Incorporation of Risk Index for Risk Response and Risk Mitigation Strategies of Public-Private Partnership (PPP) Housing Construction Project in Malaysia

P Z Razi, M I Ali and N I Ramli

Faculty of Civil Engineering Technology, University Malaysia Pahang, 26300, Gambang, Kuantan, Malaysia

Abstract. The present work attempt to derive a risk index that causing performance failures among Public-private partnership (PPP) housing construction project, and to propose a risk response and monitoring strategy based on the risk index obtained. A total of thirty-three (33) respondent involved in the PPP housing construction assessing the risk elements employing the Analytical Hierarchy Process (AHP). Findings reveal that among the risks that were captured for high to extreme risks ($0.100 < RI \leq 0.150$) are geologic hazard risk (0.125), and inflation and interest rate risk (0.116) whereas strategy proposed for both of the extreme risks are avoiding the risk and it best to be assigned the risks to the private sector. On contrary, results for moderate risks captured with unreliable value for money (0.066), fluctuation in currency exchange rate (0.058), absence of transparency and accountability during procurement process (0.084), absence of robust and clear agreement (0.077), unforeseen ground condition (0.058) and shortage of technical expertise (0.054) the strategy advocated for the moderate risk is to transfer the risks and shared within both parties i.e. public and private. Eventually, low risks occupied within the risk index of ($0.000 < RI \leq 0.050$) are financial incapacity if private partners (0.034), weak state intervention (0.039), persistent land acquisition (0.039), insufficient capacity in procurement and negotiation (0.035), frequent design change (0.039), design over specification (0.023), poor quality workmanship (0.029), absence of specific PPP framework (0.046) and inadequate PPP skills and knowledge leading to poor planning (0.043) all the risks best to accept and retained within the public sectors. Taken together, the development of risk response and risk mitigation plan that emerged from the risk index offered significant contribution which has gain a new understanding that risks with severe or low exposure can be reduced or avoided taking into account its strategic and effective response and mitigation approaches.

1. Introduction

Public-private partnerships (PPP) since its establishment is often associated with infrastructure development [1], however in line with current developments, PPP has extended to other sectors such as housing, tourism and hospitals [2]. The principle of construction of PPP housing project is that the private sector is expected to carry out the project whereas the government provided the land and other incentives that may benefit both parties [1]. PPP in housing project bonded under the turnkey contract, whereas the government will motivate the private sector by providing an attractive payment method [3]. Malaysia government have tremendously introduced many PPP housing programmes in order to provide adequate housing for the targeted groups to name some, including One Malaysia housing programme (PR1MA), 1Malaysia Civil Servants Housing (PPA1M) and others. In a similar vein, to ensure an adequate supply of low-cost houses, government, as the public sector sets that for any mixed development projects undertaken by private developers are required to allocate a minimum of 30% to low-cost housing [4].

The adoption of Public-Private Partnership (PPP) in a housing facility in Malaysia is intended to increase urban housing standard and address housing affordability and convenience. However, there is still a lack of or limited consensus on the key risk factors that adversely impact on PPP housing success performances in terms of the schedule delay, significant increase of cost and the poor quality of the house built. Thus, this study incorporates the risks involved in the construction of PPP housing through risk management processes comprising risk identification, risk analysis, risk response, risk mitigation and the construction performance of the housing construction itself through several risk elements that presented in the m section.

2. Literature Review

Although literature review underscores the tremendous development of PPP projects in the infrastructure project, however this is not happening for the construction of PPP housing. Even though the developed countries have achieved a successful PPP implementation, however there are evident in the accounts of many failed PPP projects around the world [5], [6]. While in developing countries, PPP is still at the beginning of the learning process [7]. Despite the fact that few previous studies reports on the PPP housing including [3], [8]–[11], however there is still a lack of or limited consensus on the key risk factors that adversely impact on PPP housing success performances. Such failure of this PPP demonstrates fallacies on the risk management approach on which, absence of convincing risk assessment models [12] and arguments on the risk transference for which parties best to bear the risk [13]. Apart from that, the relevancy is called upon for a dearth of publications on the actual implementation of housing public-private partnerships (PPPs), especially in developing countries [10], [14] couple with the lack of success reporting on the PPP housing approach [9]. Aggravating the current situation is much depended to the lack of knowledge on the mechanism in PPP procurement, criticisms on the early stage of development are becoming more and more significant [15] couple with absence of integration between public and private in handling the housing issues [16] as the level of understanding of the implications of risk and constraints differs in the public and private sectors, since public sector seems to underestimate the extent of risk that needs seriously addressed before considering implementing a reliable PPP project [17]. Risk Management is a proactive decision-making process used to minimise and manage the risks most efficiently and appropriately. Risk management is indeed a dynamic tool which must be continuous throughout the project life cycle, and it is based on intuition and experience for a high level of judgment [18]. Risk management is primarily a decision to be made, rather than a predetermined outcome [19].

3. Research Methodology

This study employing questionnaire survey as its tools, designed with a pair-wise comparison of scale 1 to 9 (Table 1) following the AHP method, to determine the prioritisation of risks that caused poor performance of PPP housing construction project. The weightage obtained for each risk elements deemed as the probability (P). In addition, as AHP is a multi-criteria decision making tools, the methodological of AHP requires an expert to be the subject respondent. Experts are needed to determine the relative importance of each element and sub-elements using pair-wise comparison and their constructive insight thus provides a weightage for each REs. A quantitative approach was also used to determine the impact of occurrence (I) adopting the mean rank analysis using SPSS version.

Table 1. AHP Rating Scale [20], [21]

Intensity	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgement slightly favors one activity over another
5	Essential or strong importance	Experience and judgement strongly favor one activity over another
7	Very strongly importance	An activity is strongly favored and its dominance demonstrated in practice
9	Extremely importance	Evidence favoring one over another of

		highest possible order of affirmation
2,4,6,8	Intermediate values	When compromise is needed

4. Results and Discussion

4.1. Demographic Data
A total of sixty-four (64) construction project team that inclusive of the project developer, civil & structural engineer, architect, main contractor, and mechanical and electrical engineer in accordance to the listing provided in PR1MA corporation official website further contacted requesting for their willingness to participate in answering the survey. Hence, sixty-four (64) questionnaire distributed and, thirty three (33) responded giving the response rate of the survey instrument at 52%. The response rate is considered sufficient as recommended by [22], a response rate of 50% for a questionnaire survey is considered adequate. Table 2 depicts the expert respondent profession. Civil Engineer monopolised the highest number of respondents with (N = 11), followed by Quantity Surveyor (N=7) and Architects (N=6). While the remaining is Main Contractor (N=3), "Others" as their profession categories that consist of (land surveyor, property manager and project manager). Similarly, Subcontractors (N=2) while Mechanical and Electrical Engineers (N=1). As this study relying on the expert judgement, the expertise of each of the respondent undeniable since most of them have more than ten years of experience and the detail tabulated in the table below.

Table 2. Expert's respondent profiles

Profession (N)	Experience (years)	
	10 to 14 years	Over 15 years
Civil Engineer (11)	8	3
Architect (6)	5	1
Mechanical Engineer (1)	1	-
Quantity Surveyor (7)	4	3
Main Contractor (3)	1	2
Sub-Contractors (2)	1	1
Others (3)	2	1
Total (33)	22	11

4.2. Risk probability and impact
Analysis for risk probability employing the AHP method whereas it gave the prioritisation of risk elements and sub-elements (REs) in terms of their weighted importance. On the other hand, analysis of the risk impact presented in descriptive statistics using the mean score. The scale value of risk impact presented in Table 3 was proposed and guided from rating impacts for the risk from the project management body of knowledge (PMBOK® guide) [23]. The description shown in the table below was adjusted to suit within the context of this study.

Table 3. Scale of impact and description

Scale Value	Scale	Description of Scale
0.1	Little impact	The impact is insignificant; minimal impact or nor apparent impact at all
0.3	Minor impact	Minor impact to the project progress performance
0.5	Moderate impact	Significant impact on the project performance caused to high cost, time and quality of work

0.7	Major impact	Serious or major impact on the project performance caused to stop work of the project
0.9	Catastrophic impact	Catastrophic impact to the project performance including project termination

Table 4 depicts the results of the risk probability and impact analysis. It is worth noting that the risk element was divided into two core element namely the external (country level) and internal (project level). From an analysis of impact, it is apparent from the mean values of the external risks for the risk impact of sub-elements risk ranged from the highest mean at (0.682) and the lowest mean at (0.536), which shows that, the impact upon performance of PPP housing construction ranging from moderate impact to major impact for the external risks. On the contrary, for the internal risks it is apparent that the mean values ranging from the highest (0.664) to the lowest (0.367). The impact upon the performance of PPP housing construction ranging from moderate impact to minor impact for the internal risks.

The ranking for the risk sub-elements captured the highest for geologic hazards risks (earthquakes, tsunami, landslide and floods) at 0.184, followed by inflation and interest rate risk at 0.179, unreliable value for money (VfM) at 0.104, fluctuation in currency exchange rate at 0.092, weak state intervention at 0.064 followed by persistent land acquisition issues at 0.058. On the other hand, absence of transparency and accountability during procurement process were rated the highest risk sub-elements at 0.126, followed by absence of robust and clear agreement at 0.120, unforeseen ground conditions at 0.091, need for a specific PPP framework at 0.077 and lastly inadequate PPP skills and knowledge leading to poor planning at 0.070. The findings of ranking for the risk sub-elements is quite revealing that most of the prioritised risk monopolised by the economic and financial risk for external risk, meanwhile procurement and contractual risks dominate in the internal risks.

Table 4. Result of risk probability and impact

Core Element	Risk Element	Risk Sub-Elements (REs)	Probability (P)	Impact (I)
External	EF Economic & Financial Risk	EF1 (Inflation & interest rate risk)	0.179	0.645
		EF2 (Fluctuation in the currency exchange rate)	0.092	0.633
		EF3 (Financial incapacity of private partners)	0.055	0.615
		EF4 (Unstable macro-economic condition & absence of sound economic policy)	0.051	0.567
		EF5 (Unreliable value for money project)	0.104	0.633
	SP Socio & Politic Risk	SP1 (Absence of good & favourable governance and political support)	0.049	0.063
		SP2 (Absence of uniform policy on PPP housing provision)	0.025	0.585
		SP3 (Weak state intervention)	0.064	0.603
		SP4 (Persistent land acquisition issue)	0.058	0.676
	MR Market Risk	MR1 (Government interference in PPP construction market)	0.056	0.597
		MR2 (Unanticipated housing demand risk)	0.019	0.567
		MR3 (Inadequate PPP housing ownership)	0.020	0.536
	NH Natural Hazard Risk	NH1 (Geologic hazards – earthquakes, tsunami, landslide, floods)	0.184	0.682
		NH2 (Atmospheric hazards – tropical cyclone, droughts, severe thunderstorms)	0.044	0.633
	PC	PC1 (Inappropriate indemnity provision)	0.035	0.561

Internal	Procurement & Contractual Risk	PC2 (Absence of transparency & accountability during the procurement process)	0.126	0.664
		PC3 (Absence of robust and clear agreement)	0.120	0.645
		PC4 (Insufficient capacity in procurement & negotiations)	0.059	0.591
	CR Construction Resources Risk	CR1 (Shortage of workers)	0.021	0.579
		CR2 (Poor quality workmanship)	0.046	0.633
		CR3 (Suppliers inability to supply material)	0.018	0.585
		CR4 (Shortage of technical expertise)	0.085	0.633
Internal	TF Technical Faulty Risk	TF1(Insufficient drawings & specifications)	0.028	0.597
		TF2 (Frequent design change)	0.062	0.627
		TF3 (Unforeseen ground conditions)	0.091	0.639
		TF4(Misinterpretation of technical specifications)	0.037	0.615
		TF5 (Design over specification)	0.038	0.615
	PO Project Organization Risk	PO1 (Inadequate PPP skills & knowledge leading to poor planning)	0.079	0.609
		PO2 (Lack of cordial relationship among construction parties)	0.027	0.518
		PO3 (Need for a specific PPP framework)	0.077	0.597
		PO4(Disputes & conflicts between parties)	0.021	0.579
	TA, Technological Advancement Risk	TA1 (Insufficient technology investment)	0.035	0.397
		TA2 (Unavailability of technology advancement)	0.019	0.367

4.3. Risk Index

Generally, the risk index (RI) is derived from the probability (P) and impact (I) analysis as illustrated by the following equation.

Risk Index (RI) = Risk Probability (P) x Risk Impact (I) Equation (1)

This risk index may serve as a construction indicator from a PPP housing construction perspective. Figure 1 below illustrates the risk index for external and internal risk sub-elements respectively. The evidence from this study captured risk index for external risk dominates by geologic hazards (earthquakes, tsunami, landslides, floods) - NH1 (0.125), inflation and interest rate risk - EF1 (0.116), unreliable value for money (vfm) project - EF5 (0.066), fluctuation in currency exchange rate - EF2 (0.058), persistent land acquisition issue - SP4 (0.039), weak state intervention - SP3 (0.039) and financial incapacity of private partners - EF3 (0.034). On the other hand, risk index of internal risk demonstrates the highest risk index monopolized by absence of transparency and accountability during procurement process - PC2 (0.084), absence of robust and clear agreement - PC3 (0.077), unforeseen ground conditions - TF3 (0.058), shortage of technical expertise - CR4 (0.054), absence of a specific PPP framework - PO3 (0.046), inadequate PPP skills and knowledge leading to poor planning - PO1 (0.043), frequent design change - TF2 (0.039), Insufficient capacity in procurement and negotiations - PC4 (0.035), poor quality workmanship - CR2 (0.029) and design over specification - TF5 (0.023).

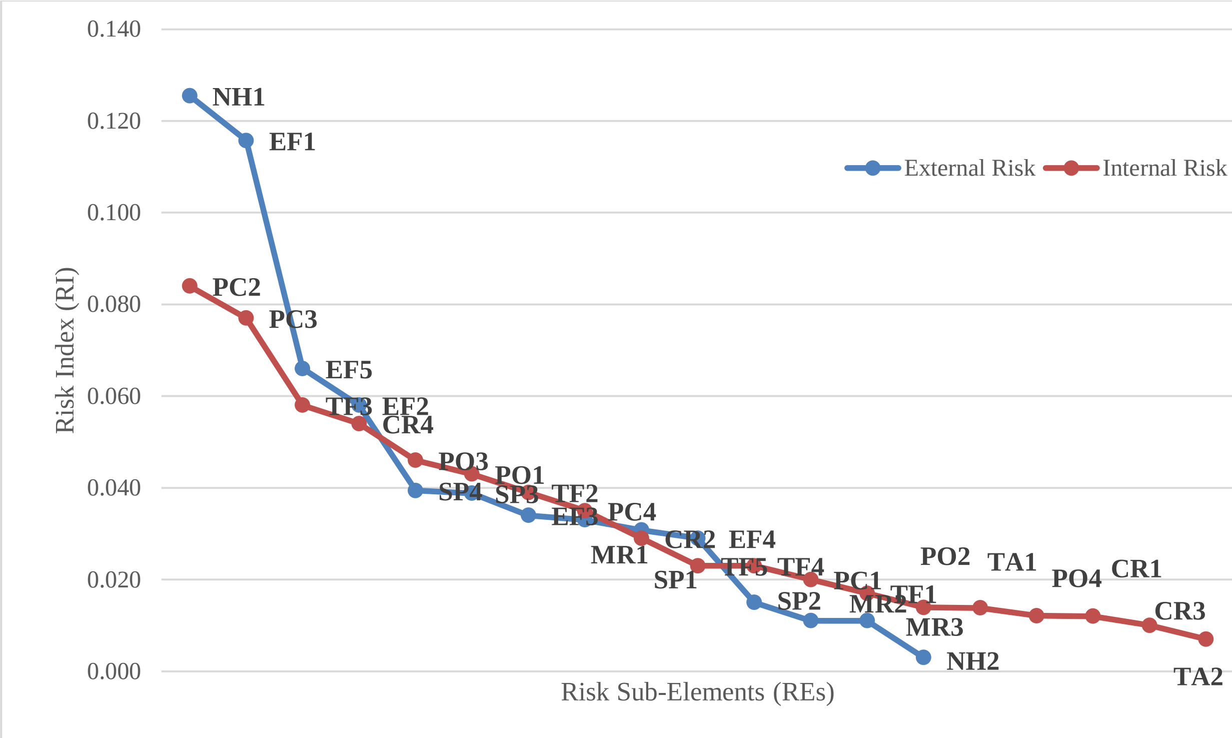

Figure 1. Risk index of external and internal risk

4.4. Risk Response

The risk response mechanism for this study is drawing largely on "risk allocation preferences" developed by [24] whom also borrowing similar study during earlier analyses conducted by [25] focusing on PPP infrastructure project. For the context of this study, to suit the risk index that was developed in previous section, the risk allocation preferences were develop based on the equalities and inequalities function form as described below:

$0.100 < RI \leq 0.150$	Extreme/High risk (Threshold 1)
$0.050 < RI \leq 0.100$	Medium risk (Threshold 2)
$0 < RI \leq 0.050$	Low risk (Threshold 3)

Whereas, for the risks falls within threshold 1, all the risks should borne by the private sectors, while, in threshold 2 risk shared within the public and private and else threshold 3 all the risk will borne by the public sector. Therefore, figure 2 illustrates the risks that divided according to their respective risk index and the preferences on the risk allocation strategies.

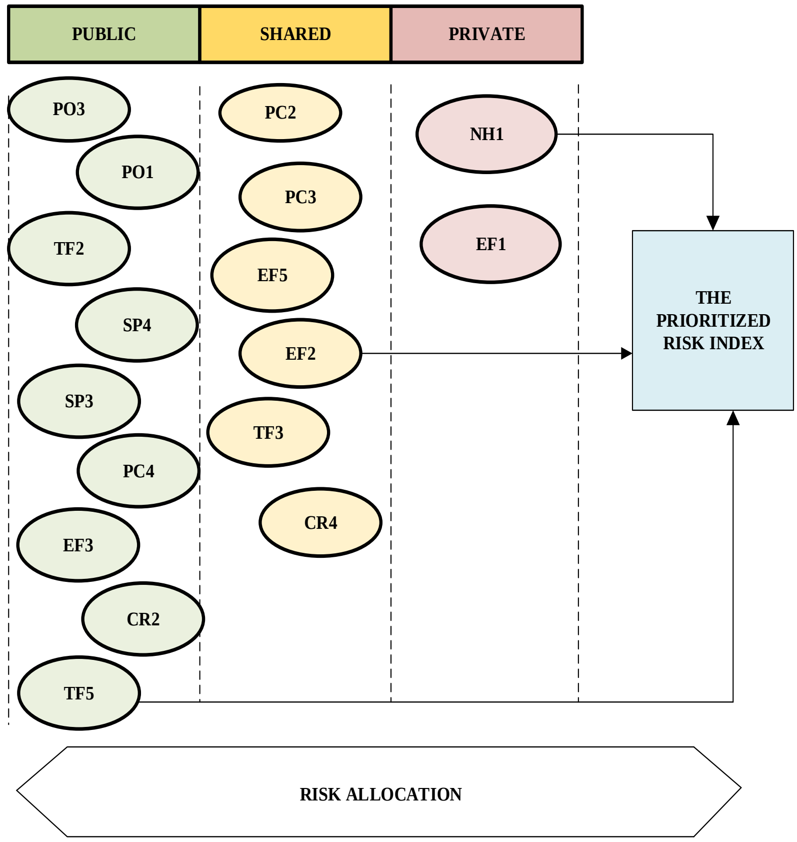

Figure 2. Integration Model of Risk Allocation for PPP Housing Construction

4.5. Risk Mitigation

In ensuring the success of PPP projects, it is important for all partners to manage the risks from a project life cycle perspective, in which risks are identified and assessed in the earliest possible project stage and allocated to the parties who are in the best position to control them. Furthermore, it is also important to continuous monitor the risks and develops proactive risk respond strategies throughout the project life cycle [26]. Within the context of risk mitigation, for threshold 1 shows that within the risk index falls in the category will classified as extreme/high thus the mitigation requires immediate government decision for intervening in the issue with involvement of state and highest project management, threshold 2 will be served as medium risk that requires higher senior management decision and manages by specific monitoring or response procedures, if the resources allow, this kind of risk requires to develop more detailed actions, while threshold 3 all the risk regards as low risk, thus the mitigation merely requires a project routine procedure.

5. Conclusion

By integrating the performance measurement (time, cost and quality) in the forms of the risk impact towards the PPP housing construction and risk management pillars process, it strengthens the main goals of this study. The incorporation of risk index based upon the weighting rates by its importance for the Malaysian context, the weightings may need for restructuring before the tools employed in other countries outside of Malaysia. Notwithstanding the limitation, this studies main contributions relevant to academia and industry practice: it open insight of the construction industry practitioners in particular the PPP housing construction needs and the importance of risk management in PPP housing construction projects. Also, the risk analysis process, besides giving weighted to prioritisation of each risk, it can be used as a key performance indicator to anticipate the risks to be encountered, the response to those risks and the effective strategies to mitigate those risks.

6. References

[1] Abdul Aziz AR 2010 Housing private public partnerships: perspectives from the government agencies in *4th NAPREC Conf.* 2010 September 1–24.

[2] Hossain M, Guest R and Smith C 2019 Performance indicators of public private partnership in Bangladesh *Int. J. Product. Perform. Manag.* **68** 1 pp 46–68

[3] Trangkanont S and Charoenngam C 2014 Private partner's risk response in PPP low-cost housing projects *Prop. Manag.* **32** 1 pp 67–94

[4] Bakhtyar B, Zaharim A, Sopian K, Saadatian O and Abdulateef J 2012 Affordable quality housing for urban low income earners in Malaysia *SSRN Electron. J.* December

[5] Loosemore M and Cheung E 2015 Implementing systems thinking to manage risk in public private partnership projects *Int. J. Proj. Manag.* **33** 6 pp 1325–34

[6] El-Gohary NM, Osman H and El-Diraby TE 2006 Stakeholder management for public private partnerships *Int. J. Proj. Manag.* **24** 7 pp 595–604.

[7] Sastoque LM, Arboleda CA and Ponz JL 2016 A proposal for risk allocation in social infrastructure projects applying PPP in Colombia *Procedia Eng.* **145** pp 1354–61

[8] Kavishe N 2016 Risks associated with public private partnership (PPP) housing projects delivery in Tanzania *Int. J. Constr. Eng. Manag.* *7* 2 pp 81–7.

[9] Kwofie TE, Afram S and Botchway E 2016 A critical success model for PPP public housing delivery in Ghana *Built Environ. Proj. Asset Manag.* **6** 1 pp 58–73

[10] Abdul-Aziz AR 2012 Control mechanisms exercised in Malaysian housing public-private partnerships *Constr. Manag. Econ.* **30** 1 pp 37–55

[11] Liu T, Chan A and Wang S 2014 PPP framework for public rental housing projects in China *Int.Conf. on Construction and Real Estate Management (ICCREM)* pp 573–581

[12] Tang L, Shen Q and Cheng EWL 2010 A review of studies on Public–Private Partnership projects in the construction industry *Int. J. Proj. Manag.* **28** 7 pp 683–94

[13] Reeves E 2013 The not so good, the bad and the ugly: over twelve years of PPP in Ireland *Local Gov. Stud.* **39** 3 pp 375–95

[14] Sengupta U 2006 Government intervention and public-private partnerships in housing delivery in Kolkata *Habitat Int.* **30** 3 pp 448–61

[15] Wan Zahari WY and Xuen JWM 2013 Private Finance Initiative (PFI)/ Public Private Partnership (PPP) in Malaysia context *Int. J. Inf. Technol. Bus. Manag.* **17** 1 pp 29–42

[16] Rahardjo H, Suryani F and Trikariastoto ST 2014 Key success factors for public private partnership in urban renewal in Jakarta *Int. J. Eng. Technol.* **6** 3 pp 217–19

[17] Akerele D and Gidado K 3-5 September 2003 The risks and constraints in the implementation of PFI/PPP in Nigeria Greenwood DJ (Ed.) *19th Ann.Assoc.of Researchers in Construction Management ARCOM Conf.* University of Brighton **1** pp 379-91

[18] Abdul-Rahman H, Wang C and Sheik Mohamad F 2015 Implementation of risk management in Malaysian construction industry: case studies *J. Constr. Eng.* pp 1–6

[19] Kang BG, Fazlie MA, Goh BH, Song MK and Zhang C 2015 Current practice of risk management in the Malaysia construction industry–the process and tools/techniques *Int. J. Struct. Civ. Eng. Res.* **4** 4 pp 371–77

[20] Saaty TL 1988 What is the Analytic Hierarchy Process? *Mathematical Models for Decision Support* **48** Berlin, Heidelberg: Springer Berlin Heidelberg pp 109–21.

[21] Saaty TL and Vargas LG 2012 The possibility of group choice: Pairwise comparisons and merging functions *Soc. Choice Welfare* **38** 3 pp. 481–496

[22] Creswell JW 2014 *Research design* Sage Publications Inc California 4th ed.

[23] Project Management Institute (PMI) 2013 A guide to the project management body of knowledge Pennsylvania USA

[24] Ke Y, Wang SQ, Chan APC and Lam PTI 2010 Preferred risk allocation in China's public-private partnership (PPP) projects *Int. J. Proj. Manag.* **28** 5 pp 482–92

[25] Bing L, Akintoye A, Edwards P and Hardcastle C 2005 The allocation of risk in PPP/PFI construction projects in the UK *Int. J. Proj. Manag.* **23** 1 pp 25–35

[26] Zou PXW, Wang S and Fang D 2008 A life- cycle risk management framework for PPP infrastructure projects *J. Financ. Manag. Prop. Constr.* **13** 2 pp 123–42

Acknowledgement

Authors would like to thank all relevant respondents that willingly participate in the survey.