Determinants of Efficient Risk Allocation in Privately Financed Public Infrastructure Projects in Australia

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Abstract: Risk allocation in privately financed public infrastructure projects, which are mainly referred to as public-private partnership (PPP) projects, is a challenging job due to the nature of incomplete contracting. An investigation into the mechanism that guides the formation of efficient risk allocation strategies is thus desirable. Drawing on the transaction cost economics and resource-based view of organizational capability, this paper has identified five main features of the transactions associated with risk allocation in PPP projects. They include partners' risk management routine, partners' risk management mechanism, partners' cooperation history, risk management environmental uncertainty, and partners' risk management commitment. For achieving cost efficiency, different risk allocation strategies may suit different conditions of the features. Accordingly, a theoretical framework and five hypotheses were proposed for testing. Data collected in an industrywide survey were analyzed using multiple linear regression technique. It was found that generally, the identified features are determinants in the decision-making process of efficient risk allocation. Therefore, the proposed theoretical framework provides both government and private agencies with not only a logical and holistic understanding of but also a support tool for decision making on risk allocation strategy in PPP projects. Study limitations and future research directions are also set out.

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Introduction

Countries that are experiencing rapid growth require substantial investment in infrastructure (The World Bank 2008). This is challenging because the traditional methods of government procurement are inefficient and the provision of projects are limited by the availability of government funds. In order to tackle these challenges and enable countries to meet growth demands, a range of public-private partnership (PPP) arrangements have been established. These PPP arrangements have rapidly become the preferred way to provide public services in many countries, including Australia (Jin and Doloi 2008). In this study, PPP refers to a complex long-term contractual arrangement involving the provision of services that require the construction of infrastructure assets [Australian Dept. of Finance and Administration (DFA) 2006]. Although there are many parties involved in a PPP transaction, the focus in this study is on the government agency and the private consortium. Various risks are allocated between these two broad groups of stakeholders.

In PPP, the greatest value-for-money driver is risk transfer, which means that appropriate risks are transferred to the private sector, who is supposed to be capable of managing those risks better, and thereby cheaper and higher-quality infrastructure services may be provided than in conventional ways (Hayford 2006). However, the incomplete contracting nature of PPP has been found to increase risk exposure of all partners (Woodward 1995). Efficient risk allocation (RA) is therefore a demanding job in PPP projects. As such, whether there is any mechanism that underlies the formation of efficient RA strategies deserves serious investigation.

In the following sections, a brief review of the literature on transaction cost economics (TCE) and the resource-based view (RBV) of organizational capability is given first. Then the main features of the transactions inherent in RA are identified. Accordingly, a theoretical framework is established and corresponding hypotheses are proposed based on systematic discussion and analysis of TCE and RBV theories. The research method is then reported, followed by a detailed discussion on the findings of an industrywide survey in Australia. Finally, a brief conclusion is presented, including recommendation for future research.

Literature Review

Transaction Cost Economics (TCE)

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). Regarding RA, if a risk is improperly allocated, then the resultant transaction costs may include, among others, (1) the extra costs for clients of a higher contingency (or premium) included in the bid price from contractors; (2) the extra costs for

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clients of more resources for monitoring the risk management (RM) work; (3) the extra costs for clients and/or contractors of recovering lower quality work (i.e., the materialized or deteriorated risk) for a given price; (4) the extra costs for contractors of increasing safeguards (both ex ante and ex post) against any opportunistic exploitation of one's own RM service (RMS)-specific assets by other parties; (5) the extra costs for contractors of the resources dedicated to lodging claims related to the misallocated risk; and (6) the extra costs for both parties of dealing with the disputes or litigation related to the misallocated risk.

The TCE poses the problem of economic organization as a problem of contracting and assumes that (1) human agents are subject to bounded rationality, where behavior is "*intendedly rational but only limitedly so* (Simon 1961, p. xxiv)," and (2) are 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 asset specificity, uncertainty, and frequency. Asset specificity is the degree to which an asset can be redeployed to alternative uses and by alternative users without sacrificing productive value (Williamson 1996). Uncertainty may arise from 'state of nature' or changes in the external environment affecting a system (Rao 2003) or when incomplete contracting and asset specificity are joined (Williamson 1996). Frequency admits the fact that the pairwise identity of the parties matters and has pervasive consequences for the organization of economic activity (Williamson 1996). 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).

The TCE approach is suitable to the current research because TCE integrates economics, organization theory, contract law and behavioral assumptions in an interdisciplinary study of organizational phenomena (Williamson 1981). The comparative institutional approach adopted in TCE facilitates analysis in which absolute amount of transaction costs is difficult to collect (Williamson 1985). Choosing a RA strategy could actually be viewed as the process of deciding the proportion of RM responsibility between internal and external organizations based on a series of characteristics of RMS transaction in question (Jin and Doloi 2008). RA in PPP projects is thus 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 partnership, heavy investment into assets, complex uncertainty, etc. (Jin and Doloi 2007).

There have been a number of attempts to apply TCE in construction management research, such as Eccles (1981), Gunnarson and Levitt (1982), Cheung (1983), Reve and Levitt (1984), Bon (1989), Winch (1989, 2001, 2006), Masten et al. (1991), Walker (1996), Walker and Chau (1999), Lai (2000), and Turner (2004). Nonetheless, these works focused on the type of transaction in traditional construction projects and did not take into account the special characteristics of PPP projects. Moreover, most of them drew on little empirical research. Actually, it was found that there have been very few empirical efforts dedicated to the application of TCE to the management, especially RM, in PPP projects.

Resource-Based View (RBV) of Organizational Capability

The object of TCE is not to minimize production and governance costs separately but to economize on the total cost of a transaction (Williamson 1985, 1996). Thus, both production and governance costs must be taken into account in any analysis adopting TCE approach. Nonetheless, production costs are sometimes neglected in TCE analysis. The goods and services to be transacted and their production costs have often been assumed as "mature" and in a "steady state," respectively, to avoid the need for adaptation, and the advantage in production costs respects has been ascribed to the economies of scale and/or scope only [see, e.g., Williamson (1985, 1996)]. These constraints need to be relieved because nonimitable and nonsubstitutable organizational capabilities are a key source of interfirm performance differences (Barney 1991; Dosi et al. 2000; Nelson 1991; Rumelt 1984; Wernerfelt 1984). Given a specified output level, less capable organization would incur more costs to improve its capabilities and to meet the requirements (Helfat and Peteraf 2003).

The notion of capabilities can be traced back to the work of Penrose (1959). A number of theories have been established to address how firms may develop organizational capabilities. They primarily include the RBV (Barney 1991; Wernerfelt 1984), dynamic capabilities (Teece et al. 1997), evolutionary economics (Nelson and Winter 1982), and the emerging knowledge-based view (Conner and Prahalad 1996; Grant 1996; Kogut and Zander 1992, 1995, 1996). In particular, more complementarities exist between TCE and RBV due to their focus on asset specificity (Rao 2003; Silverman 1999). 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 RBV, it has been increasingly recognized that 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). Therefore, organizational capability, which production costs are greatly contingent on, should be taken into consideration when seeking efficient governance structure.

In PPP projects, partners' organizational capabilities in RM are currently deemed as a major determinant of who should be responsible for various risks. Based on the preceding literature review, therefore, it is evident that the RBV plays a critical role in economic theory by providing one means to analyze the effect of organizational capabilities on governance decisions. It is believed that by relaxing its constraint that firms maintain homogeneous capability and by being integrated with the RBV, the traditional TCE will provide a more logical and holistic understanding of governance decision.

Main Hypotheses and Theoretical Framework

Based on the literature review, the following research questions are of the most concern in this paper: what are the main characteristics of an RMS transaction; whether these characteristics significantly influence the decision-making process of efficient RA; and how. In response to the identified research questions, drawing on the TCE and the RBV theories, it was submitted in this paper that the major characteristics of an RMS transaction include (1) partners' RM routine, which is the major specified assets in the view of TCE; (2) partners' RM mechanism, which is the organizational capability in RBV; (3) partners' cooperation history,

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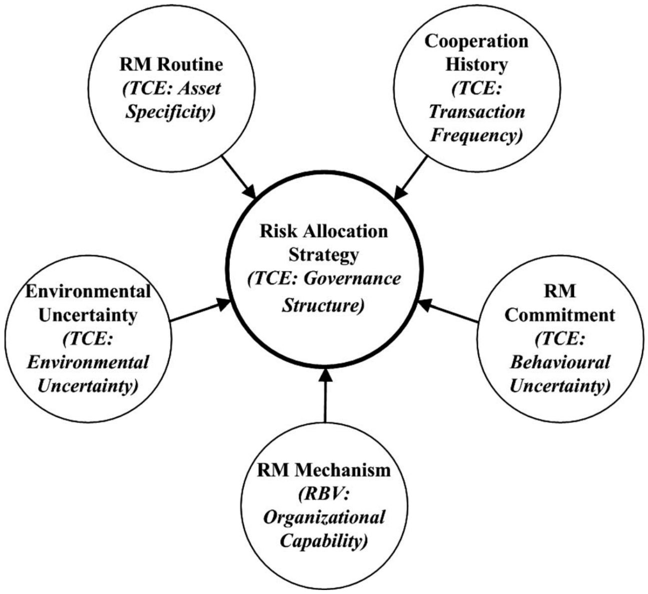

Fig. 1. Theoretical framework for RA decision making in PPP projects

which approximates to transaction frequency in the view of TCE; (4) RM environmental uncertainty; and (5) partners' RM commitment, both of which are uncertainty in the view of TCE. According to TCE, these five main characteristics of an RMS transaction will serve to predict a cost-efficient RA strategy, which is the efficient governance structure in the view of TCE. Accordingly, a theoretical framework is established as shown in Fig. 1.

In the following subsections, five main hypotheses based on the theoretical framework are proposed for testing. Detailed analysis and explanation are provided. Different from traditional TCE-based analysis, organizational capability and hybrid governance were considered throughout. Moreover, the value of the production and governance costs rather than their difference was analyzed in order to interpret and understand TCE more logically. The linkage term "depend on" is used in the hypotheses since it is an intermediate category with its meaning between causation and correlation (Tan 2004).

Specific Assets for Providing Risk Management Service (RMS)

The principal factor in explaining TCE is asset specificity, which increases the transaction costs of all forms of governance (Williamson 1996, p. 106). Without it, markets have good economizing properties because not only production can be economized by an external supplier due to economies of scale and scope, but governance costs are negligible due to no transaction-specific interest in the continuity of the trade. As such, the analysis of production and governance costs of market, hybrid, and hierarchy is reinterpreted in Fig. 2. Similar to Williamson (1985), let (1) k be an index of asset specificity; (2) $H(k)$, $X(k)$, and $M(k)$ be the costs of hierarchical, hybrid, and market governance, respectively; (3) $C_H(k)$, $C_X(k)$, and $C_M(k)$ be the steady state production cost of producing to one's own requirements, both producing internally and procuring in the market, and procuring the same item in the market, respectively; and (4) $\mathrm{TC}_H(k)=C_H(k)+H(k)$, $\mathrm{TC}_X(k)=C_X(k)+X(k)$, $\mathrm{TC}_M(k)=C_M(k)+M(k)$ be the total cost under a hierarchical, hybrid, and market governance, respectively.

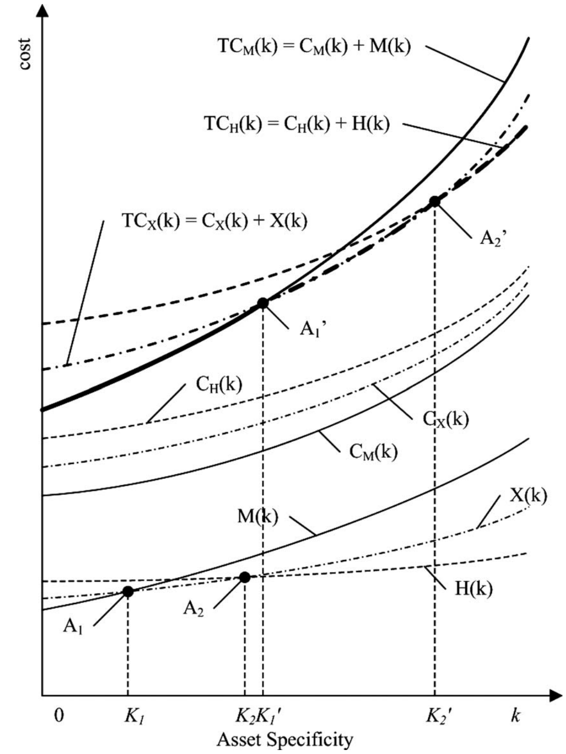

Fig. 2. Production and transaction costs of market, hybrid, and hierarchy

According to Williamson (1985, 1996), assuming that (1) the output of a transaction is unchanged; (2) uncertainty is present in a sufficient degree to require sequential adaptations; (3) $H(0)>X(0)>M(0)$, in that the bureaucratic costs of hierarchy, hybrid, and market modes are relatively high, medium, and low, respectively, due to the superiority of the market in Type A adaptation; (4) $M(k)'>X(k)'>H(k)'>0$ evaluated at every k, by reason of the marginal disability of these governance modes in Type C adaptability in a descending order, i.e., as the bilateral dependency of the relation between the parties builds up, high-powered incentives impede the ease of Type C adaptation; (5) $C_H(k)>C_X(k)>C_M(k)$ at every k, i.e., in production cost respects, the market is everywhere at an advantage and the hybrid both enjoys the advantage of the market and suffers the disadvantage of the hierarchy everywhere; and (6) $C_M(k)'>C_X(k)'>C_H(k)'$ at every k and thereby as k increases, $C_H(k)$, $C_X(k)$, and $C_M(k)$ approach one another asymptotically but never intersect, i.e., the cost advantage of the market remains but decreases as the degree of asset specificity increases until the economies of scale and scope can no longer be realized when goods and services become very close to unique.

The economized total cost against k is highlighted in a bold curve in Fig. 2. It can be seen that the cost balance shifts away from market to hierarchy as asset specificity (k) increases and that over some intermediate range of k, the mixed adaptation (both Types A and C) of hybrids could be superior to the Types A and C adaptations supported by markets and hierarchies, respectively, which supports the Williamson (1985, 1996) analysis. Therefore, it was hypothesized that $H1_0$: in an RMS transaction, the proportion of the given type of risk transferred to a private partner depends on the level of asset specificity.

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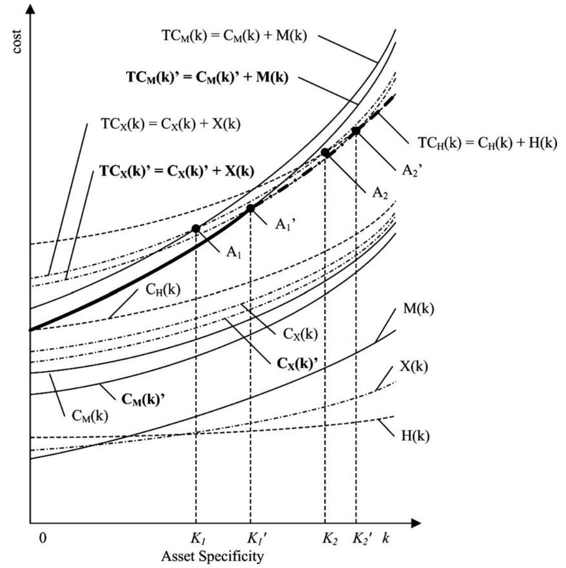

Fig. 3. Production and transaction costs of market, hybrid, and hierarchy (decreased C_M)

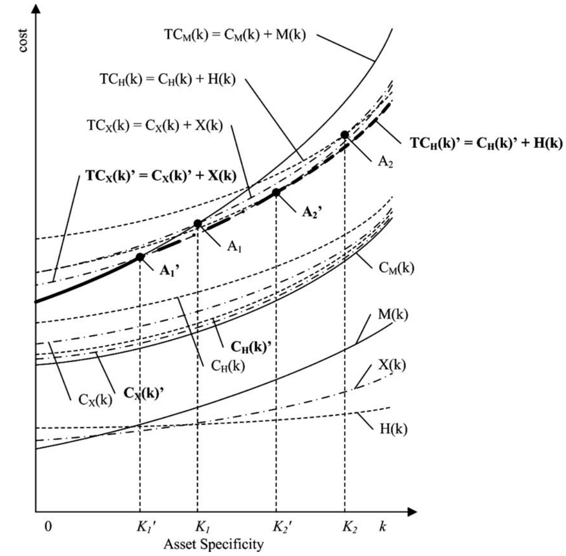

Fig. 4. Production and transaction costs of market, hybrid, and hierarchy [decreased C_H (a)]

Capability to Manage a Risk

As pointed out in the literature review, constraints on the production costs of goods and services to be transacted, such as mature and in a steady state, need to be relieved because of the heterogeneity of organizational capabilities Accordingly, organizational capability, which production costs are greatly contingent on, was considered.

First, consider the situation in which private partner's RM capability has been improved to a nontrivial degree, i.e., the production costs of markets and hybrids have been reduced. Holding other assumptions unchanged, let (1) $C_X(k)'$ and $C_M(k)'$ be the reduced production cost of hybrid and market, respectively; (2) $C_X(k)-C_X(k)'<C_M(k)-C_M(k)'$ at every k; and (3) $\mathrm{TC}_X(k)'=C_X(k)'+X(k)$ and $\mathrm{TC}_M(k)'=C_M(k)'+M(k)$ be the reduced total cost under a hybrid and market governance, respectively. The costs of production and governance and their summation before and after the capability improvement are shown in Fig. 3. The optimal supply was highlighted in a bold curve. It can be seen plainly that markets enjoy a wider range of asset specificity values (between 0 and K_1') after capability improvement than before (between 0 and K_1). In contrast, hierarchies and hybrids retreat to a smaller range of k values. It can be arguably obtained that the effects of public partner's deteriorated RM capability are arguably similar to those of private partner's improved RM capability.

Next, consider the situation in which public partner's own RM capability has been improved to a nontrivial degree, i.e., the production costs of hierarchy and hybrids have been reduced. Holding other assumptions unchanged, let (1) $C_H(k)'$ and $C_X(k)'$ be the reduced production cost of hierarchy and hybrid, respectively; (2) $C_H(k)-C_H(k)'>C_X(k)-C_X(k)'$ at every k; and (3) $\mathrm{TC}_H(k)'=C_H(k)'+H(k)$ and $\mathrm{TC}_X(k)'=C_X(k)'+X(k)$ be the reduced total cost under a hierarchy and hybrid governance, respectively. The costs of production and governance and their summation before and after the capability improvement are shown in Fig. 4. The optimal supply was highlighted in a bold curve. It can be observed that hierarchies enjoy a wider range of asset specificity values (from K_2' onward) after capability improvement than before (from K_2 onward). In contrast, markets and hybrids retreat to a smaller range of k values. It can be arguably obtained that the effects of private partner's deteriorated RM capability are arguably similar to those of public partner's improved RM capability.

In conventional TCE analysis as mentioned earlier, it has been assumed that $C_H(k)>C_M(k)$ at every k. Regarding RM in PPP projects, however, it is not uncommon that the public partner is sometimes more competent in managing some risks. Therefore, this assumption needs to be relieved in such situation, in which public partner's RM capability is so superior to private partner's that the production costs savings is able to offset the added bureaucratic costs when $k=0$, i.e., (1) $C_M(k)>C_H(k)$ at every k; and (2) $H(0)-M(0)=C_M(0)-C_H(0)'$ and consequently $\mathrm{TC}_H(0)'=\mathrm{TC}_M(0)$. The costs of production and governance and their summation before and after the capability improvement are shown in Fig. 5. The optimal supply was highlighted in a bold curve. It can be seen that hierarchies enjoy the whole range of asset specificity

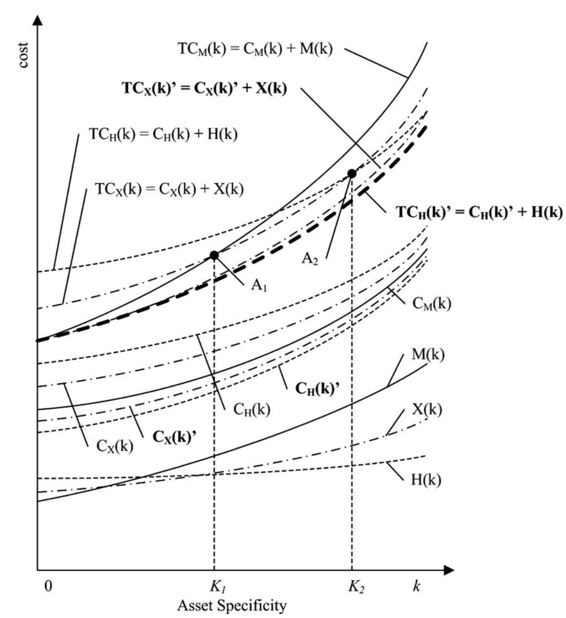

Fig. 5. Production and transaction costs of market, hybrid, and hierarchy [decreased C_H (b)]

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after capability improvement. In contrast, markets and hybrids suffer disadvantage in total costs respects throughout although they are advantageous in governance costs respects within a certain range of asset specificity.

It was therefore hypothesized that $H2_0$: in an RMS transaction, the proportion of the given type of risk transferred to a private partner depends on the level of the superiority of a private partner's RM capability to a public partner's.

Transaction Frequency of Risk Management Service

One of the most important factors in partnership success is previous partnership experience (Jin and Ling 2005). Unlike existing goods, efficient RM in building and construction projects cannot be obtained by a one-off transaction and requires time to develop. During that time, the public partner and the private partner or public partner's internal divisions must interact to develop mutually acceptable specifications (Monteverde and Teece 1982). Much empirical research found that partners could better address challenges of communication and governance, which is necessitated by interaction, if they have more similar transactions in the past (Heide and Miner 1992; Parkhe 1993). Because the cost of managing relationship is also a type of governance cost, transaction frequency must also be considered in RMS transactions.

According to Williamson (1996), transaction frequency matters only when asset specificity deepens and consequently bilateral dependency builds up. This is because the buyer must induce potential suppliers to make similar specialized investments should he seek least-cost supply from an outsider and the supplier would be unable to realize equivalent value should the specialized assets be redeployed to other uses (Williamson 1996, p. 61). The added costs of such nonstandard contracting may be recovered by frequent transaction (Williamson 1985).

Taking the situation illustrated in Fig. 2 as the initial state, first consider the situation in which partners' RMS transaction frequency has increased to a nontrivial degree, i.e., only the governance costs of hybrids have been reduced because little bilateral dependency arises in markets and hierarchies and frequency thus lacks relevancy. Let (1) $X(k)'$ be the reduced governance cost of hybrid; and (2) $\mathrm{TC}_X(k)'=C_X(k)+X(k)'$ be the reduced total cost of hybrid. Holding other assumptions unchanged, assume that (1) $X(0)'=X(0)$, by reason of that frequency matters only when asset specificity is nontrivial; and (2) $X(k)'<X(k)$ at every k except at $k=0$ because higher frequency serves to reduce governance costs. The costs of production and governance and their summation before and after the frequency increase are shown in Fig. 6. The optimal supply was highlighted in a bold curve. It can be seen that hybrid mode enjoys a wider range of asset specificity values (between K_1' and K_2') after the increase in transaction frequency than before (between K_1 and K_2) although the shift may not be significant. In contrast, markets and hierarchies retreat to a smaller range of k values, i.e., between 0 and K_1' and K_2' onward, respectively.

In comparison, consider the situation in which partners' transaction frequency has decreased to a nontrivial degree, i.e., added governance costs of hybrids have been introduced. Let (1) $X(k)''$ be the increased governance cost of hybrid; and (2) $\mathrm{TC}_X(k)''=C_X(k)+X(k)''$ be the increased total cost of hybrid. Holding other assumptions unchanged, assume that (1) $X(0)''=X(0)$; and (2) $X(k)''>X(k)$ at every k except at $k=0$. The costs of production and governance and their summation before and after the frequency decrease are also shown in Fig. 6. It was observed that hybrid mode retreats drastically to a much smaller range of k values if transaction frequency decreases. At $k=K''$, if frequency further decreases (e.g., a one-off transaction), hybrid mode will be disadvantageous throughout and consequently will not be considered as a governance alternative. Accordingly, markets and hierarchies enlarge the range of k values that they occupy until they become the only two alternatives. It was therefore hypothesized that $H3_0$: in an RMS transaction, the proportion of a given type of risk transferred to a private partner depends on the level of transaction frequency.

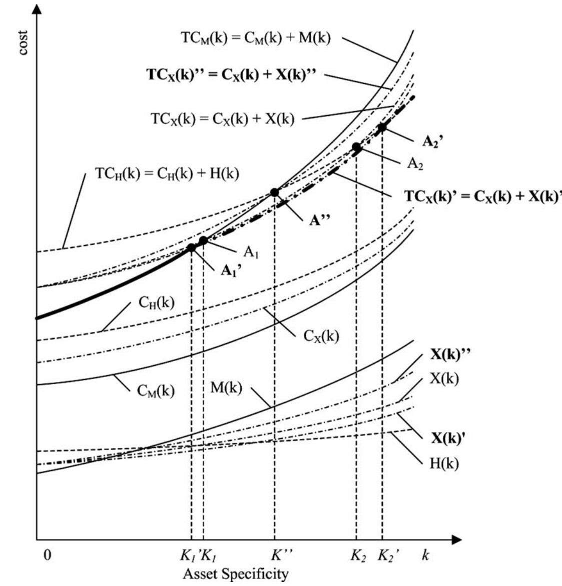

Fig. 6. Production and transaction costs of market, hybrid, and hierarchy (changing frequency)

Uncertainty in Risk Management Service Transaction

Past transactions with a partner alone, however, do not necessarily make that partner the most attractive choice (Jin et al. 2007). Internal suppliers offer many of the same advantages as long-term suppliers, although for different reasons (Hoetker 2005). Generally, an organization can better manage the challenges of communication and governance that occur over the RM process internally than with an external supplier. The communication and governance advantages of working internally become increasingly apparent as uncertainty increases (Helper 1991; Williamson 1985, pp. 140–153). Beyond a certain high level of uncertainty, internal RM may offer the lowest total cost. Consequently, uncertainty is another critical factor to be considered when deciding RA strategies.

Generally, the efficiency of all forms of governance may weaken in the presence of greater uncertainties. Williamson (1996) argued that the effects of greater uncertainties are especially pertinent for those uncertainties for which mainly or strictly coordinated responses are required. As a result, when facing greater uncertainties, the hybrid mode is the most easily affected. This is because hybrid adaptations cannot be made unilaterally as in markets or by fiat as in hierarchies. They necessitate mutual consent and coordinated actions.

Therefore, the situation in which transaction-related uncertainties become greater should be considered, i.e., the governance costs of all governance forms have been increased and particularly those of hybrids. Taking the situation illustrated in Fig. 2 as the initial state, and holding other assumptions unchanged, as-

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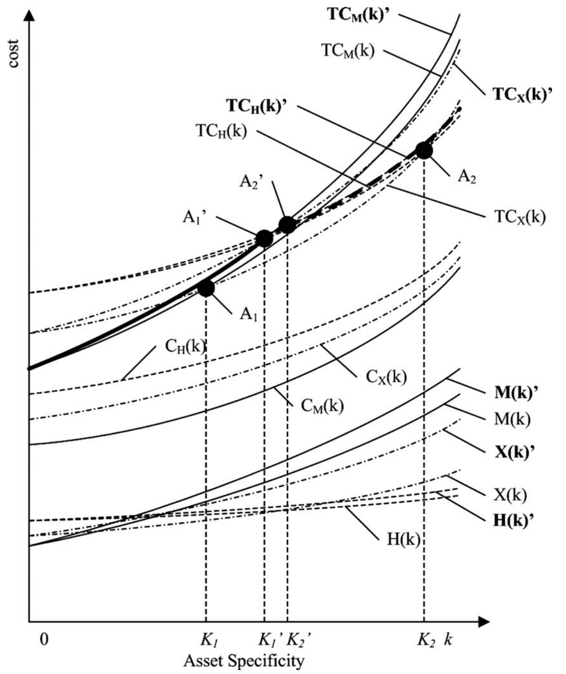

Fig. 7. Production and transaction costs of market, hybrid, and hierarchy (increasing uncertainty)

sume that (1) $M(0)'=M(0)$, $X(0)'=X(0)$, $H(0)'=H(0)$, because uncertainty matters only when asset specificity is nontrivial; (2) $M(k)'>M(k)$, $X(k)'>X(k)$, and $H(k)'>H(k)$ at every k except at $k=0$ because greater uncertainty increases governance costs; and (3) $X(k)'-X(k)>M(k)'-M(k)>H(k)'-H(k)$, in that hybrids are the most susceptible. The costs of production and governance and their summation before and after the frequency increase are shown in Fig. 7. The optimal supply was highlighted in a bold curve. It can be seen that hybrid mode retreats drastically to a much smaller range of k values (between K_1' and K_2') as uncertainties become greater. In contrast, markets and hierarchies enjoy a wider range of k values. It arguably obtains that if uncertainty further increases, hybrid mode will be disadvantageous throughout and consequently will not be considered as a governance alternative. Accordingly, markets and hierarchies then become the only two options.

Because TCE practically recognizes behavioral uncertainty in addition to primary and secondary uncertainties, uncertainty in an RMS transaction was categorized into two distinct but related groups, i.e., project environmental uncertainty and partner's behavioral uncertainty. It was therefore hypothesized that $H4_0$: in an RMS transaction, the proportion of a given type of risk transferred to a private partner depends on the level of project environmental uncertainty; and $H5_0$: in an RMS transaction, the proportion of a given type of risk transferred to a private partner depends on the level of partners' behavioral uncertainty.

Research Methodology

Given the complexity, longevity and large size of PPP projects, there are an enormous range of potential risks which can affect expected outcomes. These risks have been identified in previous research [see, e.g., Tiong et al. (1992), Tam (1995), Akintoye et al. (1998), Wang et al. (2000), and Thomas et al. (2003), among many others]. In this study, risks are classified in a hierarchical risk breakdown structure as shown in the Appendix. First, similar to Salzmann and Mohammed (1999), risks in PPP projects were considered in two major phases, i.e., development phase and operation (and transfer, if any) phase. Accordingly, risks were grouped into three supercategories, i.e., (1) risks mainly existing in development phase, including risks related to project planning, design, construction, and commissioning; (2) risks mainly existing in operation (and transfer, if any) phase; and (3) lifetime risks, which are those may materialize in both phases (Jin 2007). Then, within each of the three supercategories, risks were grouped into different number of categories.

For the sake of brevity, the operationalization of the constructs is briefly presented in Table 1 except for that of environmental uncertainty, which is briefly presented in Table 2. 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 university-funded PPP workshop. Among 65 attendants from industry, six provided feedbacks on the relevance, accuracy, phrasing, sequencing, and layout of the questionnaire. Following the pilot survey and consequent refinement of the questionnaire, an industrywide 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 RM of PPP projects in Australia. They include people from both public and private sectors. However, random sampling is difficult due to the difficulty in finding out the exact population. Therefore, judgmental sampling was used, in which a sample is drawn using judgmental selection procedures (Tan 2004). The strategy for sample selection was first to identify PPP infrastructure projects in Australian market, then to identify major partners of the identified projects, and finally to identify professionals and decision makers in major partners' organizations from 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 computer and analyzed 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 dependent and independent variables of the theoretical framework (see Table 1). It includes maximizing the multiple determination coefficient (R^2), minimizing autocorrelation, only including in the model the variables that are statistically significant in t-test, and being statistically significant in F-test to prove that the included independent variables are capable of explaining the variation in the dependent variable. The stepwise method was used to select independent variables in that it accommodates partial correlation structures for variables already in the model (Coakes et al. 2006). 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 dependent variables

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Table 1. Operationalization of Theoretical Framework Constructs

Construct	Operationalized var.	Code	Measurement	Scale
Asset specificity (TCE)	RM routine	IV1	Level of private partner's experience in managing risk *X*	1=low; 5=high
Organizational capability (RBV)	Capability superiority	IV2	Level of private partner's mechanism superiority to public partner's; =IV2.2−IV2.1	
	Public partner's RM mechanism	IV2.1	Level of maturity of public partner's identification, analysis, response planning, and monitoring and control mechanisms for risk *X* (the four attributes were subject to a confirmatory factor analysis and statistically converged to one factor)	1=immature; 5=mature
	Private partner's RM mechanism	IV2.2	Level of maturity of private partner's identification, analysis, response planning, and monitoring and control mechanisms for risk *X* (the four attributes were subject to a confirmatory factor analysis and statistically converged to one factor)	1=immature; 5=mature
Transaction frequency (TCE)	Partners' cooperation history	IV3	Level of cooperation history between public partner and leading members of private partner	1=low; 5=high
Environmental uncertainty (TCE)	Environmental uncertainty	IV4	Level of 21 environmental uncertainty factors (see Table 2)	1=low; 5=high
Behavioral uncertainty (TCE)	Public partner's RM commitment	IV5.1	Level of 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 attributes were subject to a confirmatory factor analysis and statistically converged to one factor)	1=low; 5=high
	Private partner's RM commitment	IV5.2	Level of 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 attributes were subject to a confirmatory factor analysis and statistically converged to one factor)	1=low; 5=high
Governance structure (TCE)	Efficient RA strategy	DV	Proportion of RM task transferred from public to private partner regarding risk *X*, by which risk *X* is perceived to be managed most efficiently	1=retain all; 5=transfer all

Note: Var.=variable; IV=independent variable; DV=dependent variable.

Table 2. Operationalization of Environmental Uncertainty Factors

Category	Code	Environmental uncertainty factor	Description	Measurement
Institutional	EI01	Political system instability	Government policies on infrastructure PPPs are consistent and stable*	1 = stable; 5 = volatile
	EI02	Legislative system instability	Laws and regulations associated with infrastructure PPPs are incomplete and liable to change	1 = stable; 5 = volatile
	EI03	Government approval process complexity	Government inclines to follow complex procedures and inflexible rules	1 = simple; 5 = complex
Social and industrial	ES01	Community resistance	Associated community endorses developing this project*	1 = supportive; 5 = resistant
	ES02	Related industry instability	Structure of related industry is subject to abrupt changes	1 = stable; 5 = volatile
	ES03	Supporting infrastructure unavailability	Sufficient supporting infrastructures are available for this project*	1 = available; 5 = unavailable
Economic	EE01	Regional economy instability	Regional economy is subject to abrupt changes	1 = stable; 5 = volatile
	EE02	Financial market unreliability	Reliable financing instruments are available in the market*	1 = reliable; 5 = unreliable
	EE03	Insurance market unreliability	Reliable financing instruments are available in the market*	1 = reliable; 5 = unreliable
Project	EP01	Project idiosyncrasy	Many similar projects have been delivered in the market*	1 = identical; 5 = distinct
	EP02	Ambiguity of performance requirement	Facility performance requirements are clearly provided*	1 = clear; 5 = ambiguous
	EP03	Design complexity	Design of project is complex	1 = simple; 5 = complex
	EP04	Construction complexity	Construction of project is complex	1 = simple; 5 = complex
	EP05	Operation and maintenance complexity	Operation and/or maintenance of project is complex	1 = simple; 5 = complex
	EP06	Unreliability of reference data	All reference data are reliable and accurate*	1 = reliable; 5 = unreliable
	EP07	Competition in project tendering	Number of private consortia that have been short-listed for contract negotiation	1 = none (0); 2 = one (1); 3 = two (2); 4 = three (3); 5 = four (4) or more
	EP08	Rigidity of contract provision	Contract provision is flexible and accommodates future amendments*	1 = flexible 5 = rigid
	EP09	Ineffectiveness of partners communication	Communication between public and private partners is NOT effective	1 = effective; 5 = ineffective
	EP10	Ineffectiveness of dispute resolution mechanism	Partners have established efficient mechanism for dispute resolution*	1 = effective; 5 = ineffective
	EP11	Gigantic project scale	The approximate value of project (AU$ million)	1 = value < = 100 2 = 100 < value < = 250 3 = 250 < value < = 500 4 = 500 < value < = 1000 5 = value > 1000
	EP12	Long concession period	The concession duration of project (years)	1 = duration < = 5 2 = 5 < duration < = 10 3 = 10 < duration < = 20 4 = 20 < duration < = 30 5 = duration > 30

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Table 3. Profile of Respondents

Item	Category	Frequency	%
Respondents' designation	Senior level	41	93.2
	Midlevel	3	6.8
	Junior level	0	0.0
Respondents' experiences in construction industry	$\leq$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

that is explained by the set of independent 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 independent variables, respectively. The Durbin-Watson statistic ranges in value from 0 to 4. A value near 2, toward 0, or toward 4 indicates nonautocorrelation, positive autocorrelation, or negative autocorrelation, respectively. If a set of independent 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

A total of 386 survey packages were sent out in Australia through email and recipients were invited to respond within 2 months. In total, 44 useful responses were received. The survey response rate of 11.4% is not high but 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 response to the survey due to their ample experience in PPP projects and in the construction industry.

While RM and RA may vary from risk to risk and from project to project, the theoretical mechanism that dominates the RA decision-making process with regard to different risks remains the same (Jin and Doloi 2008). Therefore, due to the space limit and pursuant to the triangulation concept (Hammersley and Atkinson 2007), the results regarding three risks are reported in this paper. The three selected risks are (1) "defects in design" in development stage (coded as R_D); (2) "demand below anticipation" in operation stage (coded as R_O); and (3) "adverse changes in law, policy or regulations" during the lifecycle (coded as R_L). They are selected for report because (1) they have been deemed controversial and problematic in terms of their allocation (Carrillo et al. 2006; Medda 2007; Ng and Loosemore 2007; Shen et al. 2006; Tiong 1990; Tiong 1995) and (2) they exist in different stages of project lifecycle. Similar strategies have been adopted in previous research [see, e.g., Kangari and Riggs (1989)].

Furthermore, also due to space limit, only the MLR analysis results with regard to R_L are discussed. This risk was chosen for discussion because the financing, pricing, entry, and other important elements of PPP projects and their ability to repay debts and investments greatly depends on laws, policies, and regulations that govern the appropriability of returns, property rights, and contracts (Miller and Lessard 2001). Consequently, this risk is one of the most significant risks that PPP projects face (Carrillo et al. 2006) and may have a significant impact on all the other risks (Tiong 1990).

As shown in Table 4, all the three models are statistically fit with the significant values of the F statistic being close to zero. The values of R^2_{adj}, ranging between 0.650 and 0.770, are relatively high in social science research. The values of the Durbin-Watson statistic for all models are close to 2, which excludes significant collinearity. It can be seen that, generally, the independent variables are able to explain a large proportion of variance of efficient RA. This indicates that the set of identified predictors are suitable for modeling the efficient RA decision-making process regarding R_D, R_O, and R_L. Furthermore, Table 5 presents the results of the MLR analysis, where all coefficients are statistically significant and the values of VIF are far less than 5, indicating little evidence of collinearity in the models.

Regarding R_L, it was found that in efficient RA, private partner's better RM routine (*IV1*), which refers to lower assets specificity, made the public side to transfer more risk. Moreover, IV1 is the most influential one ($\beta=-0.623$) among all significant predictors. This finding is consistent with TCE's assertion that assets specificity is the most important characteristic of any transaction; and market, hybrid, or hierarchy governance suits transactions with low, medium, or high assets specificity, respectively (Williamson 1986).

Private partner's RM mechanism superiority (*IV2*) was found insignificant and thus not included in the optimal model. However, IV2 was found significantly correlated to IV1 (-0.613 at 0.01 level), *IV5.1* (-0.414 at 0.01 level), and *IV5.2* (0.556 at 0.01 level). Such correlation is explainable as private partner's superior RM mechanism may be due to their better RM routine, and lead to their higher RM commitment. Consequently, public partner may be more willing to let private partner manage the risk and thus show lower commitment. As such, a probable reason that

Table 4. Summary of MLR Models (Dependent Variable: Efficient RA Strategy)

Risk	F	Sig.	R	R^2	R^2_{adj}	Durbin-Watson
R_D	20.995	0.000	0.826	0.683	0.650	2.047
R_O	36.958	0.000	0.890	0.791	0.770	1.897
R_L	43.180	0.000	0.823	0.678	0.662	1.937

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

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Table 5. Results of MLR Analysis (Dependent Variable: Efficient RA Strategy)

Risk	IV	Predictor	B	t	Sig.	VIF
R_D		(Constant)	6.046	9.129	0.000	N.A.
	IV1	RM routine (R)	−0.497	−4.604	0.000	1.200
	IV2	Capability superiority	0.514	4.114	0.000	1.298
	IV5.1	Public partner's RM commitment	−0.257	−2.285	0.028	1.087
	ES02	Related industry instability	−0.699	−4.779	0.000	1.067
R_O		(Constant)	4.985	8.385	0.000	N.A.
	IV1	RM routine (R)	−0.828	−9.405	0.000	1.073
	IV5.1	Public partner's RM commitment	−0.243	−2.799	0.008	1.040
	IV5.2	Private partner's RM commitment	0.434	4.150	0.000	1.345
	EP03	Design complexity	−0.655	−3.041	0.004	1.285
R_L		Constant	2.833	3.347	0.002	N.A.
	IV1	Private partner's RM routine (R)	−0.695	−6.286	0.000	1.592
	IV3	Partners' cooperation history	0.195	2.202	0.034	1.029
	IV5.2	Private partner's RM commitment	0.306	2.456	0.019	1.652
	EI01	Political system instability	−0.261	−2.148	0.038	1.446
	EI02	Legislative system instability	0.461	3.138	0.003	1.407
	EE01	Regional economy Instability	−0.316	−1.796	0.081	1.174

Note: B=unstandardized coefficient; t=statistic of t-test; Sig.=significance level of t-test; VIF=variance inflationary factor; and N.A.=not applicable.

IV2 was not included in the optimal model is that the stepwise analysis method was used in MLR analysis and useful information was lost simultaneously when collinearity was minimized.

It was found that partners' longer cooperation history (*IV3*) lead to larger proportion of R_L to be transferred to private partner. This finding is consistent with TCE's claim that higher transaction frequency may lead to higher possibility of hybrid governance, which means joint RM. However, such effect of IV3 was found weak ($\beta=0.175$). Based on TCE theory, this is probably because IV3's relationship with DV may not necessarily be linear in efficient RA. An efficient RA strategy may, for example, be either "retain" or entirely "transfer" when IV3 is very low, depending on other transaction features. However, linear relationship is the only relationship that is considered in MLR analysis.

It was found that private partner's higher RM commitment (IV5.2) resulted in larger proportion of the risk to be transferred to private partner. This finding is consistent with TCE's claim that lower behavioral uncertainty may lead to higher possibility of hybrid governance. However, public partner's RM commitment (IV5.1) was found insignificant and thus not included in the optimal model. One possible reason is that in efficient RA regarding R_L, buyer's (public partner's) behavioral uncertainty may be of less importance to deciding governance structure.

As for environmental uncertainties, higher political system instability (EI01) was found to increase the portion of R_L that public partner would assume. This is because a lack of consistency in government priorities and objectives may induce losses for private investors (Medda 2007) and thereby opportunistic behavior. Political pressures can also interfere with the effective funding, management, and procurement of a project (Ng and Loosemore 2007). Indeed, political pressure can grow to such an extent that it blinds policy makers to the risks involved in projects. Therefore, political uncertainty is the most significant challenges that PPP projects face (Carrillo et al. 2006). As a result, for example, the Victorian Department of Treasury and Finance in Australia noted that the political and social context in which infrastructure projects are undertaken requires that public consultation be fully integrated into the planning process (Sharpe 2004).

It was also found that in efficient RA, higher legislative system instability (EI02) increased the portion of R_L that public partner would transfer. Laws and regulations concerning pricing, entry, unbundling, and other elements, if undergoing major changes, will open opportunisms (Miller and Lessard 2001). Greater chance of opportunism usually reduces the possibility of hybrid governance (Williamson 1986). Because laws and regulations are typically seen as most volatile in developing countries due to their incompleteness and propensity to fluctuation and as relatively stable in Australia, public partner may in general transfer R_L although sometimes EI02 is not low.

Finally, higher regional economy instability (EE01) was also found to increase the portion of R_L that public partner would assume. This is probably because that major shifts of economical factors, such as inflation and material shortages, usually cause construction costs to exceed original estimates (Tiong 1990) by 5–300% of original costs (Castle 1975) and thereby often cause adjustment in legislation and regulation by government (Andi 2006). This proves that private sector is not so capable of addressing economy fluctuation as previously thought.

In a nutshell, the discussion on the MLR analysis regarding R_L shows that the null hypotheses of H1 through H5 were supported except that the null hypothesis of H2 was rejected. The rejection was found to be probably due to the stepwise method used in MLR analysis, which usually causes the loss of useful information when minimizing collinearity simultaneously. In realistic situations, however, 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.

Nonetheless, the proposed independent variables have been found to be able to explain a large proportion of the variance of dependent variable, i.e., efficient RA (see Table 4). Given that the aim of this paper is to identify the major determinants to efficient RA strategies, the optimum models can therefore serve this purpose, although they cannot be used for more accurate prediction purpose.

Conclusions

This paper, drawing on the TCE theory and the RBV of organizational capability, has identified five main characteristics of a

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RM service transaction in PPP projects, including partners' RM routine, partners' RM mechanism, partners' cooperation history, RM environmental uncertainty, and partners' RM commitment. According to TCE, these main characteristics can serve to predict a cost-efficient RA strategy. Accordingly, a theoretical framework was established and five main hypotheses based on the theoretical framework were proposed for testing. The components of the framework were then operationalized and data were collected in an industry wide survey.

Appendix. Classification of Risks in Public-Private Partnership Projects

Supercategory	Category	Risk
Development phase	Planning and design risks	Changes in output specification
		Defects in design
	Construction risks	Failure/delay in land acquisition
		Unforeseen site condition
		Failure/delay in materials delivery
		Defects in construction
	Commissioning risks	Failure/delay in commissioning test
Operation (and transfer) phase	Operating risks	Failure/delay in operation
		Excessive maintenance and refurbishment
		Adverse impact of core services delivery
	Market risks	Demand below anticipation
		Revenue below anticipation
		Unanticipated economic downturn
		Increased competition
		Technical obsolescence
		Adverse demographic change
		Unanticipated inflation
		Withdrawal of government support network
	Asset ownership risks	Less residual value
Lifetime	Political, legislative and regulative risks	Adverse changes in law, policy or regulations
		Failure/delay in obtaining permit/approval
	Financial risks	Unavailability of financing
		Refinancing gain
		Financial failure/delay of private consortium
		Adverse change in interest rates
		Adverse change in tax
	Social, industrial and interorganizational relations risks	Lack of cooperation of the government
		Public resistance
		Destructive industrial action
		Partners' disputes
		Different interpretation of contract
	Environmental risks	Site contamination
	Force majeure risks	Force majeure

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