing et al., 2005; Ke et al., 2010).

When constructing a new infrastructure facility or upgrading an existing one, the responsibility for providing the land to the concessionaire depends on who owns the land. If the land is already owned by the contracting authority or another public entity, it is generally the land or facility owner's duty to make it available to the concessionaire. However, if the preferred site is owned by a third party or includes third-party-owned sites, the private party undertaking the project assumes the risks associated with acquiring the land. Nonetheless, the government authority has the option to coordinate and even take control of the land acquisition process if needed. In situations where voluntary acquisition becomes challenging and expensive, and if the government is intended to become the ultimate owner of the land, it may be more cost-effective for the government to assume responsibility for the process. This includes utilizing its legal powers of compulsory acquisition, if necessary.

The reason for this arrangement is that negotiating with multiple landowners, especially when there are a significant number of owners involved, can lead to delays and increased costs. Additionally, in certain jurisdictions, complex procedures are required to establish the legitimacy of each owner's title. Considering these factors, it is not suitable for the concessionaire to take on the responsibility of acquiring land for a project when the land is not already owned by the contracting authority. To prevent unnecessary delays and cost overruns, it is typically the role of the contracting authority to handle land acquisition in such cases.

Land acquisition is a crucial component of infrastructure projects, but it comes with various risks. The negotiation process with landowners can be complex and time-consuming, especially when dealing with multiple owners and differing interests. Validating land titles can be challenging due to legal procedures and potential disputes. Opposition from local communities can lead to protests and delays, while limited availability of suitable land can complicate the search. High land prices pose financial challenges for private sector partners. To mitigate these risks, early and transparent communication with stakeholders is crucial. Thorough studies and fair negotiations help address challenges. Involving local communities fosters inclusivity and sustainability. Proactive risk management, including surveys and collaboration with experts, is essential. Adherence to legal requirements and stakeholder engagement builds trust and minimises conflicts. Overall, effective stakeholder engagement and risk management are crucial to successful land acquisition in PPP projects.

5.5.2 Delay in project approvals and permit (RF_9)

The risk of project approvals and permits in a public-private partnership (PPP) project refers to the challenges and uncertainties associated with obtaining the necessary regulatory approvals and permits required to initiate and proceed with the project. These approvals and permits are typically obtained from government authorities at various levels, such as local, regional, or national agencies, depending on the nature and scale of the project. In terms of risk management capability of public sector this risk ranked second with an RMC score of 3.34. Private sector ranked this risk at 4th place with an RMC score of 3.06. Ke et al., (2010) suggest that this risk should be mostly borne by public sector, however Bing et al., (2005) argue in favour of allocation based on characteristics of project.

Several factors contribute to the risk of project approvals and permits in a PPP project. The complexity of the regulatory framework and the numerous approvals and permits required can cause significant delays and administrative burdens. Involvement of multiple stakeholders and authorities further complicates the process, as each may have different priorities and requirements. Public perception and potential opposition can also impact approvals, leading to increased scrutiny and resistance. Political factors, such as changes in government or public policy, can introduce uncertainties and affect the regulatory landscape. To mitigate these risks, effective communication and collaboration among stakeholders are crucial. Early engagement with regulatory authorities and communities helps address concerns and streamline the approval process. Thorough assessments of the regulatory environment and proactive measures during project development help identify and address potential issues. Careful planning, stakeholder engagement, and proactive risk management are vital for navigating the complex regulatory landscape and ensuring successful project implementation.

5.5.3 Public opposition to project (RF_5)

The risk of public opposition to a public-private partnership (PPP) project refers to the potential resistance, criticism, or objections from the general public or specific interest groups towards the project. This opposition can manifest in various forms, such as protests, legal challenges, media scrutiny, or negative public perception. Understanding and addressing this risk is crucial for the successful implementation of a PPP project. Public sector respondents ranked this risk at 3rd place with an RMC score of 3.31 representing moderate to high capability for managing it. Bing et al., (2005) propose that the primary responsibility for managing this risk should lie with the public sector, although Ke et al. (2010) contend in favour of distributing it equally between the two sectors.

Public opposition to PPP projects often stems from concerns about negative outcomes associated with private sector involvement in public infrastructure. These concerns include increased costs, reduced public control, potential loss of public services, and profit motives of private entities. Environmental impact and social/community impacts are also common areas of concern, with objections related to harm to the environment, loss of natural habitats, displacement of communities, disruption of livelihoods, and cultural heritage. Political factors can also influence opposition. According to Chung et al. (2010), the risk of public misperception can have negative consequences for public infrastructure projects. It often results in a lack of public support, leading to delays in project approval and variations in contracts.

To address the risk of public opposition, effective communication and stakeholder engagement are essential. Engaging with the public, community leaders, and relevant stakeholders from the project's early stages builds trust and addresses concerns. Transparency in decision-making and providing opportunities for public input, such as through consultations, help incorporate public feedback and reduce opposition. Comprehensive environmental and social impact assessments, along with proactive community engagement programs, demonstrate a commitment to sustainable development and minimise disruptions. Transparency in procurement, clear project objectives and benefits, and demonstrating value for money help mitigate skepticism. Compliance with legal and regulatory requirements related to public engagement is crucial, as is addressing concerns in public forums and engaging with the media to counter misinformation. By recognizing and addressing the risk of public opposition, PPP stakeholders can create a more supportive environment, foster public acceptance, and mitigate delays, conflicts, or reputational damage.

5.5.4 Design Changes (RF_16)

The risk of design changes in a public-private partnership (PPP) project refers to the potential need for modifications or revisions to the project's original design. Design changes can arise due to various factors, including evolving project requirements, unforeseen challenges, stakeholder input, or technical issues. Survey data showed that private sector has the highest RMC score for this risk (3.38), whereas public sector RMC score for this risk ranked 5th (3.01). Both sectors represent moderate to high capability to manage this risk. The existing body of research demonstrates that the burden of design change risk is predominantly assigned to the private sector, as evidenced by studies such as Bing et al. (2005) and Ke et al. (2010).

Design changes in a PPP project can occur due to unforeseen technical complexities, evolving project requirements, and stakeholder input. Technical or engineering challenges, site conditions, and limitations may emerge during project implementation, necessitating adjustments to the original design. Shifting regulatory standards, environmental considerations, or community expectations may also require design modifications. Stakeholder engagement and public consultations can prompt changes to address concerns and incorporate suggestions. Design changes can impact risk allocation and may require contract renegotiations. To mitigate these risks, thorough project planning, feasibility studies, and risk assessments are crucial. Effective communication and collaboration among all stakeholders, including authorities and communities, help identify and address design-related issues. Flexibility in project contracts and clear decision-making protocols aid in streamlining the process. Open communication and transparent reporting keep stakeholders informed. Effective risk management and contingency planning are essential for successful implementation and minimizing disruptions caused by design changes in a PPP project.

5.5.5 Lack of PPP experience (RF_13)

The risk of "Lack of PPP experience" in a public-private partnership (PPP) project refers to the potential challenges and uncertainties that arise when one or more parties involved in the project have limited or insufficient experience in implementing and managing PPP arrangements. This lack of experience can affect various aspects of the project and may introduce risks that need to be addressed. With an RMC score of 3.17, private sector ranked this risk 3rd and public sector ranked it at 6th place with a score of 2.93. In their risk allocation investigation within the realm of UK's PPP, Bing et al. (2005) discovered that the risk allocation decision associated with lack of PPP experience varies significantly depending on the project.

The lack of PPP experience can impact project planning, procurement, and implementation. Inexperienced parties may struggle with project assessment, risk identification, and establishing realistic timelines and financial models, hindering the project's success. The quality of the procurement process may be compromised, resulting in suboptimal partner selection and inadequate risk allocation. Inexperienced parties may face challenges in contract management, project monitoring, and performance assessment, leading to delays and cost overruns. Building capacity and expertise within the organizations involved, seeking assistance from experienced entities, conducting thorough studies, and employing experienced advisors can mitigate the risk of lack of PPP experience. By addressing this risk, projects can enhance outcomes and improve overall success.

5.6 Conclusion

The transfer of risk is crucial in achieving value for money in PPP projects. However, implementing this risk transfer has faced criticism and challenges. To ensure the success of PPP projects, it is imperative to achieve the optimal allocation of risks. The conventional method of risk allocation has been scrutinized for misallocation of risk by a number of previous studies. Capability-based risk management has been identified as an alternative risk allocation approach. This study aimed to address this issue by investigating risk management capability of public and private sector in New Zealand's social infrastructure PPP projects based on seven RAC for 16 risks.

Data for the study was collected through a questionnaire survey from 3 schools and 2 prisons PPP projects in New Zealand. The research employed mean value analysis and independent t-test to determine the risk management capability and significance variance in perception of both sectors. Result show that public sector's overall risk management capability is highest for risk factor "land acquisition" and lowest for "financing risk". Similarly, private sector's participants demonstrated highest level of RMC for risk factor "design changes" and lowest for "variation in foreign exchange rate". Independent sample t-test result showed that opinions of public and private sector for 7 out of 16 risks were significantly different. Among these 7 risks most risks were of either regulatory or macroeconomic nature.

The generalizability of the research findings could be restricted due to several factors. Firstly, despite making every effort to boost response rates, the number of received responses was relatively low. Nonetheless, it is important to note that the sample size was considered adequate when compared to similar studies. Therefore, even with this limitation, meaningful conclusions can still be drawn and applied in future practices and as a reference point. Secondly, the less common mode of Public-Private Partnerships (PPPs) in New Zealand, particularly the DBFMO model, might impact the transferability of the results to other regions of the world. However, it is essential to recognize the unique nature of PPPs in New Zealand, which in itself presents an opportunity for learning and understanding distinct risk allocation practices. Despite potential limitations in generalizability, the research findings hold significant value in guiding future investigations and informing international policy practices.

6 Risk allocation in social infrastructure public-private partnership projects in New Zealand: A fuzzy method

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Abstract

Recognizing the importance of proper distribution of risk, the effective management of risk allocation has historically proven pivotal for the success of public-private partnerships projects (PPP). Utilizing the principles of fuzzy set theory, the method of assigning risks, is elucidated in New Zealand's social infrastructure PPP projects. This approach delineates the criteria for risk assignment, offering a framework for equitable decisions on risk distribution for both public and private stakeholders. In this chapter, a methodology is established through the utilization of data obtained through a comprehensive questionnaire survey. The analysis of risk allocation employs fuzzy set theory, chosen for its adeptness in handling intricate multi-faceted challenges, particularly in the context of risk distribution decisions that involve the inherent vagueness within human cognitive processes. Sixteen contentious risk factors are assessed against each risk allocation criterion, meticulously examined, and apportioned between the public and private sectors. The findings indicate that for 12 of the risks, the distribution proportions between the government and the private sector are comparable. Risks associated with land acquisition and public opposition are predominantly assigned to the public sector, while risks linked to unforeseen geotechnical conditions and financing are predominantly allotted to the private sector. At present, there exists an absence of comprehensive investigation into risk distribution within social infrastructure PPPs in advanced economies, particularly within the DBFMO model. This research addresses this gap

by thoroughly analyzing key risks and avenues for transferring those risks in New Zealand's DBFMO-based PPPs for schools and prisons. The outcomes of this study are anticipated to guide policymakers in formulating effective strategies for assigning risks and devising well-balanced risk sharing arrangements within PPP contracts. Ultimately, the aim is to achieve outcomes mutually agreeable to both the public and private sectors.

6.1 Introduction

In the midst of the worldwide infrastructure dilemma as the projected investment demand continues to climb (Batra, 2022), public-private partnerships (PPPs) have emerged as a favourable and effective approach for public infrastructure provision such as roads, water supply systems, schools, prisons and hospitals. There is substantial evidence supporting the notion that PPPs yield better performance and value for money (VFM) compared to traditional procurement systems, where the public sector bears sole responsibility for project delivery (Almarri et al., 2019; Koppenjan et al., 2022). However, it should be noted that PPPs are not without challenges, as they involve complex financial arrangements, high investor expectations of returns, extended contract durations, and inherently risky project environments (Kukah et al., 2022).

Construction endeavors carry inherent uncertainties, and when considering PPPs, the risks escalate further. This is due to the expanded scope of responsibilities encompassing not only project construction, but also its ongoing operation, maintenance, and financial aspects (Jefferies and McGeorge, 2009). Effective risk management emerges as a critical strategy to address these significant construction industry risks by: evaluating and confirming project feasibility, examining and managing risks to mitigate potential losses, mitigating risks through meticulous planning, and sidestepping unsatisfactory projects, thereby bolstering profit margins (Lam et al., 2007). Risk management is a methodical process involving the identification, planning for responses, monitoring, and control of project risks (Schieg, 2006). It begins with creating an overall strategy and defining key stakeholder roles, followed by identifying potential project risks. The next steps encompass evaluating risk importance using qualitative, quantitative, or combined methods. Further scrutiny can be applied to vital project risks, aiding in cost projections for risk handling. This leads to risk response planning, where risks are accepted, transferred, avoided, or reduced using various methods. A crucial aspect is appropriately allocating identified risks, often involving assigning risks to parties best equipped to manage them (Karim & Alkaf, 2011). Lastly, risk behavior is observed through monitoring and control, aligning with earlier projections.

Risk transfer is a key benefit of PPPs, enabling the public and private sector to assume and manage specific project risks (Debela, 2022). Previous research has explored the issue of risk transfer and sharing in PPP projects and has identified inefficient risk allocation as a common problem (Shrestha et al., 2018). Numerous studies have compared the actual distribution of risks in PPP projects with recommended allocations based on expert opinions, often using surveys (Rasheed et al., 2022). These studies have consistently revealed a significant mismatch between the preferred and actual risk distributions, resulting in inefficiencies in risk allocation. Recently, some scholars have proposed best practices aimed at evaluating each party's ability to manage identified risks (Ameyaw and Chan, 2016, Mazher et al., 2019).

This paper aims to establish a risk allocation model by employing various RAC derived from existing literature and allocate risks among the two sectors using FSE model. The research findings have implications for both practical applications and academic studies in the field of risk management for PPP projects.

6.2 Literature Review

6.2.1 Previous research on risk allocation

The aim of the risk allocation procedure is to determine suitable methods for transferring and distributing risks between government and private entities (Zhang et al., 2020). The distribution of risks in PPPs has garnered significant interest from researchers in previous studies. Osei-Kyei and Chan (2015) highlighted that a crucial key to successful implementation of PPP projects is the proper allocation of risk, either through transferring it to the private partner or retaining it by the public partner, along with effective risk sharing. Despite its significance, several studies have pointed out insufficient risk allocation practices in PPP projects (Marques & Berg, 2011; (Rasheed et al., 2022; Zou et al., 2008).

According to existing scholarly works, risk allocation frameworks can be sorted into two groups: (i) preferred, and (ii) capability-based. The preferred risk allocation classification strives to comprehend the favoured distribution of risks by analyzing the prevalent or predominant viewpoints and inclinations of decision-makers, along with their perceptions and attitudes toward risk. For example, Ke et al. (2010) conducted research on risk allocation preferences in Chinese PPP projects and revealed that the majority of risks were shared between the public and private sectors. Among the 37 risks analysed, only one risk was exclusively allocated to a public party, while the others were shared equally or proportionally between the two sectors. Similarly, Hwang et al. (2013) studied the preferred allocation of 42 risks in PPP projects in Singapore. They findings revealed the majority of risks to be allocated to private sector. These findings demonstrate a significant disparity between the actual and preferred risk allocation in PPP projects, leading to inefficiencies in risk management.

The capability-based risk allocation approach on the other hand employs a more analytical stance, involving the utilization of decision support systems. This involves the application of theoretical structures grounded in stakeholders' abilities, an organizational perspective rooted in the allocation of resources, and a range of modeling methods like game theory (Medda, 2007), artificial neural networks (ANN) (Jin & Zhang, 2011), fuzzy logic and FSE (Wang et al., 2022, Mazher et al., 2019, Ameyaw and Chan, 2015b).

Medda (2007) employed a final offer arbitration game rooted in game theory to depict the risk allocation process. The study examined this process as a negotiation between public and private partners, considering their varying degrees of risk aversion. The underlying assumption was that one participant exhibits greater risk aversion compared to the other, granting the less risk-averse player more influence over risk control. In the conventional final offer arbitration game, the more risk-averse party presents a more rational ultimate proposition, consequently enhancing their likelihood of being chosen by the arbitrator. Nevertheless, the model's scope is restricted as it overlooks the participants' capacity for risk management and relies on presumptions about their risk tolerance.

Jin and Zhang (2011) applied the theories of transaction cost economics and the resource-based view of organizational capability to formulate risk allocation choices within PPP contracts. They employed ANN methodology to calibrate the model, utilizing data obtained from questionnaires. While their model contributes significantly to the discourse on risk allocation, it does have a drawback associated with the ANN approach. ANNs tend to be unstable predictors, implying that minor alterations in the training data employed for model construction can lead to substantial differences in the resulting models (Cunningham et al., 2000). As a consequence, their proposed model demonstrates a forecast error of up to 20%, indicating the potential distortion in assessing risk allocation. Additionally, Chang (2013) raised criticisms against the utilization of transaction cost economics in elucidating risk allocation decisions, questioning qualification of risk allocation as governance structure.

In light of the limitations inherent in the aforementioned strategies and models, Ameyaw and Chan (2016) introduced a risk allocation model centered around FSE for water infrastructure PPP projects in Ghana. They contend that risk allocation choices, which encompass the utilization of linguistic expressions, experiential expertise, and qualitative evaluations by specialists, can be more effectively captured using FSE. As FSE is better suited to compute and reason about inherent ambiguity linked with linguistic assessments of experts (Lam et al., 2007). Furthermore, Mazher et al. (2019) in their study about fuzzy risk allocation decision modelling in road infrastructure projects in Pakistan remark that most analytical approaches, with the exception of FSE, might necessitate a greater quantity of input information, either for implementation or for the comprehensive and proficient modeling of the fundamental decision quandary. Risk allocation models grounded in FSE, although simpler to apply, rest upon aggregation mechanisms founded on additive metrics, assuming the independence of the RAC. The risk management capability of a party is determined using certain decision criteria in these studies which are explained in next section.

6.2.2 Risk allocation criteria

Commonly known as RAC, these decision criteria provide guidance on the "what, which, and how" aspects of risk allocation in PPP projects. They determine which risks should be allocated to which party and the appropriate methods for doing so. The RAC combined can be good indicator of the risk-taking capacity of a party. Lam et al. (2007) identified a set of seven critical criteria for risk allocation in PPP projects within China, which later served as the foundation for Ameyaw and Chan's (2016) examination of risk allocation in PPP water supply projects in Ghana. Furthermore, Mazher (2019) utilized these same criteria to model risk allocation decisions in road and power infrastructure PPP projects in Pakistan. Despite slight variations, these criteria share common elements. Given the comprehensive nature of the RAC established in Xu et al. (2010), Ameyaw and Chan (2016), and Mazher et al. (2019), this present study adopts the same criteria to develop a risk allocation model for assessing the adequacy of risk allocation in social infrastructure PPP projects in New Zealand. Table 6.1 presents summary of these criteria, which have been previously presented in Table 3.5.

Table 6.1 Risk allocation criteria

(modified with permission from Rasheed et al., 2022)

Risk allocation criteria (RAC)	Description of the criteria
Risk foresight	The capacity of the party to recognize and evaluate risk by foreseeing the likelihood of its occurrence and the potential consequences in occurrence.
Risk response	The capability of the party to proactively reduce both the likelihood and consequences of risk prior to its occurrence.
Curtail risk loss	The capacity of the party to mitigate losses or minimise the impact of the risk if it materializes.
Absorb risk impact	The party's capacity to endure the impact of the risk based on their prior experience.
Reduce risk cost	The party's capability to handle risk with the lowest feasible cost.
Acquire risk premium	The capacity to obtain compensation for a loss incurred due to the occurrence of risk.
Risk attitude	The stance of a party regarding risk management, such as being risk-averse, risk-seeking, risk-neutral, or risk-transfer.

6.2.3 Fuzzy synthetic evaluation

FSE is a decision-making technique used in the field of fuzzy logic and fuzzy systems. It is designed to handle complex, uncertain, and imprecise information by utilizing fuzzy set theory first introduced by Zadeh (1965) to evaluate alternatives or make decisions. A fuzzy set is characterized by its membership being distributed within the closed interval from 0 to 1, allowing for different degrees of membership (Mazher et al., 2019). FSE is particularly useful when dealing with subjective, uncertain, or qualitative information (Ameyaw et al., 2015; Boussabaine, 2013), making it applicable to various fields, such as engineering, economics, environmental management, and decision analysis, where there is often a lack of precise data or when experts' opinions are valuable.

The FSE process involves several steps: criteria and factors are represented as fuzzy sets, allowing gradual membership; criteria are evaluated with linguistic variables and fuzzy membership functions; evaluations are aggregated using methods like weighted average; a defuzzification method turns fuzzy evaluations into crisp values for ranking and decision-making based on preferences or rules (Liu et al., 2013, Osei-Kyei et al., 2017).

The application of this technique extends beyond its use in construction management research, particularly in the assessment of multi-criteria decision making. Notably, Hu et al. (2016) employed FSE to develop a program organization performance index for effectively delivering construction megaprojects in China. They conducted a Delphi survey to gather expert opinions and then utilized FSE to analyse the data.

Furthermore, Oni et al. (2023) utilized FSE analysis to identify critical factors influencing health and safety practices within the Malaysian construction industry. Through this approach, they were able to gain valuable insights into enhancing safety measures and practices in the construction sector. Similarly, Gurmu (2021) applied the FSE approach to calculate the overall importance index of human resource management practices that impact construction labor productivity. This study shed light on the key factors influencing productivity and provided a systematic method for decision-making in workforce management.

In more recent times, the FSE technique has found application in risk assessment and allocation in PPP projects, as demonstrated by (Ameyaw and Chan, 2016, Mazher et al., 2019, Mazher et al., 2018). Building upon this trend, the present study aims to utilize FSE to determine risk allocation proportions for social infrastructure PPP projects in New Zealand. By doing so, the researchers seek to address risk management concerns and optimize the allocation of responsibilities between public and private stakeholders in such projects.

The preference for using FSE over the traditional weighted method stems from its capacity to make the decision-making process more objective and manageable, effectively addressing the inherent subjectivity that often arises in human cognitive processes (Ameyaw and Chan, 2015). By incorporating a fuzzy logic-based approach, this study aims to provide a more nuanced and comprehensive understanding of risk allocation in PPP projects, taking into account various uncertainties and imprecisions that are characteristic of real-world scenarios. This not only enhances the reliability of the results but also ensures that the decision-making process is more robust and adaptable to the complexities of the construction management domain.

6.3 Methodology

The study began with a thorough examination of existing literature, focusing on risk distribution in PPPs and investigating different approaches and techniques to facilitate risk assignment. This literature review led to the initial compilation and documentation of a set of risks and corresponding RACs, establishing a groundwork for the following research steps. A pilot involving two scholars and two industry experts was carried out to assess the effectiveness and applicability of the RAC and risk list, drawing on their substantial expertise. The insights and suggestions from these specialists played a role in enhancing the clarity and reliability of the survey instrument.

To collect data for the study, a questionnaire survey was developed based on the finalized set of criteria and risks identified in the research. Questionnaire surveys have been widely used in the field of construction management research, making it a suitable approach for this study

(Wahid et al., 2023). The questionnaire consisted of two main sections. The survey was administered using an online questionnaire tool called Qualtrics. The utilization of an online questionnaire tool, such as Qualtrics, provided a convenient and efficient means of administering the survey. It enabled easy distribution, data collection, and data management, streamlining the research process.

The first section gathered details about the participants' backgrounds in order to evaluate their experience and familiarity concerning PPP projects. The second section of the survey aimed to capture the participants' perceived capability for risk management within their organizations, concerning each of the recognized RACs for the corresponding risks. They were also asked to rate the importance of each RAC with respect to others. This assessment was conducted using a five-point Likert scale, spanning from 1 (very low) to 5 (very high). Furthermore, a "no idea" (NI) option was included, allowing respondents to indicate their uncertainty in answering specific questions. This approach ensured that the data collection process accommodated the diverse levels of expertise among the participants.

A blend of non-probability sampling approaches, specifically convenience and judgment sampling, was utilized due to the absence of a precise population. Convenience sampling was implemented to choose participants based on their accessibility and willingness to take part, focusing on experts from PPP organizations with prior involvement in social infrastructure PPP undertakings in New Zealand. Additionally, judgment sampling was applied, whereby the researchers employed their knowledge of the PPP scene to select participants anticipated to offer insightful perspectives. In doing so, professionals were individually approached through email and professional networking platforms like LinkedIn.

43 valid survey responses were acquired for this study, 15 from public sector (35%) and 28 from private sector (65%) with an average respondent experience of 7.2 years. To gauge the

appropriateness of the sample size, comparisons were drawn with similar studies that employed questionnaire surveys. Osei–Kyei et al. (2021) garnered 48 responses, while Ameyaw and Chan (2016) secured 37 responses in their respective studies. In light of these benchmarks, the sample size for the present study was deemed satisfactory for subsequent analysis. It is also important to recognize that New Zealand has a relatively small number of PPP projects.

Independent samples t-test was performed to explore whether a notable difference existed in the mean responses between two separate groups of participants: those from the public sector and those from the private sector. This examination sought to uncover possible divergences in viewpoints concerning the 16 risks. A significance level of 0.05 was employed as the benchmark to establish whether the observed distinctions held statistical significance. Among the t-test findings, seven risks produced results falling below the significance threshold of 0.05. The results from the test are presented in Appendix F. For risk allocation modelling, FSE approach was utilized which is explained in the next section.

6.4 FSE Risk Allocation Model and its Application

In this study, the risk allocation model based on FSE is structured according to the following steps:

Step 1. Formulate a fundamental set of criteria denoted as $S = \{s_1, s_2, s_3 \ldots s_n\}$, where '$n$' represents the number of criteria. In this study, a set of seven RAC are used to formulate this set given as:

$$S = \{s_1, s_2, s_3, s_4, s_5, s_6, s_7\}$$

Step 2. Assign grade alternatives to the set, labeled as $G = \{g_1, g_2, g_3 \ldots g_n\}$. These grade categories serve as the measurement scale, for instance, utilizing a 5-point Likert scale: very low, low, medium, high, very high. Fuzzy set theory is applied to associate numerical scale values with the linguistic terms used in the grading system, hence G = {1, 2, 3, 4, 5}, where 1 represents very low and 5 corresponds to very high on scale.

Step 3. Determine the weightings W = {W_{S1}, W_{S2}, W_{S3} ... W_{Sn}} for each criterion or factor component. These weightings (W) are calculated from survey data using the following equation:

$$W_k = \frac{M_k}{\sum_{k=1}^{n} M_k} \quad where\ 0 \le W_k \le 1, and\ \sum W_k = 1 \tag{6.1}$$

Here, W_k represents the weighting of a specific criterion, and M_k is the mean score of a specific criterion or factor component. Mean scores/RAC importance level for RAC_1 through RAC_7 came out to be 4.34, 4.12, 4.08, 3.81, 3.92, 3.74 and 3.52. Results from RAC importance level from survey were used to develop weightings for all 7 criteria. Relative importance of RAC. Example calculation for RAC_1 is shown below:

$$W_{S_1} = \frac{M_k}{\sum_{k=1}^{7} M_k} = \frac{4.34}{4.34 + 4.12 + 4.08 + 3.81 + 3.92 + 3.74 + 3.52} = 0.158$$

Similarly, weighting components of remaining 6 RAC were calculated and factor component set W = {0.158, 0.150, 0.148, 0.139, 0.142, 0.136, 0.128} was achieved, whereas $\sum_{k=1}^{7} M_k = 1$

Step 4. Develop a fuzzy evaluation matrix for public and private sector against each risk. This matrix, denoted as R = $(S_{ij})_{m \times n}$, captures the extent to which graded alternative "*G*" satisfies the criterion "*S*".

$$R = \begin{vmatrix} s_{11} & r_{12} & \cdots & s_{1n} \\ s_{21} & r_{22} & \cdots & s_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ s_{m1} & s_{m2} & \cdots & s_{mn} \end{vmatrix} \tag{6.2}$$

In this step, fuzzy evaluation matrix for each of the 16 risks were computed for public and private sector participants based on their responses to each RAC. For example, for RF_1 “Inflation”, public sector respondents indicated following percentages for the criteria RAC_1 “risk foresight”: 7% as very low, 14% as low, 29% as moderate, 42% as high and 8% as very high. Hence, in the above matrix, $s_{11} = 0.07$, $s_{12} = 0.14$, $s_{13} = 0.29$, $s_{14} = 0.42$ and $s_{15} = 0.08$. Similarly, all the remaining components of above matrix were calculated for each criterion for risk of inflation from public sector responses. Final matrix of 7x5 obtained for the risk of inflation is as follows and tabulated for all the of the risks in Appendix G:

$$R_{RF\_1_{public}} = \begin{vmatrix} 0.07 & 0.14 & 0.29 & 0.42 & 0.08 \\ 0.14 & 0.36 & 0.29 & 0.14 & 0.07 \\ 0.15 & 0.14 & 0.32 & 0.32 & 0.07 \\ 0.07 & 0.14 & 0.27 & 0.45 & 0.07 \\ 0.07 & 0.21 & 0.36 & 0.36 & 0 \\ 0.14 & 0.42 & 0.29 & 0.07 & 0.08 \\ 0.56 & 0.15 & 0.22 & 0.07 & 0 \end{vmatrix}$$

Similarly, evaluation matrix for risk of inflation for private sector is given by

$$R_{RF\_1_{private}} = \begin{vmatrix} 0.21 & 0.21 & 0.29 & 0.29 & 0 \\ 0.36 & 0.43 & 0.14 & 0.07 & 0 \\ 0.14 & 0.36 & 0.36 & 0.07 & 0.07 \\ 0.14 & 0.14 & 0.36 & 0.36 & 0 \\ 0.17 & 0.33 & 0.5 & 0 & 0 \\ 0.33 & 0.58 & 0.08 & 0 & 0 \\ 0.69 & 0.23 & 0.08 & 0 & 0 \end{vmatrix}$$

Step 5. Calculate the final FSE results by considering the weighting vector and the fuzzy evaluation matrix using the following equation:

$$D = W_i \circ R_i \tag{6.3}$$

Where D is the final FSE matrix, and ∘ represents a fuzzy composition operator, W is the weighting factor and R is the evaluation matrix.

Continuing the example of risk of inflation and substituting the numerical values of W_i and R_i from above steps 3 and 4 for public sector and private sector, the final FSE matrix is obtained as follows:

$$D_{RF\_1_{public}}$$

$$= (0.158, 0.150, 0.148, 0.139, 0.142, 0.136, 0.128)x \begin{vmatrix} 0 & 0.27 & 0.27 & 0.36 & 0.09 \\ 0.27 & 0.36 & 0.27 & 0.09 & 0 \\ 0.18 & 0 & 0.36 & 0.36 & 0.09 \\ 0 & 0.09 & 0.45 & 0.45 & 0 \\ 0.09 & 0.18 & 0.18 & 0.36 & 0 \\ 0.1 & 0.5 & 0.3 & 0.1 & 0 \\ 0.54 & 0.18 & 0.18 & 0.09 & 0 \end{vmatrix}$$

$$= (0.164, 0.227, 0.317, 0.265, 0.028)$$

$$D_{RF\_1_{private}}$$

$$= (0.158, 0.150, 0.148, 0.139, 0.142, 0.136, 0.128)x \begin{vmatrix} 0.21 & 0.21 & 0.29 & 0.29 & 0 \\ 0.36 & 0.43 & 0.14 & 0.07 & 0 \\ 0.14 & 0.36 & 0.36 & 0.07 & 0.07 \\ 0.14 & 0.14 & 0.36 & 0.36 & 0 \\ 0.17 & 0.33 & 0.5 & 0 & 0 \\ 0.33 & 0.58 & 0.08 & 0 & 0 \\ 0.69 & 0.23 & 0.08 & 0 & 0 \end{vmatrix}$$

$$= (0.285, 0.326, 0.262, 0.116, 0.010)$$

Following the same approach, final FSE matrices for all of the remaining 15 risks were developed by repeating steps 4 and 5. The resulting matrices for all of the risk are reported in 3rd and 4th column of Table 6.2 for public and private sector.

Table 6.2 Risks, RMC and allocation proportions for public and private sector

Risk ID	Risk	D_{public}	$D_{private}$	RMC_{pb}	RMC_{pr}	P_{public}	$P_{private}$
RF_1	Inflation	(0.164,0.227,0.317,0.265,0.028)	(0.285,0.326,0.262,0.116,0.010)	2.83	2.24	55.77	44.23
RF_2	Variation in foreign exchange rate	(0.111,0.306,0.387,0.183,0.014)	(0.275,0.382,0.253,0.090,0.000)	2.79	2.16	56.37	43.63
RF_3	Interest rate fluctuation	(0.141,0.242,0.364,0.225,0.029)	(0.207,0.371,0.332,0.076,0.013)	2.81	2.31	54.86	45.14
RF_4	Land acquisition	(0.027,0.204,0.248,0.367,0.157)	(0.242,0.328,0.326,0.098,0.000)	3.46	2.27	60.44	39.56
RF_5	Public opposition to project	(0.047,0.154,0.336,0.401,0.074)	(0.272,0.384,0.301,0.043,0.000)	3.37	2.11	61.42	38.58
RF_6	Change in law/regulation	(0.038,0.225,0.349,0.348,0.041)	(0.124,0.478,0.295,0.084,0.021)	3.13	2.41	56.56	43.44
RF_7	Unexpected geotechnical conditions	(0.240,0.312,0.271,0.147,0.000)	(0.053,0.239,0.437,0.198,0.083)	2.30	3.05	42.97	57.03
RF_8	Supply/resourcing risk	(0.099,0.399,0.232,0.206,0.065)	(0.038,0.259,0.426,0.189,0.088)	2.72	3.03	47.34	52.66
RF_9	Delay in project approvals and permit	(0.012,0.163,0.317,0.407,0.091)	(0.050,0.157,0.492,0.257,0.041)	3.36	3.08	52.19	47.81
RF_10	Insurance risk	(0.093,0.318,0.460,0.097,0.033)	(0.032,0.322,0.489,0.135,0.023)	2.65	2.80	48.64	51.36
RF_11	Unforeseen project characteristics	(0.072,0.330,0.374,0.211,0.013)	(0.090,0.291,0.483,0.113,0.021)	2.69	2.68	50.11	49.89
RF_12	Financing risk	(0.330,0.280,0.220,0.130,0.030)	(0.059,0.110,0.425,0.286,0.115)	2.17	3.27	39.89	60.11
RF_13	Lack of PPP experience	(0.059,0.259,0.367,0.300,0.014)	(0.050,0.190,0.368,0.273,0.115)	2.90	3.20	47.54	52.46
RF_14	Weather risk	(0.164,0.222,0.313,0.207,0.095)	(0.157,0.356,0.361,0.104,0.020)	2.77	2.47	52.91	47.09
RF_15	Change in government	(0.163,0.319,0.301,0.202,0.016)	(0.192,0.440,0.306,0.063,0.000)	2.62	2.24	53.91	46.09
RF_16	Design changes	(0.108,0.182,0.303,0.380,0.028)	(0.010,0.131,0.439,0.282,0.137)	3.03	3.40	47.13	52.87

D_{public} & $D_{private}$ = FSE matrix for public and private sector, RMC_{pb} & RMC_{pr} = Risk management capability for public and private sector,
P_{public} & $P_{private}$ = Risk allocation proportion for public and private sector

Step 6. Normalize the final FSE matrix, and compute a Risk Management Capability Index (RMCI) for a particular risk using subsequent equation, where S is a defuzzification function given by S = (0.125, 0.25, 0.5, 0.75, 0.875) corresponding to the scale used:

$$RMCI = \textstyle\sum_{i=1}^{n} D \; x \; S \qquad (6.4)$$

For the risk of inflation, RMC index of public and private sector is calculated as follows.

$$RMCI_{RF\_1_{public}} = \sum_{i=1}^{5} D \; x \; S$$

$$= (0.164, 0.227, 0.317, 0.265, 0.028) x \; (0.125, 0.25, 0.50, 0.75, 0.875) = 0.47$$

$$RMCI_{RF\_1_{private}} = \sum_{i=1}^{5} D \; x \; S$$

$$= (0.285, 0.326, 0.262, 0.116, 0.010) x \; (0.125, 0.25, 0.50, 0.75, 0.875) = 0.34$$

Similarly, RMCI of remaining risk factors for public and private sectors are computed and presented in Table 6.2.

Step 7. Public and private sector partners have varying capacities to carry risks for specific risk factors, as is evident from the results of step 6. Since it's important to assign risk according to each party's capability, the RMCI levels calculated through FSE can be utilized to allocate risk proportions to both the public and private sectors. For example, the risk allocation proportions for the risk of inflation can be distributed as follows.

Risk allocation proportion of public sector for RF_1 "Inflation":

$$P_{RF\_1_{public}} = \frac{RMCI_{RF\_1_{public}}}{RMCI_{RF\_1_{total}}} = \frac{RMCI_{RF\_1_{public}}}{RMCI_{RF\_1_{public}} + RMCI_{RF\_1_{private}}} = \frac{0.47}{0.47 + 0.34}$$

$$= 57.70\%$$

Risk allocation proportion of private sector for RF_1 "Inflation":

$$P_{RF\_1_{private}} = \frac{RMCI_{RF\_1_{private}}}{RMCI_{RF\_1_{total}}} = \frac{RMCI_{RF\_1_{private}}}{RMCI_{RF\_1_{public}} + RMCI_{RF\_1_{private}}} = \frac{0.34}{0.47 + 0.34}$$

$$= 42.30\%$$

Table 6.2 also presents the risk allocation proportions of all the risks.

6.5 Discussion

The FSE model generates proportions for distributing risk between the public and private sectors based on their RMC. Ameyaw and Chan, (2016) argue that the distribution of risk proportions should be upheld by the contractual framework, payment methods, and tools for mitigating financial risk that are chosen within the contract. These elements need to be blended and incorporated into the decision-making process for risk allocation, ensuring an effective and efficient distribution of risk. Discussion regarding the distribution of risk proportions for certain risks is presented next based on the outcomes derived from the model and the potential reasoning behind those outcomes. Risks to be discussed are selected based on their proportion of allocation i.e., similar allocation between two sectors, higher allocation for one of the sectors.

6.5.1 Risks with similar allocation proportions

Risks of inflation, exchange rate and interest rate have very similar proportions of risk allocation between the two sectors with public and private sector bearing approximately 55% and 45% of risk respectively. This allocation is in agreement with previous studies which have shown such finance related risks to be shared among both sectors (Mazher et al., 2019, Ke et al., 2010b). Ke et al. (2010a) argue in their preferred risk allocation study that such risk should be equally shared between public and private sector for the reason that such risks are not in control of any of the parties involved due to their macroeconomic nature. However, others have argued that the decision to retain, share or transfer is based on the type of PPP and the payment mechanism employed. For example, in UK's toll road PPP projects such risks were transferred onto the private sector due to the increase in toll payment paid by the end user with the increasing inflation or interest rates (Bing et al., 2005). Consequently, for projects on an availability mode of PPP scheme the risk is shared (Dunn, 2017).

Overall, the consensus points towards the sharing of these risks. Both public and private sector can use different strategies to manage these risks. For the risk of inflation, private sector might absorb some of the risk through effective cost management and pricing strategies, while the public sector could share the burden, especially if it has the ability to regulate prices or provides cost guarantees. Similarly, for risk of interest rate changes, private sector has tools for managing interest rate risk (e.g., interest rate swaps, hedging mechanisms) and public sector, with its ability to issue bonds and potentially secure more stable financing, could share or assume this risk.

6.5.2 Risks with greater public sector allocation

Risks of land acquisition and public opposition display a nearly similar distribution of risk between the two sectors, where the public sector shoulders around 61% of the risk, while the private sector assumes approximately 39%. For the risk of land acquisition, the concessionaire is often not the best choice to manage land acquisition due to potential delays and costs from dealing with multiple landowners and establishing ownership titles. Typically, the contracting authority assumes this responsibility to avoid delays and extra expenses as they might be more adept at handling regulatory and community aspects of land acquisition. Similarly, for the risk of public opposition, the government as the representative of public interests, may be better positioned to handle public opposition through effective communication, addressing concerns, and ensuring that the project aligns with public welfare.

The allocation of these risks aligns with prior research findings that have demonstrated a tendency to assign these risks predominantly to the public sector. For instance, Ke et al. (2010c) found that risk of land acquisition should be mostly allocated to the private sector, and risk of public opposition to be allocated between the two sectors with an inclination towards public sector allocation in countries like China and UK. Ameyaw and Chan (2015b) argue in the favour of public sector allocation of land acquisition risk citing expropriation to acquire land for public interests. However, they proposed a sharing mechanism for the risk of public opposition arguing that both sides are jointly responsible for effectively conveying and expressing the potential project advantages to the community.

6.5.3 Risks with greater private sector allocation

Risks of unexpected geotechnical condition and financing are the only risks where private sector risk allocation percentage is relatively more than public sector. Private sector is allocated 56.96% and 59.41% share for respective risks. The distribution of this risk also reflects differing preferences in risk allocation as observed in existing literature. Yescombe (2011) suggests that allocating the risk of unexpected geological conditions on a site is challenging, and ideally, it should be transferred to the private entity and then to construction subcontractors. However, private sector may charge a hefty risk premium for assuming this risk which will ultimately affect the ‘achieving value for money’ objective of public sector. Alternatively, Ke et al. (2010a) suggest that given the complex and unpredictable nature of geotechnical risks, a shared allocation might be optimal.

A primary motivation for engaging in public-private partnerships is the attraction of private investment due to government budget limitations. Consequently, the primary duty of financing arrangements largely lies with the private sector. Existing literature also suggests that this risk should be allocated to private sector (Ke et al., 2010a, Bing et al., 2005). The financial commitments of the contracting authority or other governmental bodies are confined to those explicitly outlined in the project agreement or to direct forms of assistance provided by the government to the project. In certain instances, government backing may involve direct or indirect equity involvement in the project company to achieve a favourable debt-to-equity ratio and to show support.

6.6 Conclusion

Governments around the world are increasingly showing a preference for PPPs when it comes to carrying out public infrastructure projects. Existing literature accentuates the importance of allocation and sharing of risks based on the risk management abilities of the parties involved. Effectively assigning risks is essential for ensuring good value in PPP projects. However, there have been criticisms and difficulties in putting this into practice. The conventional method of assigning risks has been scrutinized by scholars for lacking clarity and objectivity in assessing the capabilities of the sectors participating. More recently, researchers in developing countries have put forth approaches to risk allocation based on the capabilities of the involved parties. These approaches have been applied in water and road infrastructure sectors, utilizing decision models that consider multiple criteria. Nonetheless, these models are somewhat constrained by factors like location, mode of PPP delivery, and the type of infrastructure being developed.

This study investigates how risks are allocated in New Zealand's DBFMO mode of PPP social infrastructure projects. The study relies on a well-established RAC that can be adapted to reflect the risk management abilities of both the public and private entities. To analyse and make decisions, the study adopted FSE. This approach is well-suited for handling the uncertainty present in qualitative RAC assessments and effectively considers the uncertainty in expert opinions that is inherent in decision-making about risk allocation.

Expert opinions were solicited to establish the risk management capability using seven RAC against 16 contentious risks identified from literature. FSE risk allocation results show that private sector gets more allocation percentage for risks of financing and unexpected geotechnical condition. Risks of public opposition and land acquisition lie mostly with the public sectors. Remainder of the risks exhibit close proportions of allocation between the public and private sector. Furthermore, discussion and reasoning around distribution tactics for particular risks among various infrastructure sectors is provided to better understand allocation proportions. The extent of risk assigned to a party is closely linked to the nature of the risk and the diverse underlying situations that require separate examination. This opens up opportunities for future studies to formulate frameworks that steer the determination of risk-sharing proportions among the involved parties.

The research findings might be limited due to low responses. Nevertheless, it's important to note that the sample size was considered adequate compared to similar studies. Therefore, despite this limitation, meaningful conclusions can still be drawn and applied in future applications and as a benchmark. Furthermore, the less popular DBFMO model in New Zealand could limit the transferability of the outcomes to other global regions. However, it's crucial to acknowledge the distinct nature of PPPs in New Zealand, offering a chance for learning and comprehending unique risk allocation practices. Despite potential limitations in broad applicability, the research findings remain valuable for guiding future research and informing international policy practices.

7 Validation of FSE based PPP risk allocation model

Validity is the extent to which and instrument accurately measures the target it was designed to measure (Price et al., 2015). Validity is of paramount importance in construction management research for several key reasons such as usability, credibility, replicability and generalizability of research findings. Lucko and Rojas (2010) highlighted that the validation process is contingent upon the particular objective of the study. Abowitz and Toole (2010) suggest that three types of validity are most commonly used in construction management research: construct, internal and external validity. Construct validity refers to the extent to which the indicators used in a study accurately represent the underlying theoretical constructs or concepts being investigated (Cook et al., 1979). For example, in this study, the underlying construct being measured is the risk allocation proportion based on RMC and the indicators being used to measure this construct are the seven RAC. Internal validity ensures that the research accurately establishes causal relationships and minimises alternative explanations for the results and external validity refers to the extent to which the findings and conclusions of a study can be generalized or applied to real-world settings beyond the specific context of the research.

Research validity assessment can be divided into qualitative and quantitative methods (Ameyaw, 2015). Qualitative approaches deal with subjective, opinion-based data, using expressions in words and ideas (e.g., face validation and content validation). In contrast, quantitative methods use numerical or statistical data to test relationships between variables. This study opted for a qualitative validation method due to the difficulty in quantitatively assessing abstract constructs such as critical risk factors and RAC in the proposed model. The validity approach similar to Osei-Kyei (2017) and Cheung (2009) was adopted with modifications for this study. They used a 5-point scale to determine the appropriateness of validation statement using a survey involving academic participants. For this study, author used a semi-structured interview approach and involved six industry participants to validate the model. The participants were selected considering their risk management knowledge and experience in PPPs within New Zealand. Their involvement in the prior stages of research was also considered and it was ensured that none of them participated in this research earlier. Interviewees were presented with the background of the study, summary and flowchart (Figure 7.1) of the FSE model, an illustration of the model with an example and final risk allocations for all the risks.

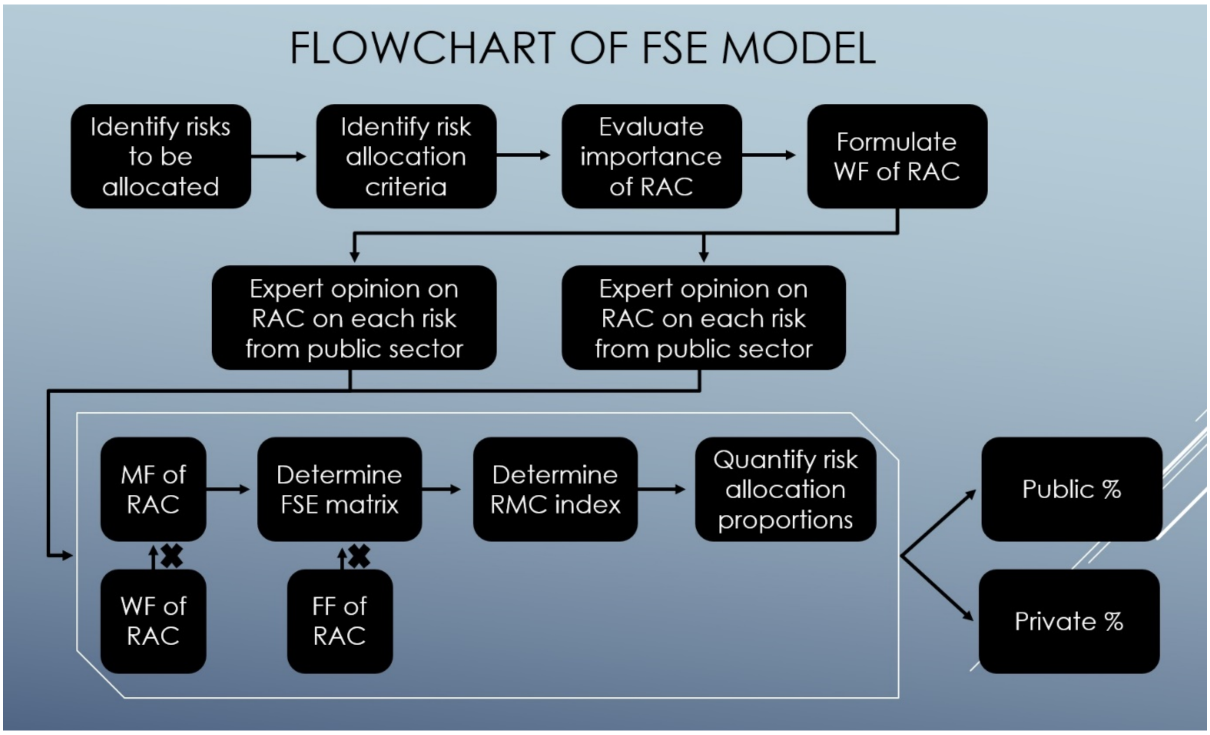

Figure 7.1 Flowchart of the fuzzy risk allocation model

(MF = Membership Function, WF = Weightage Function, FF = Fuzzification Function)

Table 7.1 shows the background of the subject matter experts (SME) involved. The table indicates that each of the six experts has considerable experience with PPPs in New Zealand. Additionally, they hold senior-level positions within their respective sectors which add to the credibility of the validation responses.

Table 7.1 Background information of experts

Expert ID	Sector	Position	Experience
SME01	Public	Policy Director	30 years
SME02	Public	Policy Advisor	10 years
SME03	Private	Technical Director Civil Engineering	25 years
SME04	Private	Technical Director Risk Management	25 years
SME05	Private	Senior Principal	30 years
SME06	Private	Chief Executive and Principal Economist	8 years

Subsequently, they were requested to evaluate and provide feedback on various facets of the model, encompassing the suitability of the risk assessment criteria employed, the simplicity of comprehension and utilization, the distributions of risk allocation, appropriateness of steps involved, and the potential for real-world application of the model. For simplicity of analysis, they were asked to evaluate these aspects of the model on a scale (1-poor, 2-average, 3-good, 4-very good and 5-excellent). The mean scores based on responses from experts to the questions are presented in Table 7.2. SME06 did not respond to the questionnaire; however, their feedback is discussed in the next section.

As indicated in the table, the mean values for all validity questions are equal to or surpass 3. This suggests that, on the whole, the experts viewed the model's validation aspects as either 'good' or ‘very good’.

Table 7.2 Validation questions of mean scores

	Questions	Mean scores
1	Are the risk allocation criteria used in the model appropriate to assessing the risk management ability?	4
2	Can practitioners easily comprehend and utilize the fuzzy synthetic evaluation risk allocation model?	3.2
3	Do the risk distribution ratios appear sensible and feasible within a standard social infrastructure PPP venture?	3.2
4	Do the steps of implementing the model follow a coherent sequence, allowing for its replication by researchers or practitioners?	3.4
5	Is the model appropriate for practical adoption in making risk allocation decisions within PPP social infrastructure endeavors in New Zealand?	3.2
6	Is the model appropriate for practical adoption in making risk allocation decisions within PPP social infrastructure endeavors in other countries?	3

7.1.1 Appropriateness of the RAC

In terms of evaluating the effectiveness of the RAC when it comes to assessing the risk management capability of either a public or private partner (question 1), the average score given by experts is 4, indicating a "very good" rating. This suggests that the RAC used in creating the model are both inclusive and pertinent. While commenting on the criteria experts used terms like “good”, “comprehensive” and “appropriate”. However, SME01 commented *“good set of criteria; potentially could also cover financial ability to cover risk”.*

7.1.2 Model comprehension

On the ease of comprehension of the proposed model (question 2) the expert's mean score is 3.2. This suggests a moderately positive perception of the model's usability within the targeted practitioner community. While commenting on this question experts expressed their concern about the complex mathematics involved and a need for clearer explanation of the steps involved. SME01, SME02 and SME03 commented, thus:

"Quite complex maths in the background but a simple and easy to follow summary graph." (SME01)

"It looks reasonably easy to understand - I think there would need to be clearer definitions and explanations for this to be more widely implemented though, so all parties were on the same page." (SME02)

"Sure, the steps look straightforward, but some practitioners might find the fuzzy part a bit challenging." (SME03)

SME05 had a different opinion on the matter:

"Interesting to see the mathematical approach, risk ownership would still get applied by discussion on individual risks rather than a mathematical formula driving by broad responses across an industry".

The responses from SME01, SME02, and SME03 indicate a general appreciation for the graphical representation of complex mathematics, with SME01 highlighting the simplicity of the summary graph. However, SME02 raises concerns about the need for clearer definitions and explanations for wider implementation, emphasizing the importance of ensuring all stakeholders share a common understanding. SME03 acknowledges the apparent straightforwardness of the steps but notes potential challenges for some practitioners, particularly in the "fuzzy" aspects. In contrast, SME05 presents a divergent viewpoint, expressing interest in the mathematical approach but suggesting that risk ownership should be determined through individual risk discussions rather than relying on a broad mathematical formula applied across an entire industry. Overall, the responses collectively reflect a nuanced perspective, recognizing both the strengths and potential limitations of the presented methodology.

7.1.3 Feasibility of risk allocation proportions

The feasibility of the risk allocation proportions received a ‘good’ score of 3.2 from the experts. This suggests that the allocation ratios are moderately acceptable and relevant, but there could be room for improvement. With regards to risk allocation in practice, experts expressed their concerns on how negotiation between the PPP partners plays an important role in deciding the most feasible allocation. Furthermore, SME05 expressed their concern about the potential challenges that may arise from the implementation of the proposed allocation proportions in practice. Similarly, SME02 commented as follow:

“the risk allocation will really depend on the contractual arrangements and the ability of the negotiating partners. A lot of the NZ experience to date has ultimately ended up with the Government left carrying the can.” (SME02)

SME03 commented on the appropriateness of the proportions as follows:

“The risk distribution ratios seem reasonable on paper, but putting them into practice within a standard social infrastructure PPP venture might pose some challenges.” (SME03)

The above responses provide critical insights into the complexities of risk allocation within contractual arrangements for social infrastructure PPP ventures. SME02 emphasizes the significance of contractual arrangements and negotiating partners in determining risk allocation, highlighting that in New Zealand's experience, the government often ends up bearing a substantial burden. This implies potential challenges in effectively distributing risks. SME03, while acknowledging the apparent reasonableness of risk distribution ratios on paper, raises concerns about the practical implementation within a standard social infrastructure PPP venture, suggesting that translating theoretical allocations into real-world scenarios may pose difficulties. These responses collectively underscore the intricate nature of risk management in PPPs and the potential gaps between theoretical frameworks and practical challenges in execution.

7.1.4 Replication of research

On the question of replication by researchers or practitioners, expert's mean score of 3.4 indicated a 'good' consensus. This suggests that the experts have a decent level of confidence in the logical sequence of steps for implementing the model, indicating that researchers and practitioners in other PPP infrastructure projects are likely to be able to replicate it successfully. This observation also implies that the overall research design appears to be sound and suitable for its intended purpose. For instance, SME04 commented "looks like a robust and repeatable model". SME03 expressed their content with the replication however they had their reservation on the complexity of the model for practitioners (similar to SME01 in response to question 2). SME03 mentioned

"Yes, the steps for implementing the model seem to follow a coherent sequence, making it easier to replicate, but again the fuzzy part might be challenging for some practitioners." (SME03)

7.1.5 Practical adoption

On the appropriate for practical adoption in making risk allocation decisions within PPP social infrastructure endeavors in New Zealand and in other countries the experts gave a mean score of 3.2 and 3 respectively, indicating a 'good' consensus among them. However, while commenting on these aspects, experts expressed their concerns about the widespread adoption of the model due to the complex nature of PPP contracts, slow adoption and need to exercise caution while adopting new practices. For adoption in New Zealand, SME01, SME02 and SME04 commented

"PPPs are very complex commercially so it's hard to know how this would get translated into the contact itself. PPPs are not well-aligned to collaborative models since they are essentially a cascade of contracts." (SME01)

"I would definitely support testing it in a real-life environment and maybe talking to Te Waihanga (New Zealand Infrastructure Commission) about the opportunity for this within their major projects master class potentially." (SME02)

"It's an interesting idea to use the model, but we must be cautious. Practical adoption depends on rigorous testing and validation within the New Zealand PPP environment. We can't rely solely on the model; human expertise and judgment will still play a significant role." (SME04)

On the question of widespread adoption of the model in other countries, most of the experts avoided to comment citing their lack of international PPP experience and knowledge of other jurisdictions. However, SME04 had this to say

"I have reservations about the model's suitability for international use. The complexities of PPP infrastructure endeavors can vary greatly from country to country, and a one-size-fits-all approach may not be advisable." (SME04)

SME05 responded no to question 5 and 6.

"Generally, no. Many of the risk allocations will be project specific. Some might be able to be applied to a PPP framework though (funding risks, change in laws, etc.)."

The responses from SME01, SME02, and SME04 in the context of adopting a PPP model in New Zealand reflect a nuanced perspective. SME01 and SME02 express concerns about the complexity of PPPs, highlighting the difficulty in translating them into contracts and suggesting a cautious approach through real-life testing and engagement with relevant bodies like the New Zealand Infrastructure Commission. In contrast, SME04 acknowledges the model's potential but emphasizes the need for rigorous testing within the New Zealand PPP environment, underscoring the importance of human expertise and judgment. The consideration of the model's international applicability by SME04 raises valid concerns about the diverse complexities of PPP infrastructure projects across countries. SME05, however, offers a straightforward "no" to the idea of widespread adoption, citing the project-specific nature of risk allocations and hinting at potential limitations in applying a PPP framework universally. Overall, the responses demonstrate a thoughtful evaluation of the practicality, adaptability, and potential risks associated with adopting the PPP model in New Zealand and internationally.

7.2 Additional Feedback from Experts

In addition to the aforementioned assessment of questions and opinions regarding the model, the expert participants were also invited to share additional remarks about risk allocation and the status of PPPs in New Zealand. Most of them offered overall qualitative input and recommendations. Presented below are some general concerns and comments expressed by these experts:

SME01 highlighted the potential effectiveness of PPPs when the desired outcomes are well-defined and the SPV is granted the flexibility to determine how to achieve those outcomes. However, the expert criticized the approach taken in New Zealand, which involves retaining many conventional contract requirements while simply adding a PPP framework on top. This approach, in their opinion, falls short of optimizing the potential benefits of PPPs.

This expert's viewpoint underscores a common challenge in PPP implementation. The success of PPPs hinge on clearly defined objectives and allowing private partners the flexibility to innovate and optimize their approaches. These factors have been identified in pertinent literature (Osei-Kyei & Chan, 2015) as well in the initial stages of this research (Chapter 2) to be critical for the success of PPPs. When traditional contract requirements are overly rigid, they can stifle innovation and efficiency (Liu & Wilkinson, 2011). In essence, the criticism points to a lack of a genuine partnership spirit in New Zealand's PPP approach, where the public and private sectors should ideally work collaboratively, leveraging each other's strengths to achieve common goals. This perspective underscores the importance of tailoring PPP arrangements to the specific needs of each project, rather than adhering strictly to a one-size-fits-all model. In practice, striking the right balance between well-defined outcomes and flexibility is a challenge that requires careful consideration to ensure PPPs deliver their intended benefits.

SME04 highlighted a critical concern regarding the expectation of transferring majority if not all of the risks to private entities in PPPs, particularly in the context of lengthy and high-risk infrastructure projects, such as Transmission Gully and Pūhoi to Warkworth, which span over 30 years. The expert asserted that risk allocation should align with the organizations best equipped to manage those risks efficiently, as a fundamental principle of procurement (Bing et al., 2005; Ke et al., 2010; Hwang et al., 2013; Chen & Zhang, 2020). They argue that the New Zealand PPP model emphasizes efficient risk allocation to the party with the most capability to handle it. However, the expert questions the use of design and construct contract models, typically reserved for well-defined and less complex projects, for such complex and high-risk endeavors. These contract models were employed in these projects to guarantee fixed prices and returns for financing companies. The expert suggested considering a shift towards more collaborative models like an 'alliance' to enhance risk-sharing. This would require accepting more risk on the returns for both financing organizations and government delivery agencies.

Analyzing this response, the expert raises a valid point about the necessity to reevaluate risk allocation in PPPs for long-term, complex projects. They argue against the common practice of completely transferring risks to the private sector, emphasizing that such a strategy may not be suitable for projects with extended timelines and significant uncertainties. The proposal to transition to a more collaborative 'alliance' model is thought-provoking and aligns with modern PPP practices that acknowledge the importance of risk-sharing and long-term cooperation. However, it's essential to consider the implications of placing more risk on financing organizations and government agencies, as this could affect the attractiveness of PPP projects for private investors and the feasibility of project delivery. While ‘alliancing’ can offer several advantages, it also presents certain disadvantages compared to traditional PPPs. Striking the right balance between risk transfer and risk-sharing in PPPs is a nuanced challenge that requires careful consideration of project-specific factors and overall policy objectives (Tallaki & Bracci, 2021).

SME02 in their response suggested the current situation of PPPs in New Zealand appeared to be at a crossroads. The current Labour government's skepticism towards PPPs, particularly for social infrastructure, reflects a broader global trend where some governments have become more cautious about involving the private sector in public projects. This caution can stem from concerns about cost, accountability, and the potential for profit-making in essential services. The absence of upcoming PPP projects suggests that the government's reluctance is translating into action, as there are no immediate plans to engage in such partnerships. This indicates that the current policy stance has a tangible impact on project procurement methods. They also mentioned of a potential *"government change (National) in the near future to favour PPPs"*, which introduced PPPs in New Zealand initially. SME02 asserted, if there were to be a change in leadership and subsequent shifts in policy, the research findings could provide a basis for reevaluating the role of PPPs in New Zealand. This reflects the dynamic nature of infrastructure policy, which can evolve with changing governments and priorities.

SME05 in their responses expressed skepticism about the applicability of a mathematical approach to risk allocation modeling in PPPs in New Zealand. The expert noted that risk profiles are typically established during the tendering phase, and contractors must accept the predetermined risk allocation in the project agreement, which in their opinion is one of the major drawbacks of current PPP approach in New Zealand. However, the expert acknowledged that certain risks, such as inflation rate, foreign exchange, interest rates, and changes in law, are standard across projects. The expert also emphasizes the project-specific nature of certain risks, such as unexpected geotechnical conditions and design changes, which may not be easily addressed through a generic mathematical proportion. Although they had concerns about the practicality of using a complex mathematical modelling approach in real life projects, but they also mentioned that this research could serve as a starting point for negotiations after Request for Proposal (RFP) stage of projects and before selection of a preferred bidder. An overview of the PPP procurement process is presented in Appendix H.

In conclusion, the value of research on risk allocation modeling in PPPs in New Zealand is evident through insights provided by expert opinions. SME01 emphasizes the potential effectiveness of PPPs when objectives are well-defined and private partners have flexibility, highlighting a need to optimize benefits beyond a conventional contractual framework. SME04 raises a crucial concern about transferring all risks to private entities, particularly for long-term, high-risk projects, proposing a shift towards collaborative models like an 'alliance' for better risk-sharing. This underscores the necessity to reevaluate risk allocation strategies for complex endeavors. SME02 points out the current crossroads in New Zealand's PPP landscape, reflecting the government's skepticism and the potential for policy shifts in the future, illustrating the dynamic nature of infrastructure policies. SME05 adds a practical perspective, expressing skepticism about a complex mathematical approach but acknowledging the research's potential role in negotiations after the RFP stage. Overall, the research provides a comprehensive understanding of risks and their allocation, concerns, and potential directions for improving PPP frameworks in New Zealand, offering valuable insights for policymakers, industry stakeholders, and future research endeavors.

8 Conclusion and recommendations

8.1 Introduction

The earlier chapters cover different aspects of the study, with Chapter 1 serving as an introduction to the research, Chapter 2, 3, 4,5 and 6 present literature and empirical findings on critical success factors, risk factors, RAC and risk allocation. Chapter 7 validates the proposed risk allocation model. The present chapter provides a comprehensive overview of the research study. It encompasses the summarization of the study, the drawing of conclusions and implications based on the findings, and the examination of its significance, limitations, along with recommendations for further research.

In the realm of construction and project management, numerous academic research endeavors have been conducted on the subjects of risk management, as well as on the drivers and success factors of PPP over the past two decades. However, there has been a notable scarcity of empirical studies dedicated to the development of dependable and practical models for assessing and allocating risks in PPP social infrastructure projects, particularly in the context of a country like New Zealand which employs a very unique mode and payment mechanism of PPP. Consequently, this lack of research makes it challenging for practitioners to objectively assess and allocate the substantial risk factors associated with social infrastructure projects, and to identify the key factors that significantly impact the success of such projects.

The overarching aim of this research is to propose an efficient risk allocation model to enhance our comprehension of risks and to create a dependable and pragmatic tool for allocating risks, which can serve as a guide for making risk allocation decisions in PPP social infrastructure projects within the context of New Zealand. To attain this objective, the following objectives were devised:

1- To identify and evaluate CSFs for PPP infrastructure projects.

2- To identify and group risks related to PPP projects.

3- To determine the optimal RAC and develop their ranking.

4- To develop a decision support framework for risk allocation in PPP social infrastructure projects.

8.2 Summary of Research Findings

Objective 1: To identify and evaluate CSFs for PPP infrastructure projects

Securing the success of a PPP project necessitates the presence of specific elements that contribute to its effectiveness. In Chapter 2, 27 such success factors (listed in table 2.1) were extracted from existing literature using a qualitative approach. Subsequently, these CSFs were subjected to expert evaluation through a comprehensive industry-wide questionnaire survey. The findings reveal that all of the identified factors are regarded as significant by the survey participants. Nevertheless, 14 out of the 27 factors received a score above the mean of 4, signifying their greater importance compared to the others. The top five important factors based on respondent's perception are client's brief, sound economic policy, approval and negotiation process, project's technical feasibility and competitive procurement process.

Analyzing the rankings of factor importance in the public and private sectors unveiled a notable disparity in how both sectors perceive these factors. For example, the top three most important factors in private sector's opinion are client's brief, sound economic policy and approval and negotiation process whereas public sector respondents ranked innovation and project complexity, strong private consortium and appropriate risk allocation as the top three most important CSFs.

Objective 2: To identify and group risks related to PPP projects

The importance of the risk identification process in efficient risk management cannot be overstated as it serves as the foundation for comprehensive and efficient risk management. A systematic literature review methodology to uncover pertinent risk factors associated with PPP projects was employed (Chapter 3). Within this review, 35 significant risks by analyzing the findings from nine highly cited studies were identified. These studies were thoughtfully selected due to their recognized credibility within the research community, making them reliable sources for extracting these risk factors.

Interest rate changes, political interference, financial constraints, and force majeure emerged as frequently highlighted risks in the literature under examination. However, despite their recurrent mention, the prevalence of these risks in studies doesn't automatically designate them as the most pivotal. Researchers have presented varying perspectives on the significance of these risks, suggesting a lack of consensus. It is crucial to factor in additional variables like the project's location, type, and the specific mode of PPP employed to accurately assess the criticality of risks in this context. Moreover, these risks were categorized into five risk groups namely financial, political, project specific, social and uncontrollable risks. Table 3.4 lists the identified risks from literature and their respective group.

Objective 3: To determine the optimal RAC and develop their ranking

PPP projects are thought to attain value for money by effectively distributing risks among the primary project participants. To ensure the successful realization of a PPP project's objectives for all stakeholders, risks are apportioned in a manner that aligns with their respective capacities to handle these risks. This approach fosters efficiency by reducing costs. Consequently, risk allocation and sharing should adhere to the principle of risk allocation, which is founded on each party's competence in risk management. In Chapter 3, initially eight

RAC (listed in table 3.6) were identified through systematic literature review. Two additional criteria were introduced through literature review in Chapter 4 to supplement the existing set of eight from Chapter 3. These criteria were assessed quantitatively through a questionnaire survey to determine their level of importance and establish their significance. All the criteria were assessed to be of importance, however three criteria, risk foresight, response to risk and minimising risk loss were regarded as highly important. Furthermore, three factor groups were established in Chapter 5 using factor analysis.

Objective 4: To develop a decision support framework for risk allocation in PPP social infrastructure projects

Infrastructure PPPs require a novel approach to risk management, emphasizing the importance of effective risk allocation and sharing. Unfortunately, there is evidence of inadequate risk allocation practices in many projects. To aid stakeholders, including public and private sector partners, in making informed decisions about risk allocation based on their capabilities, a fuzzy evaluation risk allocation model is proposed in Chapter 6 using the RAC related to risk management from Chapter 4. The model's result is the distribution of risk allocation between the public client and the private entity, determined based on their respective abilities to handle the assessed risk factors. Following a literature review, 16 risk factors were chosen for examination due to the absence of a unanimous consensus among experts regarding how to allocate and share them effectively. The literature suggests that these risks may require varying allocations depending on contextual factors such a type of infrastructure project, location, payment mechanism and mode of PPP delivery. As a result, these factors were deemed suitable for further investigation into their proper allocation and sharing using questionnaire data from social infrastructure PPP projects in New Zealand procured through DBFMO mode of delivery.

Every risk factor underwent an assessment using seven crucial criteria associated with risk management, as outlined in objective 3, by respondents from both the public and public sector. The FSE approach was employed to model the risk allocation decision based on risk management capability of both sectors. FSE risk allocation results show that private sector gets more allocation percentage (>60%) for risks of financing and unexpected geotechnical condition. Risks of public opposition and land acquisition lie mostly (>60%) with the public sectors. Remainder of the risks exhibit somewhat comparable proportions of allocation between the public and private sector.

8.3 Recommendations

In light of the research findings, the following suggestions and recommendations are made:

The research has identified and ranked 27 critical success factors for PPP projects, which are thought to exert a significant impact on both decision-making related to PPPs and their successful execution. 14 out of 27 CSFs were considered more important than the others. To guarantee the effective execution of a project, it is essential to appropriately integrate the 14 CSFs and consistently prioritize their management. Ideally, project management team should have the ability to oversee all the CSFs. Some of the top ranked factors are client's brief, sound economic policy and approval, negotiation process, innovation and project complexity, strong private consortium and appropriate risk allocation. These factors should be prioritized as they received considerable attention from researchers in other countries as well.

This study presents a significant advancement in the realm of PPP risk management by introducing a fuzzy quantitative risk allocation model. This model, designed to address the unique characteristics of each infrastructure project, offers a practical framework for collaborative risk distribution between public authorities and private entities. Its primary goal is to simplify and guide the risk allocation decision-making process, ultimately aiming for more favourable project outcomes. Notably, it promotes a balanced approach to risk allocation, aligning with the capabilities of each party to bear and manage risks, fostering a genuine sense of partnership. Furthermore, it provides both quantitative and qualitative insights, offering specific risk allocation proportions and assessing risk management capabilities. The underlying principle emphasizes that the success of partnership projects depends on appropriately allocating project risks based on the risk management abilities of the public and private partners on PPP projects. Effective risk management capabilities encompass various key aspects, such as foreseeing, controlling, and mitigating risks, ultimately encouraging parties to work together for effective risk management.

Since the model's output represents a percentage-based risk proportion tied to risk management capability, the comparison of indices between the public and private sectors, and the subsequent selection of a final risk allocation or sharing strategy, relies heavily on the subjective judgment of decision makers. This process should consider other dimensions of project management as well. The model serves as a valuable tool for adding structure to the decision-making process, but it cannot definitively pinpoint a strategy due to the inherent complexity of adequately capturing and modeling all decision parameters. While the fuzzy model effectively predicts risk allocation proportions based on RMC, deciding when and how to share a risk between the public and private sectors often remains unclear and demands a case-specific assessment. Moreover, the final risk-sharing ratio should not be solely dictated by the model's output. For each risk factor, the proportion of responsibility assigned to a party strongly hinges on the nature of the risk and the particular scenarios involved, necessitating individual investigation. This situation opens doors for further research into developing mechanisms that guide risk-sharing proportions based on RMC, and also taking into account factors like PPP experience and technical capabilities, among others. In essence, this highlights the need for a more comprehensive and nuanced approach to risk allocation in the context of PPPs.

8.4 Limitations

Like all scientific investigations, this study possesses certain limitations that deserve the attention of its readers. One notable constraint is the possibility of restricted findings due to a relatively low response rate. This primarily arises from the scarcity of projects procured using the PPP procurement method in New Zealand. Consequently, sample size was not randomly selected; instead, it was gathered through purposive sampling and a semi-snowballing approach. Nonetheless, it is worth emphasizing that when compared to similar studies, the sample size employed in this research was considered to be sufficient. Therefore, it is essential to recognize that, despite this limitation, the study still provides a basis for drawing meaningful conclusions that can be applied in future contexts and serve as a benchmark for further investigations.

Another limitation of this study centers on its predominant concentration on the social infrastructure sector within New Zealand. Main reason being, 6 out of the 8 PPP projects till date in New Zealand belong to this category. Two road infrastructure projects were under construction stage when data for this study was collected. This narrow scope raises a concern regarding the transferability of the study's findings, which encompass success factors, risk factors, and risk allocation strategies. The extent to which these findings can be applied to the broader infrastructure sectors in other countries worldwide remains uncertain. Several factors contribute to this uncertainty, including cultural disparities, socio-economic variations, geographical distinctions, as well as disparities in legal and regulatory frameworks.

Furthermore, it is imperative to acknowledge that the less widespread use of the DBFMO model in New Zealand may hinder the direct application of the study's outcomes to other global regions. However, it is equally important to appreciate the unique nature of public-private partnerships (PPPs) in New Zealand, which presents an invaluable opportunity for acquiring knowledge and understanding distinctive risk allocation practices. Despite the potential limitations regarding the generalizability of the results, the research findings retain their value as a valuable resource for guiding future research endeavors and influencing international policy practices.

Another limitation of this research lies in the development of the fuzzy based risk allocation decision model for PPP social infrastructure projects. The model's output relies on inputs gathered from industry experts through a questionnaire survey. However, a significant caveat is that this model has not undergone practical testing within the context of an actual social infrastructure project, even though its potential to enhance risk allocation decision-making has been substantiated by the validation results. Furthermore, as mentioned in section 7.1.4, the SMEs exhibited skepticism regarding the practical implementation of the model in real-world PPP projects, emphasizing concerns about the inherent challenges in translating its complexities into actionable contracts.

8.5 Future Research

Besides the practice guidelines mentioned earlier, there exist several valuable avenues for future research aimed at enhancing the state of risk management in public-private partnerships.

One of the limitations of this study implies that the study's conclusions, while valuable and insightful within the context of New Zealand's social infrastructure sector, may not seamlessly translate to similar sectors in different countries. These divergences in cultural norms, socio-economic conditions, geographical considerations, and legal and regulatory structures can significantly impact the dynamics of infrastructure projects. Therefore, it is essential for future research to explore these variables in a more diverse range of settings to develop a comprehensive understanding of success and risk factors in the global infrastructure landscape.

Although this study looked into critical success factors briefly to establish the importance of risk sharing, allocation and transfer, however, future research can explore this area in depth. A success framework, similar to Osei-Kyei (2017), may be developed for social infrastructure projects in New Zealand.

16 contentious risks were allocated using the model developed in this study from a list of 35 identified risks from literature. Further research can be carried out to establish effective risk management response and mitigation measures for these risks.

The majority of the literature examined in this study adopted a comprehensive perspective when delving into project risks, whether it was in the context of risk identification or risk allocation. Only a limited number of articles have delved into the intricate understanding of specific pivotal project risks in isolation. To bridge this gap, future research endeavors can investigate individual risks and their interconnections with other project risks. In the New Zealand context, particular emphasis should be placed on the risks associated with consents and approvals, ground conditions, and third-party risks. These specific risk factors were identified in the Infrastructure Commission's review of PPPs and were further endorsed by experts during validation interviews.

Fuzzy based risk allocation model developed although validated by subject matter experts in the current study, still needs to be practically applied on new PPP projects to establish its reliability and practicality. Further studies can be carried out to apply and improve the model on new PPP projects.

Future research could also delve into exploring alternative variations of PPPs in New Zealand, especially considering the current trend of PPPs being less fashionable. This research could aim to identify and develop innovative PPP models that address contemporary challenges and align with evolving economic and industry dynamics. Additionally, investigating the concerns raised by SME05 regarding bid success being disproportionately skewed towards the lowest price in PPP projects could be a valuable avenue. This research could focus on refining risk assessment and allocation methodologies within PPP frameworks to ensure a more balanced and sustainable approach to bidding processes, ultimately contributing to the effectiveness and resilience of PPPs in diverse economic landscapes.

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Appendices

Appendix A: Participant Consent Form

Critical Success Factors (CSFs) of Public Private Partnership in New Zealand

PARTICIPANT CONSENT FORM - INDIVIDUAL

I have read, or have had read to me in my first language, and I understand the Information Sheet attached as Appendix I. I have had the details of the study explained to me, any questions I had have been answered to my satisfaction, and I understand that I may ask further questions at any time. I have been given sufficient time to consider whether to participate in this study and I understand participation is voluntary and that I may withdraw from the study at any time. I agree to participate in this study under the conditions set out in the Information Sheet.

Declaration by Participant:

I___________[print full name]________hereby consent to take part in this study.

Signature:_____________________ Date: _______________

Appendix B: Critical Success Factors (CSFs) of Public Private Partnership in New Zealand Questionnaire

Critical Success Factors (CSFs) of Public Private Partnership in New Zealand

I. Demographic Information

1. Which of the following best describes your affiliation?

- ☐ Private Sector Organization
- ☐ Public Sector Organization
- ☐ Other

2. If you are in Public Sector, which of the following group you represent?

- ☐ Central Government
- ☐ Local Government
- ☐ Government Agency
- ☐ Public Enterprise

3. If you are in Private Sector, which of the following group you represent?

- ☐ Financier
- ☐ Main Contractor and Designer
- ☐ Designer
- ☐ Consultant/Adviser
- ☐ Subcontractor
- ☐ Supplier
- ☐ Others

4. Please indicate your position in your organisation?

Director

- ☐ Project Director

Human Resources

- ☐ Human Resources Manager
- ☐ Human Resources Advisor/Admin

Construction Team

- ☐ Area Manager
- ☐ Project Manager
- ☐ Construction Manager
- ☐ Project Engineer
- ☐ Graduate Engineer
- ☐ Foreman/Leadman
- ☐ Site Engineer
- ☐ Site Supervisor

Commercial/Procurement/Planning Team

- ☐ Commercial Manager
- ☐ Procurement Manager/Coordinator

- Quantity Surveyor Manager
- Subcontractor Manager
- Planning Manager
- Planning Engineer
- Quantity Surveyor
- Contract Administrator
- Procurement Administrator

Technical/QA/QC Team

- Technical Manager
- Geotechnical Engineer
- Technical Quantity Surveyor
- QA/QC Manager
- QA/QC Engineer
- Team Administrator

Accounts Team

- Account Manager
- Project Accountant
- Accounts Admin

HSE/Environmental/Stakeholder/Logistic

- HSE Manager
- HSE Engineer/Officer
- Environmental Manager
- Environmental/Advisor/Engineer
- Stakeholder Manager/Advisor
- Plant/Fleet Coordinator/Manager

Other

- Please specify__________________

5. Total Job experience for Public and Private Partnership Project

- 0-5 years
- 11-15 years
- 5-10 years
- 16-20 years
- Over 20 years

6. What industry domain does your company belong to

- ☐ Construction Team
- ☐ Technical & Design Team
- ☐ Project Consultant
- ☐ Procurement Team
- ☐ Commercial Team
- ☐ Contract Team
- ☐ Finance Team
- ☐ Environmental Team
- ☐ Stakeholder Team
- ☐ Administration
- ☐ Human Resource
- ☐ IT
- ☐ HSE
- ☐ Procurement
- ☐ Subcontractor

II. Identifying the Critical Success Factor of PPP in NZ

Scale Rating

1. Least Important
2. Somewhat Important
3. Neutral
4. Important
5. Most Important
6. No Idea

Group Factor 1

Please indicate your level of your agreement for each Critical Success Factors listed below keeping in mind the **Stable Macroeconomic Environment** in New Zealand's Perspective

1. Sound Economic Policy

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

2. Approval Process

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

3. **Client's Brief**

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

4. **Favorable legal framework**

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

5. **Environmental Impact**

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

6. **Innovation/Project process complexity**

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

7. **Community Support**

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

8. **Business Diversification**

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

9. Stable macroeconomic conditions

☐ Least Important
☐ Somewhat Important
☐ Neutral
☐ Important
☐ Most Important
☐ No Idea

10. Risk sharing

☐ Least Important
☐ Somewhat Important
☐ Neutral
☐ Important
☐ Most Important
☐ No Idea

11. Appropriate risk allocation

☐ Least Important
☐ Somewhat Important
☐ Neutral
☐ Important
☐ Most Important
☐ No Idea

12. Available financial market

☐ Least Important
☐ Somewhat Important
☐ Neutral
☐ Important
☐ Most Important
☐ No Idea

Identifying of Critical Success Factor

Group Factor 2

Please indicate your level of agreement on each of the Critical Success Factors listed below keeping in mind **Shared Responsibility between Public and Private Sector** in New Zealand's Perspective

13. Shared authority between public and private sectors

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

14. Commitment and responsibility of public and private sectors

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

15. Project's technical feasibility

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

16. Thorough and realistic assessment of the cost and benefits

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

17. Credit rating of Investors

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

Group Factor 3

Please indicate your level of agreement on each of the Critical Success Factors listed below keeping in mind **Transparent and Efficient Procurement Process** in New Zealand's Perspective

18. Competitive procurement process

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

19. Transparent procurement process

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

20. Well-organized and committed public agency

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

Group Factor 4

Please indicate your level of agreement on each of the Critical Success Factors listed below keeping in mind **Stable Political and Social Environment** in New Zealand's Perspective

21. Political Support

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

22. Social Support

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

23. Strong and good private consortium

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

24. Good governance

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

Group Factor 5

Please indicate your level of agreement on each of the Critical Success Factors listed below keeping in mind **Available Financial Market Control** in New Zealand's Perspective

25. Availability of a suitable financier

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

26. Adequate financial market

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

Group Factor 6

Please indicate your level of agreement on each of the Critical Success Factors listed below keeping in mind **Judicious Government** control in New Zealand's Perspective

27. Government Involvement by providing Guarantees

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

28. Multi-benefit Objectives

- ☐ Least Important
- ☐ Somewhat Important
- ☐ Neutral
- ☐ Important
- ☐ Most Important
- ☐ No Idea

III. Please add Comments and Suggestions (If any)

Appendix C: Risk Definitions and Categories

Risks	Description
Financial risks in public-private partnerships (PPPs) refer to the potential economic uncertainties and challenges that can affect the financial aspects of these collaborative arrangements between government entities and private sector partners. These risks can arise from various sources and may impact the financial viability and success of a PPP project.	
Interest rate changes	Interest rate risk in PPPs refers to the potential exposure of a PPP project to fluctuations in interest rates, which can affect the project's financing costs and overall financial viability. This risk arises from the fact that many PPP projects involve long-term financing arrangements, typically in the form of loans or bonds, to fund their construction and operation.
Inflation	Inflation risk in PPPs refers to the potential financial exposure or negative impact that rising inflation rates can have on the costs and revenues associated with a PPP project. It is a type of financial risk that arises from the possibility of a decrease in the real value of money over time. Inflation can erode the purchasing power of funds, leading to several specific challenges in PPPs.
Financial constraints	Financial constraints risk in PPPs refers to the potential challenges and limitations related to the availability of financial resources necessary for the successful planning, implementation, and operation of a PPP project. This risk arises from factors that can impede or restrict the financing of the project and may include difficulty in securing financing, variation in financing costs and availability of funds.

Asset risk	Asset risk in PPPs refers to the potential risk associated with the ownership, operation, and maintenance of the physical assets or infrastructure developed under the PPP arrangement. This risk centers around the condition, performance, and financial implications of the project assets and can impact the long-term success and sustainability of the partnership.
Demand risk	Demand risk in PPPs refers to the uncertainty and potential variability in the level of demand for the services, products, or infrastructure provided by the PPP project. This risk stems from the fact that the project's revenue and financial sustainability often depend on user or customer demand, and fluctuations in this demand can impact the project's profitability and long-term viability.
High finance cost	High financing cost risk in PPPs refers to the potential challenge of securing project financing at a significantly higher cost than initially anticipated. This risk can have a substantial impact on the financial feasibility and profitability of the PPP project.
Change in taxes	Change in taxes risk in PPPs refers to the potential for alterations in tax laws, regulations, or government policies that can affect the financial aspects of a PPP project. This risk arises when there is uncertainty regarding how tax-related factors may evolve during the course of the project.
Political risks in PPPs refer to the uncertainties and potential adverse events that stem from the political environment and government actions, which can impact the financial and operational	

aspects of a PPP project. These risks arise due to the involvement of government entities in PPPs and can manifest in various ways.	
Expropriation	Expropriation risk in PPPs refers to the potential threat or possibility that a government or public authority may seize or take control of the assets, property, or investments of the private sector partner involved in the PPP project. Expropriation can occur through various means, including outright nationalization, confiscation, or regulatory actions that significantly reduce the value or control of the private partner's assets. This risk is a concern for private sector investors as it can lead to financial losses and a breakdown of the partnership.
Government support	Lack of government support risk in PPPs refers to the potential challenge or concern that arises when the government partner, typically a public entity, does not provide the necessary support, commitment, or cooperation required for the successful initiation, execution, or continuation of a PPP project. This lack of support can manifest in various ways and can negatively impact the project's viability and effectiveness.
Corruption	Corruption risk in PPPs refers to the potential for dishonest or fraudulent behavior that can compromise the integrity, fairness, and effectiveness of the partnership. This risk arises from the interaction between public sector entities and private sector partners and involves various forms of unethical conduct, including bribery, embezzlement, kickbacks, and other corrupt practices. Corruption risk in PPPs can have serious

	consequences, including financial losses, project delays, and damage to a country's reputation.
Political interference	Political interference risk in PPPs refers to the potential for unwarranted or inappropriate involvement by government or political entities in the decision-making and operations of a PPP project. This risk arises when political motivations or pressures influence the project in a way that may not be in the best interest of the project's success, its stakeholders, or the public.
Unstable government	Unstable government risk in PPPs refers to the risk associated with the political and governmental environment in a particular country or region where a PPP project is being undertaken. This risk arises from the potential for instability, unpredictability, or inconsistency in government policies, regulations, or actions, which can impact the viability and success of the PPP project.
Insufficient authority	Insufficient authority risk in PPPs refers to a situation where a government agency or entity lacks the legal or regulatory authority necessary to fully execute and enforce the terms of a PPP agreement. In PPP projects, various government approvals, permits, licenses, and legal authorizations are often required to enable the private sector partner to perform its obligations and operate the project effectively.
Project specific risks in PPPs refer to the unique and project-specific challenges, uncertainties, and issues that can affect the successful implementation and operation of a particular PPP	

project. These risks are specific to the nature, scope, and characteristics of the project itself and can vary widely depending on the sector and the specific circumstances.	
Communication risk	Communication risk in PPP projects refers to the potential challenges and uncertainties associated with the exchange of information and messages among various stakeholders involved in the project.
Construction time overrun	Construction time overrun risk in PPP projects refers to the potential delay in completing the construction phase of the project beyond the initially planned or agreed-upon schedule.
Approval issues	Approval issues risk in PPP projects refer to the potential challenges and uncertainties associated with obtaining the necessary approvals, permits, and clearances from various government authorities and stakeholders.
Scope Changes	Scope changes in PPP projects refer to alterations, modifications, or additions to the original project plan, objectives, or requirements. These changes can affect various aspects of the project, including its size, design, functionality, schedule, and budget.
Geological settings	Geological settings risk in the context of PPP projects refers to the potential challenges and uncertainties associated with the geological conditions of a project site that can impact the successful implementation and operation of a PPP project.
Poor workmanship	Poor workmanship risk in PPP projects refers to the potential for subpar or inadequate construction or project execution due to the negligence, incompetence, or lack of quality control by the private sector partner

	responsible for delivering and managing the project's infrastructure or services.
Environment	Environmental risk in PPP projects refers to the potential adverse impacts and uncertainties related to the natural environment that can affect the successful execution and operation of such projects.
Construction cost overrun	Construction cost overrun risk in PPP projects refers to the potential for the actual construction costs of a project to exceed the originally estimated or budgeted costs.
Legal problems	Legal risks in PPP projects refer to the various legal challenges and uncertainties that can arise during the planning, negotiation, execution, and operation of a PPP project.
Design flaws	Design flaws in PPP projects refer to shortcomings, errors, or inadequacies in the planning and conceptualization of the project's design. These flaws can manifest in various aspects of the project's design, including its infrastructure, engineering, architecture, and functional requirements.
Low productivity	Low productivity risk in the context of PPP projects refers to the potential challenges or factors that can hinder the efficient and effective use of resources, time, and effort in the execution and management of these projects.

Technical risk	Technical risk in PPP projects refers to the potential challenges and uncertainties associated with the technical aspects of a project that involve infrastructure development, construction, and operation.
Material risk	Material risk in PPP projects refers to the potential challenges and uncertainties associated with the procurement, supply, and management of construction materials throughout the project's lifecycle.
Testing new practices	Testing new practices in PPP projects refers to the implementation of innovative or unproven approaches, methods, or strategies. These new practices are often introduced with the aim of improving project outcomes, efficiency, or cost-effectiveness.
Lack of PPP experience	The lack of experience risk in PPP projects refers to the potential challenges and uncertainties that can arise when one or more of the key stakeholders involved in a PPP project lacks the necessary expertise, knowledge, or experience in planning, structuring, implementing, or managing such partnerships.
Contractual changes	Contractual changes risk in PPP projects refers to the potential challenges and uncertainties that can arise when there are alterations or modifications to the terms, conditions, or agreements outlined in the initial contract between the public sector and the private sector partner in a PPP project.

Site availability	Site availability risk in the context of PPP projects refers to the potential challenges or uncertainties related to the availability and condition of the project site.
Safety and security	Safety and security risks in PPP projects refer to the potential threats or hazards that could compromise the well-being of people, assets, or the overall success of a project
Commitment issues	Commitment issues risk in PPP projects refers to the potential challenges and uncertainties that can arise when one or both parties involved in the partnership fail to fully adhere to their obligations and responsibilities throughout the project's lifecycle.
Social risks in PPPs refer to the potential negative social consequences or challenges that can arise from the implementation of a PPP project. These risks are centered around the impact of the project on society, communities, and individuals. Social risks can encompass a wide range of factors and may vary depending on the nature of the project and its interactions with the social environment.	
Public disapproval	Public disapproval risk in PPPs refers to the potential negative perception, backlash, or opposition from the general public or specific communities regarding a PPP project. This risk arises from the fact that PPPs often involve public services, infrastructure, or facilities that directly impact the lives and well-being of the public. When the public perceives a PPP project negatively, it can lead to various challenges and consequences for the project's stakeholders.

Uncontrollable risks in PPPs refer to the unexpected and uncontrollable events or circumstances that can disrupt the normal course of a PPP project and make it difficult or impossible for the parties involved to fulfill their contractual obligations. These risks typically fall outside the control of the public and private sector partners and can have a significant impact on the project's timeline, costs, and feasibility.	
Weather	Weather risk in PPPs refers to the uncertainty and potential adverse impacts that weather-related events and conditions can have on a PPP project. These risks arise due to the vulnerability of certain projects to weather conditions and the potential for such conditions to disrupt project operations or financial performance. Weather risk can manifest in various ways and may affect different types of projects, particularly those in sectors like infrastructure, agriculture, energy, and tourism.
Force majeure	Force majeure risk in PPPs refers to the potential occurrence of unforeseeable and uncontrollable events or circumstances that can significantly disrupt or prevent the fulfillment of contractual obligations within a PPP project. These events are typically beyond the control of the parties involved and can lead to project delays, increased costs, or even the temporary suspension of project activities.
Pandemics	Widespread health crises, such as pandemics (e.g., COVID-19) or epidemics, that can lead to public health emergencies, quarantines, and restrictions on project activities.

Appendix D: PPP Risk Allocation Criteria Questionnaire

Who should bear the risks in PPP projects between public and private sector companies in NZ?

Start of Block: Who should bear the risks in PPP projects between public and private sector comp

I am a doctoral student at Massey University New Zealand. I am examining and investigating the risk management practices in Public Private Partnership (PPP) projects in New Zealand for my research. PPP projects are considered very risky in nature. This study aims to identify, assess and model risks inherent in PPP projects. I am inviting you to participate in the research study by answering this questionnaire. Despite the complex nature of each project's distinctive characteristics, this research offers awareness and informative details for the public and private sectors regarding the critical factors that need to be prioritised to ensure the smooth implementation of PPPs.   As a practitioner in infrastructures projects, you've been selected to participate in the research survey through a random sampling of industry members and in some cases through a snowball sampling approach. I undertake to provide you with a summary of the key findings of the study if you contact me directly through my contact details provided below. This survey will take around 15-25 minutes of your time to complete. Please note that there is no liability and compensation for answering this survey. The information collected using this survey will remain confidential. Collected information will only be used for research purposes.   The questionnaire is divided into three (3) sections. Section A solicits background information. Section B attempts to establish importance of some key risk allocation criteria with regards to respondent's experience. Section C tries to explore your organization's ability in managing these key risks considering seven risk allocation criteria. All the answers are solicited on specified scales which will be used for various statistical analyses.

Participation in this research is voluntary and you are under no obligation to accept this invitation. If you decide to participate, you have the right to:

- decline to answer any particular question;
- provide information on the understanding that your name will not be used unless you permit the researcher;
- be given access to a summary of the project findings when it is concluded;
- add some feedback and suggestion.

Thank you for your time to support me in my research study. If you have any question, please don't hesitate to contact me. My supervisors for this research are Associate Professor James Rotimi (main supervisor) and Dr Wajiha Shahzad (co-supervisor).   Sincerely yours,   Nasir Rasheed Doctoral Candidate   Student ID: Mobile Number: +642102341907   Email Address:

n.rasheed@massey.ac.nz Disclaimer: This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher named above is responsible for the ethical conduct of this research. If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher(s), please contact Prof Craig Johnson, Director, Research Ethics, email: humanethics@massey.ac.nz

○ I consent to participate in the survey

End of Block: Who should bear the risks in PPP projects between public and private sector comp

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Start of Block: Section A: Background Information of Respondent

Q2 Your Email Address (optional)

____

Q3 Most recent PPP project

- ☐ Transmission Gully Motorway PPP
- ☐ Puhoi to Warkworth Motorway PPP
- ☐ Auckland South Correctional Facility (ASFC)
- ☐ Auckland Prison
- ☐ Waikeria Prison
- ☐ Hobsonville Schools PPP
- ☐ PPP 2 Schools (2017)
- ☐ PPP 3 Schools (2019)
- ☐ Other (Please specify) ________________________________

Q4 Which sector best applies to your current role: Public, Private (Project Company, Contractor, Consultant, Operator, Investor), Academic, Other

- ○ Public Sector
- ○ Private Sector
- ○ Academic
- ○ Other (Please specify) ________________________________

Q5 Which one of these stakeholders best defines your current role?

- ◯ Poject Company
- ◯ Contractor
- ◯ Consultant
- ◯ Operator
- ◯ Investor
- ◯ Lending Agency
- ◯ Government Agency
- ◯ Other (Please specify) ____

Q6 PPP related experience in number of years

- ◯ 1-5
- ◯ 6-10
- ◯ 11-15
- ◯ More than 15

Q7 Most recent PPP project you worked on was

- ○ Build Operate Transfer (BOT)
- ○ Design Build Finance Maintain Operate (DBFMO)
- ○ Deisgn Build Finance Maintain (DBFM)
- ○ Build Own Operate (BOO)
- ○ Other (Please specify) ____

Q8 PPP Project type/sector you have worked on

- ▢ Power
- ▢ Social Infrastructure (hospital, school, prison etc)
- ▢ Transport
- ▢ Water supply
- ▢ Other (please specify) ____

Q9 Current designation

____

End of Block: Section A: Background Information of Respondent

Start of Block: Section B: Allocation of Key Project Risks

Q10 Section B: Importance of risk allocation criteria
The chart below outlines various risk allocation criteria identified from literature that gauge a party's ability to manage risks, whether it's a public or private entity. Drawing from your expertise, please assess the significance of these risk allocation criteria using this rating scale:: 1 = least important; 2 = somehwhat important; 3 = moderately important; 4 = highly important; 5 = most important. 0 = No idea

	Risk Allocation Criteria					
	least important (1)	somewhat important (2)	moderately important (3)	highly important (4)	most important (5)	No Idea (0)
Risk foresight	○	○	○	○	○	○
Response to risk	○	○	○	○	○	○
Minimize risk loss	○	○	○	○	○	○
Absorb risk impact	○	○	○	○	○	○
Low risk cost	○	○	○	○	○	○
Exploit risk	○	○	○	○	○	○
Risk attitude	○	○	○	○	○	○
Bargaining power/ negotiation	○	○	○	○	○	○
Experience	○	○	○	○	○	○

Q11 Optional: Please add any other criteria which might be relevant in your opinion using format, Name of criteria (score 1-5)

____

End of Block: Section B: Allocation of Key Project Risks

Start of Block: Section C: Risk Allocation Criteria for Effective Risk Allocation

Q12 Section C: Risk Allocation Criteria (RAC) for Effective Risk Allocation
Risks should be allocated to the party that has the best capability to manage the assigned risks. The table below provides multiple RAC related ro risk management that determine a party's risk management capability (public/private). Based on your experience, please indicate the ability of your organization to respond to risks listed against each risk allocation criteria on the following scale:
Very Low (VL); Low (L); Moderate (M); High (H); Very High (VH); No Idea (NI)
All the text boxes need to be filled. Take the first textbox for example. If you think there's a high chance "your organization can foresee the probability of risk occurrence and assess potential risk consequence" for risk of inflation, you can select "H" from the dropdown menu.

	My organization can foresee the probability of risk occurrence and assess potential risk consequence	My organization can avoid, minimize, monitor and control the probability of risk occurrence	My organization can minimize or control the loss if the risk occurs	My organization can sustain, diversify or absorb the consequences of the risk if the risk occurs	My organization can bear the risk at the lowest cost	My organization can get reasonable and acceptable premium for assuming the risk	My organization prefers to undertake risks

Inflation	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI
Variation in foreign exchange rate	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI
Interest rate fluctuation	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI
Land acquisition	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI
Public opposition to project	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI
Change in law/regulation	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI
Unexpected geotechnical conditions	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI
Supply/resourcing risk	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI
Delay in project approvals and permit	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI
Insurance risk	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI
Unforeseen project characteristics	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI
Financing risk	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI
Lack of PPP experience	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI
Weather risk	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI

Change in government	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI
Design changes	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI	▼ VL ... NI

End of Block: Section C: Risk Allocation Criteria for Effective Risk Allocation

Appendix E: Validation Questions for Risk Allocation in PPP

Validation questionnaire for risk allocation in PPP

Kindly
select suitable rating for each validation question to signify the degree of your contentment:
1–poor; 2–average; 3–good; 4–very good; 5–excellent

Use the space below each question to provide any comment or reason for your selected rating.

This project has been evaluated by peer review and judged to be low risk. Consequently it has not been reviewed by one of the University's Human Ethics Committees. The only participant's information being collected in this case will be their position in the organization and their experience in number of years. Paricipant can withdraw at any time.

* Indicates required question

1. Are the risk allocation criteria used in the model appropriate for assessing the risk management ability? *

Mark only one oval.

Poor

1 ◯
2 ◯
3 ◯
4 ◯
5 ◯

Excellent

2. Reason/comment

3. *

Is the model easy to comprehend and utilize for risk allocation?

Mark only one oval.

Poor

1
2
3
4
5

Excellent

4. Reason/comment

5. Do the risk distribution ratios appear sensible and feasible within a standard PPP venture? *

Mark only one oval.

Poor

1

2

3

4

5

Excellent

6. Reason/comment

7. Do the steps of implementing the model follow a coherent sequence, allowing for its replication by researchers or practitioners? *

Mark only one oval.

Poor

1

2

3

4

5

Excellent

8. Reason/comment

9. Is the model appropriate for practical adoption in making risk allocation decisions within PPP endeavors in New Zealand? *

Mark only one oval.

Poor

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

Excellent

10. Reason/comment

11. Would the model be appropriate for practical adoption in making risk allocation decisions within PPP endeavors in other countries? *

Mark only one oval.

Poor

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

Excellent

12. Reason/comment

____
____
____
____
____

13. Please provide any general comments or feedback related to the model, PPP risk managemnet or making PPPs a success. *

____
____
____
____
____

14. Please enter your current role/position in your organization. *

15. Please enter your total experience in number of years. *

Appendix F: Independent t-test Results

Identified risk from literature and t-test results

Risk ID	Risk	F	t	sig.
RF_1	Inflation	1.042	2.587	0.016*
RF_2	Variation in foreign exchange rate	0.615	2.889	0.008*
RF_3	Interest rate fluctuation	0.511	2.641	0.015*
RF_4	Land acquisition	0.058	3.309	0.003*
RF_5	Public opposition to project	0.421	4.04	0.001*
RF_6	Change in law/regulation	0.065	2.936	0.007*
RF_7	Unexpected geotechnical conditions	31.194	-1.142	0.087
RF_8	Supply/resourcing risk	1.649	-0.868	0.212
RF_9	Delay in project approvals and permit	2.437	1.079	0.132
RF_10	Insurance risk	2.542	-1.019	0.125
RF_11	Unforeseen project characteristics	0.742	0.566	0.398
RF_12	Financing risk	5.009	-1.7	0.035*
RF_13	Lack of PPP experience	0.16	-0.193	0.693
RF_14	Weather risk	2.145	1.122	0.157
RF_15	Change in government	2.791	0.515	0.108
RF_16	Design changes	0.142	-0.628	0.51

Appendix G: Fuzzy Evaluation Matrices

Appendix G

Fuzzy evaluation matrices for Public and Private sectors

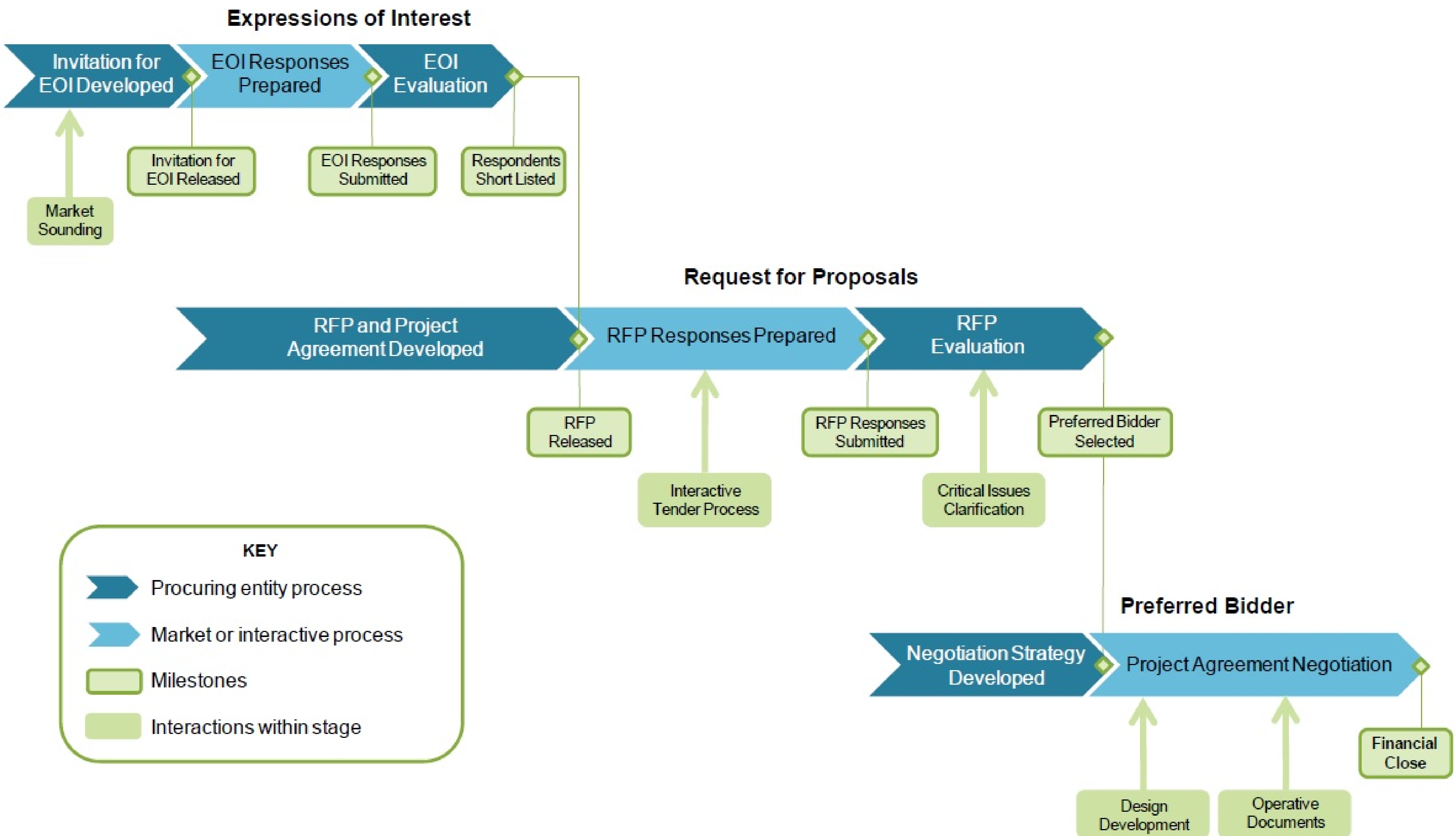
	Public sector					Private sector				
RF_1	0.07	0.14	0.29	0.42	0.08	0.21	0.21	0.29	0.29	0
	0.14	0.36	0.29	0.14	0.07	0.36	0.43	0.14	0.07	0
	0.15	0.14	0.32	0.32	0.07	0.14	0.36	0.36	0.07	0.07
	0.07	0.14	0.27	0.45	0.07	0.14	0.14	0.36	0.36	0
	0.07	0.21	0.36	0.36	0	0.17	0.33	0.5	0	0
	0.14	0.42	0.29	0.07	0.08	0.33	0.58	0.08	0	0
	0.56	0.15	0.22	0.07	0	0.69	0.23	0.08	0	0
RF_2	0.06	0.15	0.43	0.22	0.14	0.15	0.38	0.31	0.15	0
	0.14	0.42	0.15	0.22	0.07	0.38	0.46	0.15	0	0
	0.07	0.51	0.28	0.07	0.07	0.15	0.46	0.31	0.08	0
	0.06	0.07	0.27	0.54	0.06	0.08	0.23	0.38	0.31	0
	0.07	0.07	0.5	0.36	0	0.17	0.33	0.42	0.08	0
	0.13	0.49	0.21	0.11	0.06	0.42	0.42	0.17	0	0
	0.55	0.09	0.36	0	0	0.62	0.38	0	0	0
RF_3	0.07	0.28	0.15	0.28	0.21	0.15	0.31	0.31	0.15	0.08
	0.22	0.21	0.42	0.07	0.08	0.38	0.31	0.31	0	0
	0.07	0.36	0.29	0.28	0	0.15	0.31	0.54	0	0
	0	0.06	0.51	0.43	0	0	0.23	0.38	0.38	0
	0	0.07	0.57	0.36	0	0.08	0.5	0.42	0	0
	0.06	0.42	0.3	0.22	0	0.25	0.5	0.25	0	0
	0.57	0.29	0.14	0	0	0.46	0.46	0.08	0	0
RF_4	0	0.15	0.22	0.28	0.35	0.33	0.17	0.33	0.17	0
	0.14	0.07	0.29	0.36	0.14	0.08	0.5	0.33	0.08	0
	0	0.14	0.22	0.57	0.07	0.42	0.33	0.17	0.08	0
	0	0.07	0.29	0.49	0.15	0.33	0.08	0.33	0.25	0
	0.07	0.14	0.29	0.35	0.15	0.09	0.45	0.36	0.09	0
	0	0.14	0.29	0.49	0.07	0.08	0.33	0.58	0	0
	0	0.51	0.21	0.14	0.14	0.36	0.45	0.18	0	0
RF_5	0	0.07	0.56	0.29	0.08	0.17	0.33	0.43	0.07	0
	0	0.07	0.28	0.65	0	0.29	0.36	0.36	0	0
	0	0.07	0.56	0.29	0.08	0.14	0.36	0.5	0	0
	0	0.21	0.21	0.51	0.07	0.54	0.15	0.23	0.08	0
	0	0.07	0.36	0.49	0.08	0.08	0.77	0.08	0.07	0
	0.07	0.14	0.29	0.29	0.21	0.15	0.38	0.38	0.08	0
	0.28	0.28	0.07	0.22	0.15	0.58	0.33	0.08	0	0
RF_6	0	0.07	0.43	0.35	0.15	0.07	0.71	0.14	0	0.07
	0.07	0.14	0.36	0.36	0.07	0.29	0.36	0.29	0.07	0
	0	0.28	0.28	0.43	0	0.07	0.36	0.43	0.07	0.07
	0	0.21	0.35	0.44	0	0	0.43	0.43	0.14	0
	0	0.07	0.42	0.36	0.15	0	0.62	0.15	0.23	0
	0	0.5	0.21	0.29	0	0.08	0.23	0.62	0.08	0

	0.3	0.41	0.11	0.12	0.06	0.38	0.62	0	0	0
RF_7	0.15	0.56	0.15	0.07	0.07	0.07	0.29	0.43	0.14	0.07
	0.36	0.27	0.27	0.07	0	0.07	0.29	0.36	0.21	0.07
	0.14	0.29	0.28	0.28	0	0	0.14	0.64	0.21	0
	0.07	0.22	0.56	0.14	0	0	0.21	0.5	0.21	0.07
	0.14	0.35	0.28	0.22	0	0	0.23	0.31	0.38	0.08
	0.21	0.35	0.29	0.14	0	0.08	0.14	0.64	0.08	0.16
	0.71	0.21	0.07	0	0	0.16	0.38	0.16	0.15	0.15
RF_8	0.07	0.56	0.15	0.14	0.07	0	0	0.36	0.29	0.36
	0.14	0.57	0.15	0.07	0.07	0	0.21	0.57	0	0.21
	0.07	0.35	0.15	0.36	0.07	0.07	0.14	0.43	0.36	0
	0	0.28	0.36	0.36	0	0.07	0.07	0.57	0.29	0
	0.07	0.36	0.29	0.29	0	0	0.29	0.5	0.21	0
	0.14	0.29	0.29	0.28	0	0	0.54	0.38	0.08	0
	0.35	0.21	0.14	0.15	0.15	0.14	0.64	0.14	0.07	0
RF_9	0	0.07	0.35	0.42	0.15	0	0.21	0.57	0.14	0.07
	0	0.14	0.49	0.36	0	0	0.14	0.5	0.36	0
	0	0	0.36	0.56	0.07	0	0	0.5	0.43	0.07
	0	0.07	0.36	0.56	0	0.07	0	0.64	0.21	0.07
	0	0.28	0.28	0.36	0.07	0	0.15	0.62	0.23	0
	0	0.36	0.21	0.36	0.07	0.08	0.17	0.42	0.33	0
	0.07	0.28	0.22	0.29	0.14	0.23	0.46	0.15	0.08	0.08
RF_10	0.22	0.28	0.28	0.14	0.07	0.08	0.23	0.54	0.08	0.08
	0	0.43	0.35	0.22	0	0	0.31	0.46	0.23	0
	0	0.36	0.49	0.15	0	0	0.15	0.54	0.31	0
	0	0.22	0.78	0	0	0	0.23	0.62	0.15	0
	0	0.33	0.67	0	0	0	0.23	0.62	0.15	0
	0.12	0.31	0.3	0.21	0.06	0	0.54	0.38	0	0.08
	0.31	0.31	0.26	0.12	0	0.15	0.62	0.23	0	0
RF_11	0	0.49	0.29	0.22	0	0.07	0.21	0.57	0.14	0
	0.07	0.56	0.08	0.29	0	0	0.36	0.5	0.07	0.07
	0	0.29	0.43	0.21	0.07	0	0.29	0.64	0	0.07
	0.07	0.14	0.57	0.22	0	0.07	0.14	0.57	0.21	0
	0	0.35	0.49	0.15	0	0	0.14	0.79	0.07	0
	0	0.29	0.56	0.14	0	0.08	0.46	0.23	0.23	0
	0.49	0.29	0.15	0.07	0	0.46	0.46	0	0.08	0
RF_12	0.33	0.33	0.22	0.11	0	0	0	0.43	0.43	0.14
	0.33	0.22	0.22	0.22	0	0	0.14	0.28	0.5	0.07
	0.44	0.33	0.11	0.11	0	0.14	0.07	0.64	0.07	0.07
	0.33	0.33	0.22	0.11	0	0	0.21	0.36	0.21	0.21
	0.33	0.22	0.27	0.12	0.06	0	0.14	0.49	0.21	0.15
	0.22	0.44	0.22	0.11	0	0.15	0.08	0.54	0.15	0.08
	0.33	0.28	0.22	0.11	0.06	0.14	0.15	0.21	0.42	0.08
RF_13	0	0.28	0.36	0.28	0.07	0.07	0.07	0.43	0.21	0.21
	0	0.28	0.36	0.36	0	0.07	0.14	0.5	0.21	0.07

	0	0.28	0.36	0.36	0	0	0	0.21	0.58	0.21
	0	0.21	0.56	0.23	0	0.07	0	0.43	0.43	0.07
	0.07	0.27	0.45	0.18	0	0	0.14	0.5	0.21	0.14
	0	0.27	0.27	0.45	0	0	0.58	0.25	0.17	0
	0.36	0.36	0.14	0.14	0	0.15	0.46	0.23	0.08	0.08
RF_14	0.07	0.07	0.51	0.21	0.14	0.07	0.14	0.64	0.14	0
	0.14	0.49	0.14	0.14	0.07	0.14	0.36	0.29	0.15	0.07
	0.12	0.18	0.46	0.12	0.12	0.07	0.36	0.5	0.07	0
	0	0.36	0.28	0.28	0.07	0	0.5	0.29	0.14	0.07
	0.07	0.36	0.21	0.28	0.07	0.15	0.54	0.23	0.08	0
	0.21	0.28	0.28	0.14	0.07	0.08	0.46	0.38	0.07	0
	0.51	0.07	0.14	0.28	0	0.64	0.14	0.14	0.07	0
RF_15	0	0.28	0.42	0.18	0.12	0	0.57	0.29	0.14	0
	0.18	0.31	0.31	0.2	0	0.29	0.5	0.21	0	0
	0.12	0.54	0.12	0.22	0	0.21	0.29	0.5	0	0
	0	0.42	0.42	0.16	0	0.07	0.29	0.57	0.07	0
	0.12	0.12	0.46	0.3	0	0.15	0.46	0.31	0.08	0
	0.18	0.52	0.12	0.18	0	0.23	0.46	0.23	0.08	0
	0.4	0.18	0.3	0.12	0	0.43	0.5	0	0.07	0
RF_16	0	0.14	0.36	0.36	0.14	0	0	0.64	0.14	0.21
	0.07	0.14	0.43	0.28	0.07	0	0.07	0.36	0.36	0.21
	0	0.28	0.21	0.51	0	0	0.07	0.43	0.43	0.07
	0.07	0.07	0.49	0.36	0	0	0.07	0.43	0.36	0.14
	0.07	0.14	0.22	0.56	0	0	0.08	0.54	0.23	0.15
	0.07	0.28	0.28	0.36	0	0	0.15	0.54	0.23	0.08
	0.51	0.21	0.14	0.14	0	0.08	0.54	0.08	0.22	0.08

Appendix H: PPP Procurement Process under New Zealand PPP Model

Overview of the PPP procurement process



The New Zealand PPP Model and Policy (The Treasury, 2015)

Appendix I: Human Ethics Notification

Human Ethics Notification - 4000021396

Tue, Jul 30, 2019 at 8:55 AM

HoU Review Group

Ethics Notification Number: 4000021396
Title: Public private partnerships : A New Zealand perspective

Thank you for your notification which you have assessed as Low Risk.

Your project has been recorded in our system which is reported in the Annual Report of the Massey University Human Ethics Committee.

The low risk notification for this project is valid for a maximum of three years.

Please note that travel undertaken by students must be approved by the supervisor and the relevant Pro Vice-Chancellor and be in accordance with the Policy and Procedures for Course-Related Student Travel Overseas. In addition, the supervisor must advise the University's Insurance Officer.

A reminder to include the following statement on all public documents:

"This project has been evaluated by peer review and judged to be low risk. Consequently it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named in this document are responsible for the ethical conduct of this research.
If you have any concerns about the conduct of this research that you want to raise with someone other than the researcher(s), please contact Professor Craig Johnson, Director (Research Ethics), email humanethics@massey.ac.nz. "

Please note that if a sponsoring organisation, funding authority or a journal in which you wish to publish require evidence of committee approval (with an approval number), you will have to complete the application form again answering yes to the publication question to provide more information to go before one of the University's Human Ethics Committees. You should also note that such an approval can only be provided prior to the commencement of the research.

You are reminded that staff researchers and supervisors are fully responsible for ensuring that the information in the low risk notification has met the requirements and guidelines for submission of a low risk notification.

If you wish to print an official copy of this letter, please login to the RIMS system, and under the Reporting section, View Reports you will find a link to run the LR Report.

Yours sincerely

Professor Craig Johnson
Chair, Human Ethics Chairs' Committee and
Director (Research Ethics)

Appendix J: Statement of Contribution (DRC-16)

MASSEY UNIVERSITY
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UNIVERSITY OF NEW ZEALAND

GRADUATE RESEARCH SCHOOL

STATEMENT OF CONTRIBUTION
DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the student and the student's main supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the student's contribution as indicated below in the Statement of Originality.

Student name:	Nasir Rasheed
Name and title of main supervisor:	Professor James Olabode Bamidele Rotimi
In which chapter is the manuscript/published work?	2
What percentage of the manuscript/published work was contributed by the student?	80

Describe the contribution that the student has made to the manuscript/published work:

Literature review, methodology, data collection and analysis, original draft preparation.

Please select one of the following three options:

(●) **The manuscript/published work is published or in press**

Please provide the full reference of the research output:

Rasheed, N., Jr, C. A. T., Shahzad, W., & Rotimi, J. O. (2019). CRITICAL SUCCESS FACTORS OF PUBLIC PRIVATE PARTNERSHIPS (PPPs) IN NEW ZEALAND. Proceedings of the 43rd Australasian Universities Building Education Association (AUBEA) Conference, November 2019, QLD, Australia, p. 223.

( ) **The manuscript is currently under review for publication**

Please provide the name of the journal:

( ) **It is intended that the manuscript will be published, but it has not yet been submitted to a journal**

Student's signature:	Nasir Rasheed — Digitally signed by Nasir Rasheed Date: 2023.10.22 22:38:04 +13'00'	Main supervisor's signature:	James Olabode Bamidele Rotimi — Digitally signed by James Olabode Bamidele Rotimi DN: cn=James Olabode Bamidele Rotimi, c=NZ, o=Massey University, ou=School of Built Environment, email=j.rotimi@massey.ac.nz Date: 2024.01.15 19:28:14 +13'00'

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Name and title of main supervisor:	Professor James Olabode Bamidele Rotimi
In which chapter is the manuscript/published work?	2
What percentage of the manuscript/published work was contributed by the student?	80

Describe the contribution that the student has made to the manuscript/published work:

Literature review, methodology, data collection and analysis, original draft preparation.

Please select one of the following three options:

(●) **The manuscript/published work is published or in press**

Please provide the full reference of the research output:

Rasheed, N., Wahid, I., Shahzad, W., & Rotimi, J. O. B. (2020, February). Understanding the Factors Critical to Success of PPPs in New Zealand: Public and Private Sector Standpoint. In Proceedings–New Zealand Built Environment Research Symposium (p. 13).

( ) **The manuscript is currently under review for publication**

Please provide the name of the journal:

( ) **It is intended that the manuscript will be published, but it has not yet been submitted to a journal**

Student's signature:	Nasir Rasheed Digitally signed by Nasir Rasheed Date: 2023.10.22 22:39:13 +13'00'	Main supervisor's signature:	James Olabode Bamidele Rotimi Digitally signed by James Olabode Bamidele Rotimi DN: cn=James Olabode Bamidele Rotimi, c=NZ, o=Massey University, ou=School of Built Environment, email=j.rotimi@massey.ac.nz Date: 2024.01.15 19:28:47 +13'00'

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Student name:	Nasir Rasheed
Name and title of main supervisor:	Professor James Olabode Bamidele Rotimi
In which chapter is the manuscript/published work?	3
What percentage of the manuscript/published work was contributed by the student?	80

Describe the contribution that the student has made to the manuscript/published work:

Literature review, methodology, data collection and analysis, original draft preparation.

Please select one of the following three options:

- (●) **The manuscript/published work is published or in press**

  Please provide the full reference of the research output:

  Rasheed, N., Shahzad, W., Khalfan, M., & Rotimi, J. O. B. (2022). Risk identification, assessment, and allocation in PPP projects: A systematic review. Buildings, 12(8), 1109.

- ( ) **The manuscript is currently under review for publication**

  Please provide the name of the journal:

- ( ) **It is intended that the manuscript will be published, but it has not yet been submitted to a journal**

Student's signature:	Nasir Rasheed — Digitally signed by Nasir Rasheed Date: 2023.10.22 22:39:59 +13'00'	Main supervisor's signature:	James Olabode Bamidele Rotimi — Digitally signed by James Olabode Bamidele Rotimi DN: cn=James Olabode Bamidele Rotimi, c=NZ, o=Massey University, ou=School of Built Environment, email=j.rotimi@massey.ac.nz Date: 2024.01.15 19:27:40 +13'00'

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Student name:	Nasir Rasheed
Name and title of main supervisor:	Professor James Olabode Bamidele Rotimi
In which chapter is the manuscript/published work?	4
What percentage of the manuscript/published work was contributed by the student?	80

Describe the contribution that the student has made to the manuscript/published work:

Literature review, methodology, data collection and analysis, original draft preparation.

Indicative article title: Factor analysis of risk allocation criteria (RAC) in public-private partnership (PPP) projects: A case of New Zealand

Please select one of the following three options:

- ○ **The manuscript/published work is published or in press**

  Please provide the full reference of the research output:

- ○ **The manuscript is currently under review for publication**

  Please provide the name of the journal:

- ● **It is intended that the manuscript will be published, but it has not yet been submitted to a journal**

Student's signature:	Nasir Rasheed — Digitally signed by Nasir Rasheed Date: 2023.10.22 22:40:29 +13'00'	Main supervisor's signature:	James Olabode Bamidele Rotimi — Digitally signed by James Olabode Bamidele Rotimi DN: cn=James Olabode Bamidele Rotimi, c=NZ, o=Massey University, ou=School of Built Environment, email=j.rotimi@massey.ac.nz Date: 2024.01.15 19:30:46 +13'00'

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Student name:	Nasir Rasheed
Name and title of main supervisor:	Professor James Olabode Bamidele Rotimi
In which chapter is the manuscript/published work?	5
What percentage of the manuscript/published work was contributed by the student?	80

Describe the contribution that the student has made to the manuscript/published work:

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STATEMENT OF CONTRIBUTION
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We, the student and the student's main supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the student's contribution as indicated below in the Statement of Originality.

Student name:	Nasir Rasheed
Name and title of main supervisor:	Professor James Olabode Bamidele Rotimi
In which chapter is the manuscript/published work?	6
What percentage of the manuscript/published work was contributed by the student?	80

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