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Modelling optimal risk allocation in PPP projects using artificial neural networks

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Abstract

This paper aims to establish, train, validate, and test artificial neural network (ANN) models for modelling risk allocation decision-making process in public–private partnership (PPP) projects, mainly drawing upon transaction cost economics. An industry-wide questionnaire survey was conducted to examine the risk allocation practice in PPP projects and collect the data for training the ANN models. The training and evaluation results, when compared with those of using traditional MLR modelling technique, show that the ANN models are satisfactory for modelling risk allocation decision-making process. The empirical evidence further verifies that it is appropriate to utilize transaction cost economics to interpret risk allocation decision-making process. It is recommended that, in addition to partners' risk management mechanism maturity level, decision-makers, both from public and private sectors, should also seriously consider influential factors including partner's risk management routines, partners' cooperation history, partners' risk management commitment, and risk management environmental uncertainty. All these factors influence the formation of optimal risk allocation strategies, either by their individual or interacting effects.

Keywords: Risk allocation; Transaction cost economics; Artificial neural networks; PPP/PFI; Australia

1. Introduction

Public–Private Partnership (PPP) arrangements are rapidly becoming the preferred way to provide public services in many countries. Risk allocation in PPP projects is fundamentally different from that in traditional public projects, where the public sector purchases an asset from private sector contractors and consultants whose liability is limited to the design and construction of the asset and financial and operational risks remain with the public sector. In PPP projects, the government bears little or no asset-based risk and is entitled to reducing payments, abatements and compensation if the service is not delivered to the specified standards. Accordingly, one of the most important drivers for value-for-money is risk transfer, which means appropriate risks can be transferred to the private sector, who is supposed to be capable of managing those risks better (Hayford, 2006). As a result, cheaper and higher-quality infrastructure services may be provided than in conventional way.

Unfortunately, risk transfer is often handled poorly in PPP projects (Ng and Loosemore, 2007). A common perception that privatization involves transfer of all risks to the private sector is prevalent in many countries. 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. Furthermore, the complex arrangements and incomplete contracting in PPP projects have led to increased risk exposure for both public and private partners (Jin, 2010; Jin and Doloi, 2008b). Effective risk allocation in PPP projects is therefore challenging and demanding.

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In this paper, the determinants of efficient risk allocation were identified based on the transaction cost economics (TCE) theory and the resource-based view (RBV) of organizational capabilities. Accordingly, a theoretical framework was proposed to model the risk allocation decision-making process in PPP projects. In the next section, the risk allocation decision-making determinants and theoretical framework are presented. Then, the artificial intelligence technique based on artificial neural networks (ANNs) is briefly reviewed. Research methodology including an industry-wide survey in Australia is then reported, followed by a detailed description of the construction, training, and evaluation of ANN models. Finally, a brief conclusion is presented.

2. Determinants of risk allocation strategy

Risk allocation practices in PPP projects have been found highly variable, intuitive, subjective and unsophisticated (Ng and Loosemore, 2007). Given its critical importance in PPP projects, a number of studies have been conducted to explore how to achieve efficient risk allocation, such as Arndt (1999) developing a framework for efficient risk allocation to help obtain the optimum outcomes from the BOOT delivery method, Thomas et al. (2003) conducting a risk perception analysis in the Indian BOT roads sector to evaluate the risk criticality, risk management capability, risk allocation/sharing preference, and factors influencing risk acceptance of major stakeholders, Faulkner (2004) proposing that sharing risks rather than transferring them and a win–win mutual gain be the characteristics of true PPPs, Hayford (2006) proposing that optimal risk allocation should have sufficient flexibility to enable the partners to deal with external changes and events, Medda (2007) exploring the behaviour of the public and private partners when confronted with opposite objectives in the allocation of risks, and Ng and Loosemore (2007) analysing the rationale behind decisions about risk distributions between public and private sectors and their consequences and demonstrating the complexity and obscurity of risks facing such projects and the difficulties in distributing them appropriately. However, these studies either deems the risk allocation process as one that is only affected by agents' risk attitudes (e.g. Thomas et al. (2003)) or management capabilities (e.g. Arndt (1999)); or lacks theoretical foundations and/or empirical evidence to support their submissions.

More importantly, the design of risk allocation has rarely been judged on a cost–benefit basis (Miller and Lessard, 2001) given the claim that appropriate risk allocation would significantly reduce transaction cost (Zaghloul and Hartman, 2003). This is probably because research in project management, including risk management, has been concerned mainly with process and technique (Walker and Chau, 1999; Winch, 2006). While both aspects aim at increasing efficacy, neither is successful in understanding which kind of existing governance structures best suits a particular construction project in terms of efficiency and why (Jin, 2010). Miller and Lessard (2001) argued that costs of controlling risks must fit with expected benefits when dealing with risks in large engineering projects and proposed to adopt a real-options approach. Nonetheless, no further empirical study has been conducted to support their submissions.

Recently, Jin and colleague argue that the transaction cost economics (TCE), if integrated with the resource-based view (RBV) of organizational capability, can contribute to this and allow a more logical and holistic understanding and interpretation of the risk allocation decision-making process (Jin, 2010; Jin and Doloi, 2008b). The rationale and relevant framework are briefly discussed below.

Transaction costs are the costs of running the economic system (Arrow, 1969). Accordingly, TCE poses the problem of economic organization as a problem of contracting and maintains that there are rational economic reasons for organizing some transactions one way and other transactions another (Williamson, 1985). The principal dimensions with respect to which transactions differ are (1) asset specificity, (2) uncertainty, and (3) frequency (see Williamson (1985, 1996) for details). 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).

Regarding risk allocation, if a risk is improperly allocated, possible 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 clients of more resources for monitoring the risk management 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 risk management service-specific assets by other parties; (5) the extra costs for contractors of the resources dedicated to lodging claims related to the misallocated risk; (6) the extra costs for both parties of dealing with the disputes or litigation related to the misallocated risk (Jin, 2010).

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 risk management service transaction in question (Jin, 2010; Jin and Doloi, 2008b). Risk allocation 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). However, it has been found that decisions regarding governance structures are strongly influenced by both exchange conditions at the transaction level and organizational capabilities at the firm level (Jacobides and Winter, 2005; Leiblein and Miller, 2003). Unfortunately, the TCE approach has historically neglected the differences in organizational productive capabilities by holding the constraint that firms maintain homogeneous capability (Jacobides and Hitt, 2005).

Non-imitable and non-substitutable organizational capabilities are a key source of inter-firm performance differences (Barney, 1991; Dosi et al., 2000; Nelson, 1991; Rumelt, 1984; Wernerfelt, 1984). Given a specified output level, a less capable