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A model for determining the optimal project life span and concession period of BOT projects

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Abstract

The concession agreement is the core feature of BOT projects, with the concession period being the most essential feature in determining the time span of the various rights, obligations and responsibilities of the government and concessionaire. Concession period design is therefore crucial for financial viability and determining the benefit/cost allocation between the host government and the concessionaire. However, while the concession period and project life span are essentially interdependent, most methods to date consider their determination as contiguous events that are determined exogenously. Moreover, these methods seldom consider the, often uncertain, social benefits and costs involved that are critical in defining, pricing and distributing benefits and costs between the various parties and evaluating potentially distributable cash flows. In this paper, we present the results of the first stage of a research project aimed at determining the optimal build-operate-transfer (BOT) project life span and concession period endogenously and interdependently by maximizing the combined benefits of stakeholders. Based on the estimation of the economic and social development involved, a negotiation space of the concession period interval is obtained, with its lower boundary creating the desired financial return for the private investors and its upper boundary ensuring the economic feasibility of the host government as well as the maximized welfare within the project life. The outcome of the new quantitative model is considered as a suitable basis for future field trials prior to implementation. The structure and details of the model are provided in the paper with Hong Kong tunnel project as a case study to demonstrate its detailed application.

The basic contributions of the paper to the theory of construction procurement are that the project life span and concession period are determined jointly and the social benefits taken into account in the examination of project financial benefits. In practical terms, the model goes beyond the current practice of linear-process thinking and should enable engineering consultants to provide project information more rationally and accurately to BOT project bidders and increase the government's prospects of successfully entering into a contract with a concessionaire. This is expected to generate more negotiation space for the government and concessionaire in determining the major socioeconomic features of individual BOT contracts when negotiating the concession period. As a result, the use of the model should increase the total benefit to both parties.

Keywords: Project management; Build-operate-transfer; Project life span; Concession period; Optimization

1. Introduction

The public sector is traditionally responsible for infrastructure development within its jurisdiction and is the sole financer of the projects involved. However, this form of procurement is becoming increasingly outdated due to a perceived over-reliance on public

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finance, soft budget constraints, deficiencies in managing financial risks, lack of user responsibility and inefficiencies in the construction and operation processes. It is against this backdrop that, since the 1980s, the private sectors of Western nations are increasingly participating in infrastructure development (Delorme et al., 1999; Bao, 2009).

The build-operate-transfer (BOT) contractual arrangement is today an important example of such participation. Here, the government provides the private investor/concessionaire with the specific concession period (for brevity, the terms 'private investors' and 'concessionaire' are used interchangeably). This period, termed the transfer point, is purposely set to enable the concessionaire to collect revenues by operating and maintaining the infrastructure involved before its transference back to the government (Levy, 1996) at the end of the period. The BOT model, therefore, provides an effective way of utilizing private funds in the provision of public infrastructure while affording the opportunity for the use of the innovative technologies, management skills and operational efficiencies possessed by private businesses (Shen et al., 2007).

The BOT approach makes an important contribution to the development of infrastructure both in developed and developing countries and a significant research effort has investigated the methods needed to help in its effective application. Most of this effort focuses on the identification and distribution of risks (e.g. Wibowo and Wilhelm Alfen, 2014), project pricing and finance arrangements (Yang and Meng, 2000; Devapriya and Pretorius, 2002), as well as sustainable organizational structures and characteristics (Lokiec and Kronenberg, 2003). Research has also been conducted on the methods and tactics involved in project financing (Smith et al., 2004) and still other studies investigating the role of government in BOT-led infrastructure development (e.g., Ye and Tiong, 2000; Kumaraswamy and Zhang, 2001; Wibowo and Wilhelm Alfen, 2014) in providing an important theoretical basis for their financing, pricing, managing and implementation.

The concession agreement is the core feature of a BOT project, with the concession period being the most essential feature in determining the time span of the various rights, obligations and responsibilities of the government and concessionaire, e.g. ownership and user rights (Qin, 2005; Khanzadi et al., 2012). Ye and Tiong (2010) conducted a systematical introduction of the concession period design, which includes the concession period structure, length of concession period and the incentive scheme. In this paper, the discussion of concession period particularly focuses on the 'length' rather than 'structure' or 'incentive scheme'. There are many studies of the BOT concession period length. Of these, two approaches are apparent: *descriptive research* and *analytical research*. *Descriptive research* is usually only to report what have been "observed"—aiming to identify the affect factors and their relationship with the concession period of a specific BOT project. For example, it is found that the concession period depends upon the negotiations between government and investors (Shen et al., 2002; Wang et al., 2008; Ye and Tiong, 2010). *Analytical research*, on the other hand, examines the internal mechanism about how the factors lead to the results—in this case aiming to explicate the decision-making methods for determining the concession period by quantitative analysis. Of the many treatments are asset pricing methods (Shen and Wu, 2005; Garvin and Cheah, 2004; Wu et al., 2011; Xu et al., 2012); fuzzy-Delphi related techniques (Ng et al., 2007; Islam and Mohamed, 2009; Mostafa et al., 2010; Shen and Wang, 2010; Khanzadi et al., 2012); the net present value (NPV) approach (Shen et al., 2002; Xu and Moon, 2013); bargaining game theory (Shen et al., 2007; Wang et al., 2011; Hanaoka and Palapus, 2012; Song et al., 2012); real option models (Ho and Liu, 2002; Huang and Pi, 2013); and simulation or programming enabled methods, such as genetic algorithm based time–cost tradeoff analysis (Li et al., 2010), web-based analysis (Zhang, 2011) and simulation with optimization programming (Lai, 2012). Some research deals with uncertainties in the determination of the concession period, e.g. through risk allocation (Carbonara et al., 2014; Wibowo and Kochendörfer, 2005), guarantees, compensation and penalties (Wibowo, 2004; Xiong and Zhang, 2014).

The basic economic consensus in analytical research concerns financial viability and the benefit/cost allocation between the host government and the concessionaire, much of which is addressed in the literature above. For example, Shen et al. (2002); Zhang (2011) and Fan et al. (2012) all argue that the concession period needs to be well designed to guarantee an attractive internal return rate for the concessionaire while meeting the budget constraints of the government, given the prediction of the cash flows occurring at different stages in the project life. However, most mechanism research methods to date consider the determination of the concession period and project life span as contiguous events that are determined exogenously. Bao and Wang (2010), however, criticize this by arguing that the concession period and project life span should be treated as interdependent, from both financial and social perspectives.

Moreover, analytical research methods have seldom considered the social benefits and costs in concession decision-making (e.g. Zhao and Tan, 2009; Bao and Wang, 2010), while it is well recognized that public works projects calculating only project financial outcomes is "absurd" (Foster and Beesley, 1963). The European PPP Expertise Centre reported on the assessment of the non-financial benefits of Public Private Partnership (PPP) projects, for example, highlighting the importance of incorporating non-financial benefits into the value for money analysis (EPEC, 2011). Consideration of social benefits and costs is critical in defining, pricing and distributing benefits and costs between the various parties and evaluating potentially distributable cash flows. Zhao and Tan (2009) extend the NPV approach to include the social benefit factor in the concession negotiation. Following their research, Bao and Wang (2010) propose a theoretical model to include social benefits and costs as well as incorporating the interdependency of the project life span and concession period in BOT contract formulations, and this paper is therefore motivated and developed from their work through model development and empirical validation.

The scope of the study here is to develop a comprehensive model for determining the concession period of a BOT project