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Interpreting risk allocation mechanism in public–private partnership projects: an empirical study in a transaction cost economics perspective

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Interpreting risk allocation mechanism in public–private partnership projects: an empirical study in a transaction cost economics perspective

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Risk allocation in public–private partnership (PPP) projects is currently claimed as capability driven. While lacking theoretical support, the claim is often 'violated' by current industrial practice. There is thus a need for formal mechanisms to interpret why a particular risk is retained by government in one project while transferred to private partners in another. From the viewpoint of transaction cost economics (TCE), integrated with the resource-based view (RBV) of organizational capabilities, this paper proposed a theoretical framework for understanding risk allocation practice in PPP projects. The theories underlying the major constructs and their links were articulated. Data gathered from an industry-wide survey were used to test the framework. The results of multiple linear regression (MLR) generally support the proposed framework. It has been found that partners' risk management routine, mechanism, commitment, cooperation history, and uncertainties associated with project risk management could serve to determine the risk allocation strategies adopted in a PPP project. This theoretical framework thus provides both government and private agencies with a logical and complete understanding of the process of selecting the allocation strategy for a particular risk in PPP projects. Moreover, it could be utilized to steer the risk allocation strategy by controlling certain critical determinants identified in the study. Study limitations and future research directions have also been set out.

Keywords: Risk management, risk allocation, organizational capability, commitment, uncertainty, transaction cost economics, PPP.

Introduction

Rapid urbanization in many countries has led to a massive demand for investment in infrastructure (World Bank, 2006). Conventional provision of infrastructure funded by governments has led to inefficacies and subjected infrastructure development to the availability of governmental funds. As a mechanism to balance such anomalies, a range of public–private partnership (PPP) arrangements are rapidly becoming the preferred way to provide public services in many countries, including Australia (Doloi and Jin, 2007). PPP has been interpreted widely to encompass any arrangement between the government and private sector to deliver services to the public (Li and Akintoye, 2003). However, PPPs in this study refer to a complex long-term contractual arrangement involving the provision of services that require the construction of infrastructure assets (DFA, 2005c). Though there are many parties involved in a PPP transaction, the focus in this study is on two broad groups of stakeholders, i.e. the government agency and the private consortium, between whom risks are allocated.

The core principle for PPPs is value for money (VFM) (DTF, 2000). One of the greatest VFM drivers is risk transfer, which means appropriate risks can be transferred to the private sector, which is supposed to be capable of managing those risks better (Hayford, 2006). Accordingly, infrastructure services may be provided more cheaply and of a higher quality than in the conventional way. However, the complexity of the arrangements and incomplete contracting nature have led to increased risk exposure for all the parties involved (Woodward, 1995). Effective risk allocation in PPP projects is therefore no easy job. How do public and

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private partners allocate risks between them? In particular, how does a government agency respond to risks? Why is a particular risk transferred to the private consortium in one project while retained by government or shared in another? Most important, is there any mechanism guiding the formation of risk allocation strategies? The answers to these questions are critically important to the success (or failure) of PPP projects (DFA, 2005a; Jin and Doloi, 2007b).

In this paper, a theoretical framework is proposed to address those questions in the perspective of transaction cost economics (TCE), integrated with the resource-based view (RBV) of organizational capabilities. This is part of a large project aiming at developing robust knowledge-based system techniques capable of improving risk allocation and management processes. In the next section, risk allocation practices in PPP projects, organizational capability and transaction cost economics are briefly reviewed. The theoretical framework and its key constructs are then described. Research methodology and the results of an industry-wide survey in Australia are then reported, followed by a discussion on research limitations and future directions. Finally, a brief conclusion is presented.

Literature review

Risk allocation in PPP projects

Risk is 'the chance of something happening that will have an impact upon objectives' (SAA, 1998). Construction projects manifest more risks than do other industries (Han and Diekmann, 2004). The success of a project management exercise depends very much on the extent to which the risks involved can be identified, measured, understood, reported, communicated and allocated to the appropriate parties (Ren, 1994; Tah and Carr, 2000). However, evidence from projects worldwide shows that this is not a straightforward event and risks are not managed properly (Thompson and Perry, 1992).

In PPP projects, it is critical for government to understand that it is sub-optimal for them not only to retain but to transfer inappropriate risks (Arndt, 1999). This is because transfer of risks to the private sector comes at a price (Hayford, 2006) and improper allocation of risks among stakeholders may lead to higher than necessary prices (Thomas *et al.*, 2003). Inappropriate risk allocation can also damage the VFM proposition because the measures of the whole-of-life project cost are highly sensitive to the allocation of risks (DFA, 2005b). If risks rest inappropriately with the public sector, government would raise taxes or reduce services to pay for its obligations when the risks materialize. In contrast, if risks rest inappropriately with the private sector, excess premiums would be charged to the government or even directly to the end users (Thompson and Perry, 1992).

Many governments now recognize that privatization is a partnership in which they must retain some risk. However, a perception that privatization involves transfer of all risks to the private sector was still prevalent in many countries until recently (Faulkner, 2004). Sometimes risks will inevitably be allocated to the party least able to refuse them rather than the party best able to manage them, especially when the government maintains maximum competitive tension (Thomas *et al.*, 2003). In Australia, for example, PPP is now seen as an opportunity for government to avoid almost all the risks by purchasing outputs. It has been expressly made clear to the private party that the allocation is offered for acceptance and little divergence is expected (DTF, 2000). This structure implicitly creates an initial risk allocation in which all risks associated with delivering the outputs to the specified service standards are allocated to the private party.

Nonetheless, ongoing efforts have been made to seek an optimal risk allocation by investigating which categories of risk governments should generally accept or transfer and, critically, why (DFA, 2005b). Optimal risk allocation seeks to minimize the risks to the project by allocating particular risks to the party in the best position to control them (Kangari, 1995; Hayford, 2006). This is because the party possessing the best capability of management with respect to a particular risk has the best opportunity to reduce the likelihood of the risk eventuation and to control the consequences of the risk if it materializes, and thus should assume it (Thomas *et al.*, 2003).

Organizational capabilities

As RM capabilities of involved parties have become the major concern when choosing a risk allocation strategy, a review on organizational capability is necessary. The notion of capabilities can be traced back to Penrose's (1959) work. While resources are available to all firms, the 'capability' to deploy them productively is not uniformly distributed (Penrose, 1959, p. 25). With the evolution of the resource-based view (RBV), it has been increasingly recognized that the RBV explains competitive heterogeneity based on the premise that close competitors differ in their capabilities and resources in important and durable ways (Helfat and Peteraf, 2003).

Literature on RBV conceptualizes resources and capabilities in two different ways. Barney (1991), among others, tended to define resources broadly by including all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc.

However, another set of authors (see, for example, Amit and Schoemaker, 1993; Grant, 1991; Makadok, 2001) sought to clearly delineate between resources and capabilities by arguing that resources are accessible by all firms at prevailing factor prices, whereas capabilities refer to a firm's capacity to deploy resources. In this paper, the latter definition of organizational capabilities was adopted.

Transaction cost economics (TCE)

Risk allocation in PPP projects is suitable to be viewed from a TCE perspective because any issue that can be formulated as a contracting problem can be investigated to advantage in transaction cost economizing terms (Williamson, 1985). The suitability also arises from many features of PPPs, which include incomplete contracting, long-term partnerships, heavy investment in assets, complex uncertainty, etc. (Jin and Doloi, 2007a). Transaction costs are the costs of running the economic system (Arrow, 1969). Such costs are the economic equivalent of friction in physical systems and distinguished from production costs (Williamson, 1985). TCE poses the problem of economic organization as a problem of contracting and assumes that human agents are (1) subject to bounded rationality, where behaviour is 'intendedly rational but only limitedly so' (Simon, 1961, p. xxiv); and (2) given to opportunism, which is a condition of 'self-interest seeking with guile' (Williamson, 1985).

TCE further maintains that there are rational economic reasons for organizing some transactions one way and other transactions another. The principal dimensions with respect to which transactions differ are (1) asset specificity, the degree to which an asset can be redeployed to alternative uses and by alternative users without sacrificing productive value (Williamson, 1996, p. 59); (2) uncertainty, which may arise from 'state of nature' or changes in the external environment affecting a system (Rao, 2003, p. 17) or when incomplete contracting and asset specificity are joined (Williamson, 1996, p. 60); and (3) frequency, which admits the fact that the pairwise identity of the parties matters and has pervasive consequences for the organization of economic activity (Williamson, 1996, p. 61). The consequent organizational imperative is to 'organize transactions so as to economize on bounded rationality while simultaneously safeguarding them against the hazards of opportunism' (Williamson, 1985). By assigning transactions to governance structures in a discriminating way, transaction costs are economized (Williamson, 1985). However, transaction costs are always assessed in a comparative institutional way (Williamson, 1996). Empirical research on transaction cost issues remains whether organizational relations align with the attributes of transactions as predicted by transaction cost reasoning or not (Williamson, 1985).

Although the RBV of organizational capability and the TCE are closely linked to the analysis of risk allocation, little research has been done by integrating these two theories. This might be due to the long-existing argument between them. The literature on TCE, for example, argues that much of the literature on organizational capabilities fails to pay attention to the business environment and the resultant potential for opportunism (Foss, 1996; Williamson, 1999; Mahoney, 2001). On the other hand, the literature on organizational capabilities argues that TCE underemphasizes differences in firm capabilities (Winter, 1988). It is submitted in this paper, however, that the RBV of organizational capability and TCE are complementary in nature. This is because the role of asset specificity, which is one of the most critical components in TCE, is most evident in the description of organizational capability. Moreover, while TCE holds that transaction frequency matters, the RBV of organizational capability attends to the fact that past transactions between partners may generate processes that alter the calculus for future transactions (Ring and Van de Ven, 1994; Gulati, 1995). These make the formulations of TCE and RBV of organizational capability closely overlap (Rao, 2003, p. 32).

Theoretical framework and hypotheses

Based on the literature review, a model that could facilitate the interpretation of risk allocation practice in PPP projects would be expected. While organizational capability in RM remains one of the major concerns, it is submitted in this paper that the decision making on risk allocation can be better explained when a holistic view is adopted. This could be achieved by integrating TCE with a RBV of organizational capability, with the former taking into consideration other important factors such as uncertainties. Therefore, choosing a risk allocation strategy could actually be viewed as the process of deciding the proportion of risk management responsibility between internal and external organizations based on a series of characteristics of the RM service transaction in question. The characteristics can be categorized into (1) partners' RM capability, which is the organizational capability in RBV and can be deemed as major specified assets of TCE; (2) partners' cooperation history, which approximates to transaction frequency of TCE; (3) RM environment uncertainty; and (4) partners' RM commitment, which matches behavioural uncertainty of TCE. Accordingly, a theoretical framework as shown in Figure 1 is established based on the following main hypotheses:

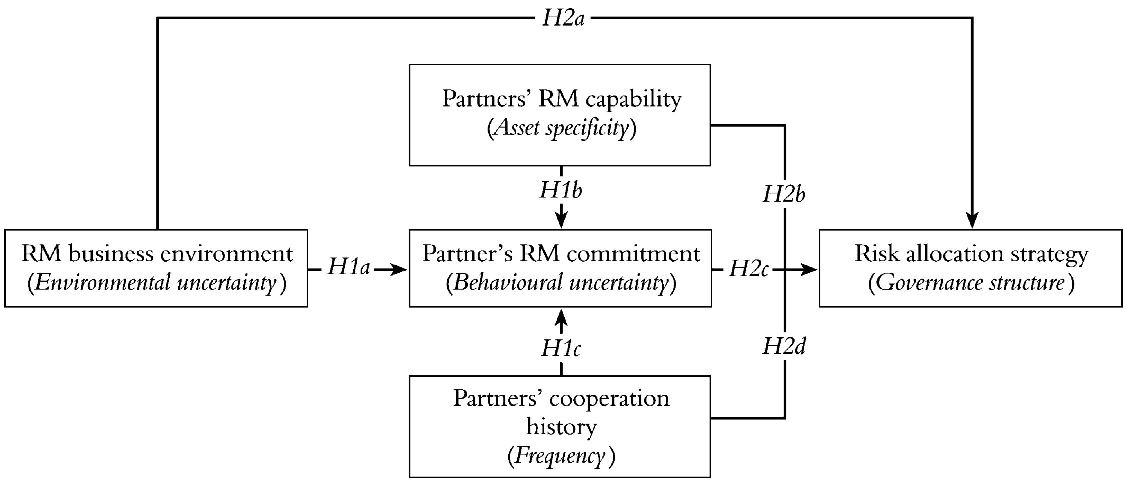

Figure 1 Theoretical framework for risk allocation in PPP projects

Hypothesis 1_0: Partners' RM capability (specific assets), partners' cooperation history (transaction frequency), and environment uncertainties determine partners' RM commitment (behavioural uncertainties); and

Hypothesis 2_0: Partners' RM capability (specific assets), partners' cooperation history (transaction frequency), environment uncertainties, and partners' RM commitment (behavioural uncertainties) determine risk allocation strategy (governance structure).

The constructs and their links are discussed below.

Organizational capability (specific assets)

It is proposed in this study that the most important specified assets in any RM service transaction would be the organizational RM capability. This is because the role of asset specificity is most evident in the description of organizational capability and thus remains closest to the TCE formulations (Rao, 2003, p. 32). RM capability can be further operationalized into RM routine and mechanism.

RM routine (assets specificity)

Organizations develop capabilities by carrying out related activities repeatedly (Nonaka and Takeuchi, 1995). Differences in past activities thus lead to heterogeneous capabilities. Firms are entities that possess heterogeneous capabilities as a function of their routines and search processes (Nelson and Winter, 1982). Over time, the knowledge accumulated through 'learning-by-doing' is embedded in bundles of 'routines' that are likened to the genetic material of the firm and serve as organizational memory to repetitively execute the sequence of productive activities without trouble.

Though the routines embody knowledge and competence in carrying out RM activities, they indicate that alternative uses could have been achieved without sacrificing productive value. That is to say, the longer the history of a RM routine (a transaction-specific asset), the more productive activities have been carried out, which means more alternative use has been made of the asset, and accordingly, the less specific the RM routines become. This is particularly understandable in the context of the construction industry, where products are generally of a one-off nature, which is distinct from the repetitive nature in such industries as manufacturing.

RM mechanism (specific assets maturity)

Capabilities tend to evolve over time to reflect the joint effects of passive learning-by-doing and deliberate firm-level investments in learning and making improvements (Ethiraj *et al.*, 2005). They are more likely to develop effectively when purposefully designed mechanisms are established to accumulate, store, integrate and diffuse relevant organizational knowledge acquired through experience (Kale *et al.*, 2002). These integrative mechanisms act as an important locus of firm learning (Pisano, 1994). Thus, while greater RM experience may be a necessary condition for organizations to build RM capability, it may not be sufficient. RM capability would also rest upon how effectively the organization is able to capture, share and disseminate the RM know-how.

According to *PMBOK* (PMI, 2001), risk management is a systematic mechanism, which involves the following major processes: (1) risk identification; (2) risk analysis; (3) risk response planning; and (4) risk monitoring and control. All together, these individual processes determine the soundness of the whole system. Therefore, the aggregated level of each process would be used to measure the maturity level of a partner's RM mechanism.

Partners' cooperation history (transaction frequency)

TCE fully accepts the description of *ex ante* bidding competition but insists that the study of contracting include *ex post* features (Williamson, 1996). Faceless contracting is thus superseded by contracting where the pairwise identity of the parties matters. Unlike existing goods, appropriate RM for building and construction projects is difficult to obtain in a one-off transaction and requires time to develop (Jin and Ling, 2005). The interaction among partners during that time necessitates communication and governance, the challenges of which partners could better address if they have had previous transactions (Heide and Miner, 1992; Parkhe, 1993). Communication and governance efficiencies increase as partners work together over time because such a relationship serves as a brake on opportunism for both partners (Williamson, 1983; Dyer, 1994, 1996).

Uncertainty

The core problem of an economic organization is that of facing and dealing with uncertainty (Koopmans, 1957). Uncertainties may arise from 'state-of-nature' or changes in the external environment affecting a system (Rao, 2003, p. 17). However, strategic features such as non-disclosure, disguise or distortion of information are unavoidably present when parties are joined in a condition of bilateral dependency (Williamson, 1996, p. 60). Behavioural uncertainties, which arise when incomplete contracting and asset specificity are joined, cause hazards. As behavioural uncertainty has been particularly recognized in TCE, uncertainty is grouped into environmental and behavioural uncertainty in this paper.

Environmental uncertainty

Environmental uncertainty is a multidimensional concept and its effects on organizations are context-specific (Bourgeois, 1980; Milliken, 1987). It is related with both micro and macro business environments (Dess and Beard, 1984; Miller, 1987). Partnership is potentially among the better governance forms when external uncertainty is high because of risk-sharing effects (Williamson, 1991). However, partnerships may suffer more due to an increased probability of opportunistic behaviour by individual parties (Luo, 2007), especially when they anticipate sustained or prolonged uncertainty (Brown *et al.* 2000). Based on the literature review, environment uncertainty is grouped into five categories in this paper, as shown in Table 1.

Organizational RM commitment (behavioural uncertainty)

Transaction costs are principally associated with guarding against opportunism, which triggers behavioural uncertainty (Williamson, 1975). Opportunism and commitment are reversely related (Kim and Mahoney, 2006) because commitment can serve as a brake to opportunism (Williamson, 1983). Organizational commitment is a willingness of partners to make short-term sacrifices to realize long-term benefits in the relationship (Dwyer *et al.*, 1987; Anderson and Weitz, 1992; Holm *et al.*, 1999). This kind of commitment suggests a level of 'affective attachment' based on the norm of reciprocity and mutual attraction (Gouldner, 1960; Eisenberger *et al.*, 1990). With lowered commitment, environment uncertainty impedes collaboration, and performance deteriorates (Luo, 2007). In this study, organizational commitment to RM would be treated as a latent variable, which would be measured by observed variables including willingness, confidence and reward expectation (see Table 2). This method has been successfully used in previous research (see Mowday *et al.*, 1979 and Johnson *et al.*, 2002).

Risk allocation strategies (governance structure)

Risk allocation is the process of dividing and assigning the responsibility associated with a particular risk for a variety of hypothetical circumstances (Uff, 1995). It was argued as a transaction of risk management responsibility between potential risk bearers (Jin and Doloi, 2007a). Thus, different allocation strategies are in fact different governance structures of risk management. TCE holds that with a certain combination of the transaction dimensions, an organization will respond to them by adopting a certain governance structure to economize on transaction costs (Williamson, 1985). The structures include hierarchy (internal or 'make'), market (external or 'buy'), and hybrid mode (both 'make' and 'buy') (Williamson, 1996). Correspondingly, in a given situation of the aforementioned features in a PPP project, a specific risk allocation strategy, i.e. a specific proportion of a given risk to be transferred from public partner to the private partner, will be agreed by partners in order to reduce transaction costs. This proportion or strategy can be 100% (entirely transfer or 'buy'), 0% (entirely retain or 'make'), or somewhere in-between ('make and buy'), e.g. 50% (bear equally). With the TCE assumption of transaction cost economizing purpose, the inherent mechanism, which assigns different RM transactions to different governance structures (transfer proportions), attracts major attention in this paper.

Table 1 Classification of RM environment uncertainty in PPP projects

Category	Code	Environment uncertainty	Measurement
Institutional	EI01	Political system stability	1=volatile; 5=stable
	EI02	Legislative system stability	1=volatile; 5=stable
	EI03	Approval process	1=hierarchical; 5=convenient
Social and industrial	ES01	Community attitude	1=resistant; 5=supportive
	ES02	Stability of related industry	1=volatile; 5=stable
	ES03	Logistics infrastructure availability	1=unavailable; 5=available
	ES04	Public involvement	1=lacking; 5=active
Economic	EE01	National economy condition	1=volatile; 5=stable
	EE02	Financial market maturity	1=immature; 5=mature
	EE03	Insurance market maturity	1=immature; 5=mature
	EE04	Raw material supply	1=scarce; 5=abundant
	EE05	Workforce supply	1=scarce; 5=abundant
Organizational	EO01	Public partner's general experience in similar projects	1=scarce; 5=abundant
	EO02	Public partner's risk attitude	1=averse; 5=seeking
	EO03	Public partner's probity	1=corrupt; 5=incorrupt
	EO04	Consortium's financial capability	1=incompetent; 5=competent
	EO05	Financier's reputation/credit	1=unreliable; 5=reliable
	EO06	Consortium's technical capability	1=incompetent; 5=competent
	EO07	Designer's general experience in similar projects	1=scarce; 5=abundant
	EO08	Contractor's general experience in similar projects	1=scarce; 5=abundant
	EO09	Operator's general experience in similar projects	1=scarce; 5=abundant
Project-specific	EP01	Project similarity with market precedents	1=distinct; 5=identical
	EP02	Design flexibility	1=rigid; 5=flexible
	EP03	Project technical novelty	1=obsolete; 5=pioneer
	EP04	Project constructability	1=poor; 5=suitable
	EP05	Reliability of reference data	1=unreliable; 5=reliable
	EP06	Exposure of project information	1=secret; 5=entirely publicized
	EP07	Competition in project tendering	1=little; 5=intensive
	EP08	Accuracy of contract provision	1=ambiguous; 5=explicit
	EP09	Effectiveness of partners' communication	1=ineffective; 5=effective
	EP10	Effectiveness of dispute resolution mechanism	1=ineffective; 5=effective
	EP11	Project sector	0=economic; 1=social
	EP12	Project value	AU$ million
	EP13	Project concession duration	Year
	EP14	Project construction duration (est.)	Month
	EP15	Project contract negotiation duration	Month

Research method

Based on the literature review, an operationalized framework is further shown in Figure 2. The operationalization of attributes of the constructs is presented in Table 2 except for those of environment uncertainty, which are presented in Table 1. In order to verify the theoretical framework, a questionnaire was designed closely based on the operationalized constructs. The questionnaire asked respondents to provide reliable information about a PPP project, in which they had appropriate involvement and/or knowledge. Respondents were also required to provide information about their PPP experience and designation.

A pilot survey was first conducted during a PPP workshop funded by the University of Melbourne. Among 65 attendants from industry, six provided feedback on the relevance, accuracy, phrasing, sequencing and layout of the questionnaire. Following the pilot survey and consequent refinement of the questionnaire, an industry-wide questionnaire survey was carried out in Australia, which constituted the primary data collection method in this study. The target population of the survey was all the professionals and decision makers who have been involved in risk management of PPP projects in Australia. They include people from both public and private sectors. However, random sampling is difficult owing to the difficulty in finding out the exact population. Therefore, judgmental or purposive sampling, in which a sample is drawn using judgmental selection procedures (Tan, 2004), was used. The strategy for sample selection was first to

Table 2 Operationalization of framework constructs

Construct	Code	Attribute	Measurement
Partner's RM routine	RtnPub	Public partner's experience in managing risk X	1=scarce; 5=abundant
	RtnPri	Private partner's experience in managing risk X	1=scarce; 5=abundant
Partner's RM mechanism	MchPub	Maturity of public partner's identification, analysis, response planning, and monitoring and control mechanisms for risk X (the four variables were subject to a confirmatory factor analysis and statistically converged to one factor)	1=immature; 5=mature
	MchPri	Maturity of private partner's identification, analysis, response planning, and monitoring and control mechanisms for risk X (the four variables were subject to a confirmatory factor analysis and statistically converged to one factor)	1=immature; 5=mature
Partner's cooperation history	CoopPubPri	Cooperation history between public partner and leading members of private partner	Number of previous cooperation
	CoopPri	Cooperation history among leading members of private partner	Number of previous cooperation
Partner's RM commitment	CmtPub	Public partner's willingness to put in greater effort than normal to manage risk X; public partner's confidence in managing risk X; public partner's expectation on possible gains by managing risk X (the three variables were subject to a confirmatory factor analysis and statistically converged to one factor)	1=very weak; 5=very strong
	CmtPri	Private partner's willingness to put in greater effort than normal to manage risk X; public partner's confidence in managing risk X; public partner's expectation on possible gains by managing risk X (the three variables were subject to a confirmatory factor analysis and statistically converged to one factor)	1=very weak; 5=very strong
Risk allocation strategy	Trsf	Proportion of risk management task transferred from public to private partner for risk X	1=retain (almost) all; 2=transfer a small portion; 3=equally share; 4=retain a small portion; 5=transfer (almost) all

identify PPP infrastructure projects in the Australian market, then to identify major partners of the identified projects, and finally to identify professionals and decision makers in major partners' organizations from the public domain. In total, 386 questionnaires were distributed. The returned questionnaires were checked and edited to ensure completeness and consistency. The data were then stored into a computer and analysed using Statistical Package for Social Sciences (SPSS) software.

Multiple linear regression

Multiple linear regression (MLR) analysis was conducted in this study to develop models to determine the relationship between explanatory and response variables (see Table 1 and Table 2) of the theoretical framework. The models were developed using SPSS software. The stepwise method was used to select explanatory variables. This method was adopted because it accommodates partial correlation structures for variables already in the model (Jin and Ling, 2006).

Regression analysis for a model includes maximizing the multiple determination coefficient (R^2), minimizing autocorrelation, and only including in the model the variables that are statistically significant in t-tests. A model should also be statistically significant in F-tests in order to prove that the included independent variables are capable of explaining the variation in the dependent variable. The optimum regression model should be the one that fits the data the best and yields the most accurate prediction of dependent variable.

R^2, the multiple determination coefficient, and R^2_{adj}, the adjusted R^2, were computed for each model. R^2, ranging from 0 to 1, represents the proportion of the variation in response variables that is explained by the

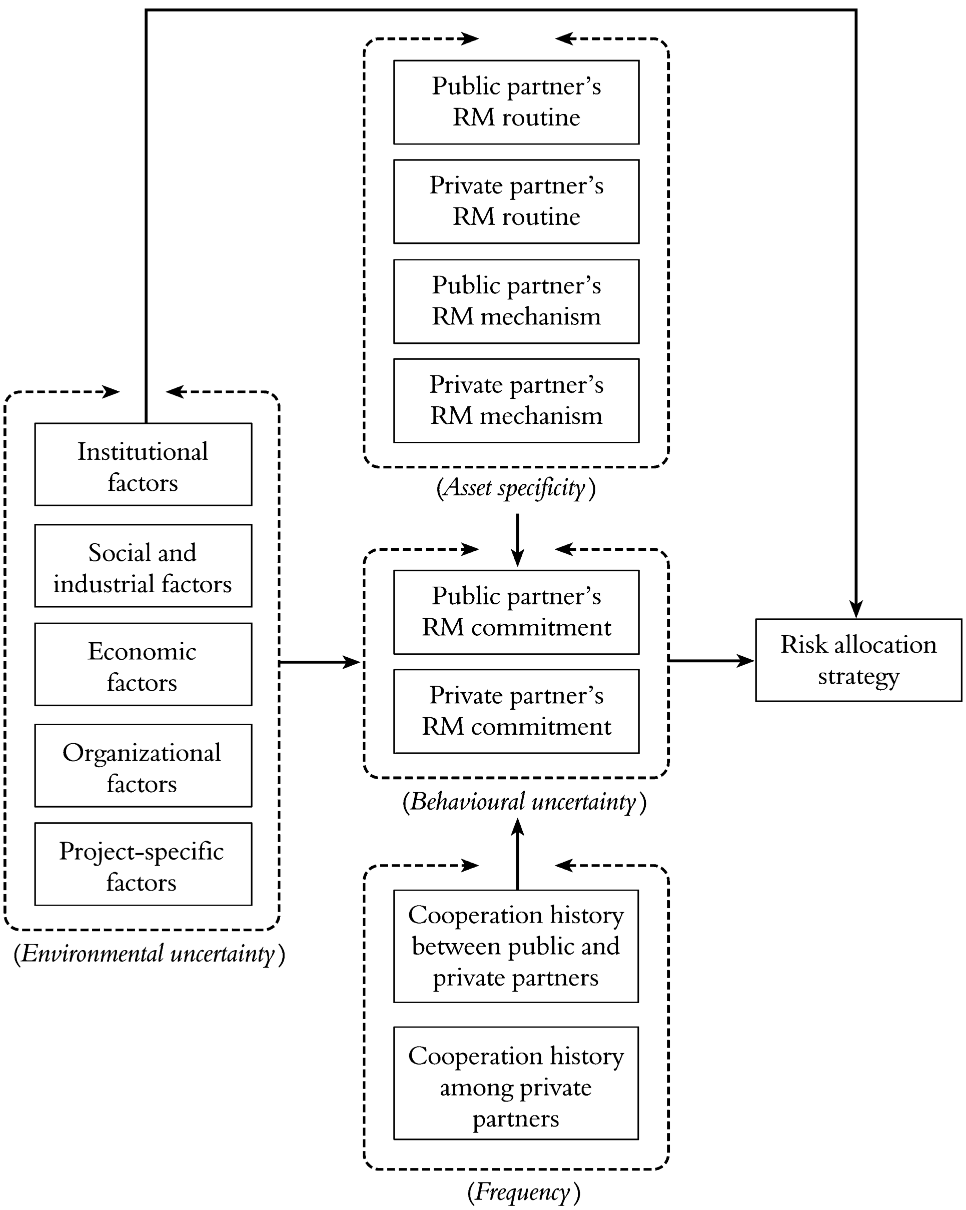

Figure 2 Operationalized theoretical framework for risk allocation in PPP projects

set of explanatory variables selected. Computing R^2_{adj} is especially necessary when comparing two or more models that predict the same dependent variable but have different numbers of explanatory variables (Levine *et al.*, 2002).

In this study, the Durbin–Watson statistic and variance inflationary factor (VIF) were used to check collinearity among explanatory variables for the model as a whole and for individual explanatory variables, respectively. The Durbin–Watson statistic ranges in value from 0 to 4. A value near 2, toward 0, or toward 4 indicates non-autocorrelation, positive autocorrelation or negative autocorrelation, respectively. If a set of explanatory variables is uncorrelated, VIF is equal to 1. If a set is highly intercorrelated, VIF might even exceed 10. In this study, the threshold is set at 5.0 (Levine *et al.*, 2002). This means that when each VIF < 5.0, there is little evidence of collinearity among a set of explanatory variables.

Residual analysis was also undertaken in this study to check normality of distribution of variables and appropriateness of MLR models.

Results and discussion

Three hundred and eighty-six survey packages were sent out in Australia by e-mail and recipients were invited to respond within two months. In total, 44 useful responses were received. The survey response rate of 11.4% is acceptable for a survey of this nature (De Vaus, 2001). The profile of the respondents is shown in Table 3. They were deemed appropriate to provide reliable responses to the survey because of their ample experience in PPP projects and in the construction industry.

For the sake of brevity, only the MLR analysis results of the allocation mechanism of the risk of 'demand below anticipation' (demand risk) are reported as an example in this paper. This risk means that the demand for contracted services is unfavourably below anticipation (Jin, 2007). The reason for choosing demand risk as an example is that demand risk is not only the major but the most controversial risk in PPP projects. It has been deemed as one of the major challenges that PPPs face (see e.g. Tiong, 1990; Carrillo *et al.*, 2006), among others). Table 4 presents the results of the MLR analysis, where the unstandardized coefficients of the optimum models to explain the response variables are shown and collinearity checked. All coefficients are statistically significant. The values of VIF are far less than 5, indicating little evidence of collinearity in the models.

As reported in Table 5, all the three models are statistically fit with the significant values of F-statistic being close to zero. The values of R^2_{adj}, which are 0.597, 0.723 and 0.748, are relatively high in social science research. The values of Durbin–Watson statistics for all models are close to 2, excluding significant collinearity again as VIF did.

The values of mean of standardized residual of each model are all very close to zero. Correspondingly, all the values of standard deviation of standardized residual of each model are very close to 1. Therefore, the residuals generally follow a normal distribution. From the aforementioned results of MLR and residual analysis, it is safe to conclude that all the models are appropriate for the data and the included predictors are able to explain the dependent variables satisfactorily. In Table 6, the influence of predictors on the three dependent variables has been mapped based on the optimum models. Details of the results are discussed in the following sections (refer to Table 1 and Table 2 for the code of variables).

It was found that a public partner's better RM mechanism (MchPub) would build up their commitment to demand risk. The reason may be that an effective mechanism denotes superior RM capability, which will increase the partner's confidence and commitment. An interesting but self-explanatory finding is that a risk-seeking public partner (EO02) is willing to be more committed. Risk attitude therefore does have an impact on the whole transaction system. This does not match traditional TCE, which holds that agents are risk-neutral (Williamson, 1996). However, the finding accorded with and extended Chiles and McMackin's (1996) proposal to add risk attitude as another influential factor into TCE analysis. It is also not difficult to understand the importance of a financier's reliability (EO05). The financier's reliable support to the non-recourse assets during the operation phase of a PPP project will fend off unfavourable impacts, especially in a financial way, which may decrease the demand. It is logical that an experienced operator (EO09) can help to minimize the demand risk during the operation stage and in turn boost the public partner's commitment. Finally, because infrastructure service demand is sensitively subject to the stability of

Table 3 Profile of Respondents

Item	Category	Freq.	%
Respondents' designation	Senior level	41	93.2
	Mid-level	3	6.8
	Junior level	0	0.0
Respondents' experiences in construction industry	$\leqslant$ 5 years	0	0.0
	5–10 years	14	31.8
	10–20 years	13	29.6
	20–30 years	10	22.7
	> 30 years	6	13.6
	Unknown	1	2.3
Respondents' experiences in PPP projects	None	0	0.0
	1–2 projects	10	22.7
	3–5 projects	10	22.7
	6–10 projects	16	36.4
	> 10 projects	8	18.2

Table 4 Results of MLR analysis

Dependent var.	Predictor	B	t	Sig.	VIF
Public partner's commitment	(Constant)	−4.439	−3.744	0.001	N.A.
	Public partner's RM mechanism (MchPub)	1.121	9.016	0.000	1.465
	Cooperation history among private partners (CoopPri)	−0.286	−3.834	0.001	1.134
	Stability of related industry (ES02)	−0.603	−3.682	0.001	1.746
	National economy condition (EE01)	0.860	4.735	0.000	1.511
	Public partner's risk attitude (EO02)	0.331	2.186	0.036	1.362
	Financier's reputation/credit (EO05)	0.547	3.203	0.003	1.206
	Operator's experience in similar projects (EO09)	0.518	4.460	0.000	1.310
	Accuracy of contract provision (EP08)	−0.411	−3.131	0.004	1.356
Private partner's commitment	(Constant)	0.325	0.422	0.675	N.A.
	Private partner's RM mechanism (MchPri)	0.647	6.054	0.000	1.021
	Cooperation history between public and private partners (CoopPubPri)	−0.281	−2.868	0.007	1.182
	Public partner's RM commitment (CmtPub)	−0.232	−2.430	0.020	1.055
	Political system stability (EI01)	0.225	2.070	0.045	1.033
	Project technical novelty (EP03)	0.470	3.301	0.002	1.166
Proportion of risk transfer	(Constant)	3.987	3.092	0.004	N.A.
	Private partner's RM routine (RtnPri)	0.462	3.025	0.005	1.578
	Public partner's RM commitment (CmtPub)	−0.758	−5.660	0.000	1.196
	Private partner's RM commitment (CmtPri)	0.543	3.227	0.003	1.740
	Legislative system stability (EI02)	−0.931	−4.858	0.000	1.244
	Public partner's general experience in similar projects (EO01)	0.482	3.514	0.001	1.284
	Project technical novelty (EP03)	−0.479	−2.283	0.029	1.462
	Exposure of project information (EP06)	0.400	2.800	0.008	1.295
	Project construction duration (est.) (EP14)	0.019	2.078	0.045	1.123

Notes: B=unstandardized coefficient; t=statistic of t-test; Sig.=significance level of t-test; VIF=variance inflationary factor (collinearity statistic); N.A.=not applicable.

Table 5 Summary of MLR models

Dependent variable	F	Sig.	R^2	R^2_{adj}	Durbin–Watson
Public partner's commitment	15.029	0.000	0.775	0.723	1.785
Private partner's commitment	13.740	0.000	0.644	0.597	1.748
Transfer	16.992	0.000	0.795	0.748	2.050

Notes: F=statistic of F-test; Sig.=significance level of F-test; R^2=multiple determination coefficient; R^2_{adj}=adjusted multiple determination coefficient.

national economy, a less volatile economy (EE01) will see a less fluctuant demand, which will also raise the partner's commitment.

In contrast, cooperation history among private partners (CoopPri) was found to reduce a public partner's commitment. This is understandable because long-term cooperation between private partners will decrease governance and communication costs. A low quality facility due to poor collaboration during construction, for example, will probably fail to attract enough end users and consequently see a lower than anticipated demand. The possible reason for stability of related industry (ES02) is that the public partner may find government's marginal efficacy in addressing demand risk in a stabilized industry is not as high as in a volatile industry. They may thus prefer the private partner to shoulder this risk. Finally, a partnership arrangement should be an incomplete contract in nature, because of bounded rationality and possible opportunism. If the clause about demand risk disregards the uncertain nature of the long-term partnership and turns out to be too 'accurate' (EP08), it may

Table 6 Map of predictor's influence on dependent variable

Code	Predictor	Dependent variable		
		CmtPub	CmtPri	Trsf
RtnPri	Private partner's RM routine			+
MchPub	Public partner's RM mechanism	+		
MchPri	Private partner's RM mechanism		+	
CoopPubPri	Cooperation history between public and private partners		−	
CoopPri	Cooperation history among private partners	−		
CmtPub	Public partner's RM commitment	N.A.	−	−
CmtPri	Private partner's RM commitment		N.A.	+
EI01	Political system stability		+	
EI02	Legislative system stability			−
ES02	Stability of related industry	−		
EE01	National economy condition	+		
EO01	Public partner's general experience in similar projects			+
EO02	Public partner's risk attitude	+		
EO05	Financier's reputation/credit	+		
EO09	Operator's experience in similar projects	+		
EP03	Project technical novelty		+	−
EP06	Exposure of project information			+
EP08	Accuracy of contract provision	−		
EP14	Project construction duration (est.)			+

Notes: +/− denotes positive or negative influence; N.A. denote 'not applicable'.

impede the implementation of private ordering during the contract execution process and therefore decrease the public partner's commitment.

Regarding the private partner's commitment to demand risk, the important and dominant link between their RM mechanism (MchPri) and commitment is the same as that for the public partner. But the increase of a private partner's commitment may also result from one macro and one micro influence. The former is a stable policy throughout the project life cycle (EI01). Owing to the involvement of the public partner, PPP projects will subject themselves much more to the change of relevant policy than other projects. In particular, the minimization of risks in later stages, such as demand risk, benefits from consistent policies that change little when compared with early stages. The latter influence is a novel project (EP03), which is expected to bring the benefits of innovation, one of the four PPP drivers. A technically novel project will provide more room for any feasible innovation from the private partner. The innovation increases asset specificity, which will unavoidably change the partner's commitment positively.

On the other hand, cooperation history between public and private partners (CoopPubPri) and the public partner's RM commitment (CmtPub) were the possible deadeners to the private partner's commitment. The possible reason for the former is that the more times the public and private partners have cooperated, the private side may expect that more knowledge has been transferred to the other side. They may thus expect that the public side is willing to bear more risk than before. As for the latter, it is probably due to the request for balance in a partnership. If there is too much or too little contribution from both sides concurrently, the situation may be that no one attends to the risk or efforts overlap and are wasted. Therefore, if high commitment is perceived from the public partner, the private partner would be happy to take some off their shoulders.

Finally, regarding the risk allocation strategy, it was found that the private partner's better RM routine (RtnPri) makes the public side transfer more demand risk. The private partner's ample experience in managing the demand risk has two effects. It indicates that superior RM capability has been established and at the same time refers to lower assets specificity. These two effects hint at a market mechanism and denote that scale of economy and scope will be well achieved and total costs be decreased if the private partner dominates the RM. Accordingly, it makes the public side transfer more of the risk to the private side. Moreover, higher commitment of the private partner (CmtPri) may make them behave less opportunistically because commitment serves as a brake to opportunism. As a result, governance cost is cut down and transferring more risk becomes a better choice. It sounds strange that a public partner intends to transfer more risk if they have more general experience in similar projects (EO01). But when considering the highly uncertain nature of demand risk, it is not hard to comprehend the public side's strong desire to pass on the risk, especially if they have learned by bitter experience. It was also found that in a more transparent project (EP06), a public partner is more reluctant to bear demand risk. This might be because the bounded rationality of all stakeholders is minimized and the whole project is under more scrutiny. So there is less chance for opportunistic behaviour, which reduces governance cost and encourages more risk transfer to the private side. Longer construction duration (EP14) would also result in more transfer of demand risk. A possible reason may be that longer construction is usually linked to gigantic project size and complex constructability, which could greatly increase construction time. A prolonged construction period will erode the length of payback period, during which demand risk becomes more critical. Since public partners usually don't bear construction risk, they are unwilling to shoulder a demand risk that would be worsened by a time blow-up in construction.

On the other hand, the public partner's higher RM commitment (CmtPub) is found to make them retain more risk, which is self-explanatory. Besides, an effective legislative system (EI02) would have the same effect probably because public partners prefer legal centralism or court orders to private settlements when disputes arise. Finally, a technically novel project (EP03) would also see the public partner bear more demand risk. A possible explanation may be that project development time and cost are usually expected to be reduced by innovation. A longer payback period thanks to such reduction would relieve revenue pressure and render demand risk less critical. The public partner thus would be less reluctant to shoulder some of the risk.

With the findings and discussion, it is proven that generally (1) a partner's RM capability, cooperation history and environment uncertainties determine the partner's RM commitment; and (2) with the partner's RM commitment, these factors together determine the allocation strategy for a particular risk, in this paper, the risk of 'demand below anticipation'. Though not each sub-hypothesis was supported, the two main hypotheses could be deemed as supported and resultantly the theoretical framework should be stated as logical and valid, both theoretically and empirically.

Limitation and future research

One major limitation in this study is that a linear relationship only between explanatory and response variables was considered in MLR analysis. Although the values of R^2_{adj} are high for social science research and important linearly bound determinants have not been identified, the related models cannot be used for more accurate prediction purposes because a portion of variance in the response variables, ranging from 25% to 40%, still cannot be explained by the predictors. However, non-linearity is not uncommon in realistic situations.

Another limitation is that MLR is basically probability-oriented and unable to identify all the factors necessary to reflect realistic situations (Thomas *et al.*, 2006). The partners' RM mechanism, for instance, was not included in the optimal model for risk allocation strategy although theoretically it has a causal relation with risk transfer. By using the stepwise analysis method, useful information was lost simultaneously when collinearity was minimized. In realistic situations, correlation among explanatory variables prevails, especially when the situation is complex and there are many variables involved. This partly explains why higher R^2_{adj} cannot be obtained in MLR analysis.

Therefore, future research requires non-probability-based analysis techniques and consideration of the non-linear relationship. One suitable alternative is adaptive neuro-fuzzy inference system (ANFIS), which combines the strengths of fuzzy logic and artificial neural networks and possesses the capability to handle unspecificity, uncertainty, non-linearity and complexity (Tsoukalas and Uhrig, 1997). Additionally, neural networks' strong learning ability helps to make the system suitable for prediction. This technique has been adopted in the subsequent stages of the current research, which will be reported in another article.

As mentioned above, while the proposed framework can facilitate understanding of current risk allocation mechanism, it is unable to tell whether the current practice is optimal or not. In the subsequent stages of the current study, a fuzzy inference system was built based on expert knowledge to identify optimal and sub-optimal risk allocation strategies. An ANFIS was further built to predict the optimal risk allocation strategy in different project scenarios. All the applications of artificial intelligence techniques will be reported in separate articles.

Conclusion

This paper proposed a theoretical framework for understanding the underlying mechanism of risk allocation decision making in PPP projects from the TCE perspective. By further integrating the resource-based view of organizational capabilities, this framework enables a logical and holistic interpretation of the mechanism underlying the decision-making process in the current risk allocation practice. Major components include partners' risk management routine, mechanism, cooperation history, commitment and environment uncertainty. Their links were submitted as two main hypotheses, namely (1) partners' RM capability, partners' cooperation history, and environmental uncertainties determine partners' RM commitment; and (2) partners' RM capability, partners' cooperation history, environmental uncertainties, and partners' RM commitment determine risk allocation strategy. To verify the hypotheses, the framework was operationalized and data were collected in an industry-wide survey.

Taking a typical demand risk as an example, three models were developed using MLR technique. They not only fit the data well but also explained the variance of response variables satisfactorily. It was found that the decision on how much risk to transfer to the private partner was not directly driven by partners' RM capability. The decision was actually made complying with TCE. In particular, a higher RM 'routine' of the private partner (i.e. lower asset specificity in TCE), higher commitment of the private partner (i.e. lower behavioural uncertainty in TCE), and lower uncertainty of some major environmental factors (i.e. lower environmental uncertainty in TCE, such as a less volatile legislative system, more mature technique, and longer construction period, among others) may make the public partner choose to transfer more demand risk (i.e. 'buy' more in TCE). Although organizational RM mechanism (i.e. the RBV of organizational capability) had little direct influence on the choice of risk allocation strategies, it exerted some indirect effects by changing partners' RM commitment. It is noteworthy that partners' cooperation history (i.e. transaction frequency in TCE) also had such indirect effects on risk allocation decision making by shaping partners' commitment. Furthermore, partners' RM commitment may be significantly manipulated by the situation of various business environmental factors.

With the tested framework based on TCE, risk allocation decision making was better interpreted rather than seen as a black box or only capability-driven. In the case of huge RM-specific investment, it might be more efficient for the public partner to retain most or all of the given risk. Without appropriate commitment from the private partner, if they are forced to bear a given risk, they may probably fail to efficiently manage that risk by charging higher premiums, even with excellent RM capability. Similarly, a volatile business environment should be taken as a warning signal, where the public partner should not transfer as much risk as they wish. If they do so under greater uncertainty, the project may end up with higher than necessary cost. Moreover, partners should also aim to build up a long-term cooperative relationship so that behavioural uncertainty and thereby transaction costs can be minimized. In a nutshell, the major determinants of a partner's risk management commitment and risk allocation decision making that were identified in this paper would help industrial professionals better understand the practice and underlying mechanism of risk allocation decision making, especially in an economic way.

Finally, it is noteworthy that the MLR analysis has its own inherent limitation. It is overshadowed by artificial intelligence techniques when dealing with issues characteristic of uncertainty, unspecificity and nonlinearity. It was thus suggested that the latter be used to further develop the proposed framework, which is currently in progress. The next research stages mainly include building a type of model to identify optimal risk and a type of model to predict optimal risk allocation strategy in different scenarios, with the artificial intelligence techniques.

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