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A fuzzy simulation model for evaluating the concession items of public–private partnership schemes

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Abstract

The investment return, tariff regime and concession period are the most important items that influence the success of a concession-based public–private partnership (PPP) project. From the public partner's perspective, whether a scheme is value-for-money or not dominates the decision-making process. However, a seemingly favorable deal may turn out to be the least value-for-money option should it cause unnecessary social upheaval, such as excessive tariff increases or complaints. A scheme which is truly value-for-money is one which balances the interests of the public partner, investor and end-users. In this paper, a simulation model is proposed to assist a public partner to identify the concession period based on the expected investment and tariff regime. The needs for establishing different scenarios to represent the risks and uncertainties involved are presented, and a fuzzy multi-objective decision model is introduced to trade-off the associated three concession items. The combined features of the simulation and fuzzy multi-objective decision models enable the scenario most likely to result in a "win–win–win" concession scheme to be identified. A hypothetical example is used to illustrate the proposed model. This highlights the importance of the decision-makers' perception of the concession items in influencing their selection, and the influence of the group decision-making involved.

Keywords: Concession period; Fuzzy sets; Public–private partnership; Simulation; Tariff regime

1. Introduction

An increasing number of construction industry stakeholders are striving to exploit the potential of opening up publicly owned and operated facilities/services to the private sector. Public–private partnerships (PPP) offer one means of achieving this by attaining a "win–win–win" situation among the government, business sector and end-users (*cf:* [1,2]). In fact, there is no shortage of successful PPP examples [3–8]. These have often provided significant overall cost savings for the project [9–12], more timely delivery of facilities/services [13] and better productivity performance and innovation [14].

In one of the most popular PPP alternatives, the concession scheme, the investor raises the necessary funding and provides the physical facility as well as maintaining and operating the completed asset [15]. In return, they recover their capital investment according to the terms set out in the concession agreement *viz*. the concession period, a proposed tariff regime and an expected investment return [16]. To ensure the scheme is financially viable and attractive, the investor might seek to initiate a higher expected investment return especially when the concession period is short. With an assured minimum profit proviso, the concessionaire may increase the tariff in case the scheme fails to reach its expected investment return. Yet, any upward adjustment in tariff will attract criticisms from the user and pressure groups. From the government's perspective whether or not a PPP scheme is of value-for-money is the prime concern; and those with unrealistically high expected returns and/or excessively lengthy concession periods may be conceived as a transfer of interest [17]. Hence, there is a legitimate need to balance the interests of all the stakeholders before a concession agreement is reached.

In practice, the government relies on the pay back period (PBP) under the minimal internal rate of return (IRR) as expected by the concessionaire to determine the concession

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period [18]. This enables the PBP to be easily computed by the conventional net present value (NPV) method. As an alternative, Ngee et al. [16] have developed a multiple linear regression model which enables the value of any concession item to be calculated when the other two items are known. Both these approaches, however, are dominated by high levels of risk and uncertainty (fluctuations in interest rate, inflation, cost, revenue, etc.). An overly optimistic estimate based on the cash flow evaluation, for instance, could mean that the return rate expected by the concessionaire may never be realized during the agreed concession period. Therefore, when establishing the concession items, due consideration of the effects of the risks and uncertainties involved is needed. A further salient issue is the need to embrace the views of various stakeholders – the public partner, the investor and the end-users – when the concession items are determined.

This paper proposes a model to determine the concession items that best satisfies the various stakeholders involved in a PPP scheme. This firstly uses simulation techniques to deduce a concession period based upon the minimum expected IRR and tariff regime proposed. Fuzzy set theory is then applied to enable the concession items to be evaluated via a range of possible scenarios. This enables a non-inferior solution for conflicting objectives to be deduced. Through the model results, the public partner can select the most satisfactory alternative for proposal invitation and further evaluation. The paper begins by outlining the features of the simulation model. It is then followed by an introduction of the model components. Finally, a hypothetical example is applied to illustrate the operation of the model.

2. Modeling risks through simulation

Acknowledging the strength of simulation in analyzing the effects of risks, models have been developed using the Monte Carlo approach to determine the concession period [32–34] and analyze the risks involved in concession projects [19] based on the simulated values of such financial indicators as NPV and IRR. However, the risk analysis model developed by Malini [19] was based on deterministic parameters, which restricts its applicability to the selection of a concession period only from some finite scenarios. The model also assumes that some macro-economic indicators, such as interest and inflation rates, can be estimated with certainty. In reality these macro-economic indicators may well be major risks in themselves.

Fig. 1 portrays a new simulation model to accommodate the complex implications of the various risks associated with concession-based PPP projects. In this model, the concession period is an output rather than an input parameter. Since securing a desirable return is the most important consideration of any commercial organization, it is sensible to assume that a reasonable tariff regime and a minimal IRR can be established in advance. By inputting the tariff regime and the IRR into the simulation model, the exact concession period in each simulation cycle can be computed from simulated costs and revenues. With sufficient iterations, a frequency distribution related to the concession period can be generated.

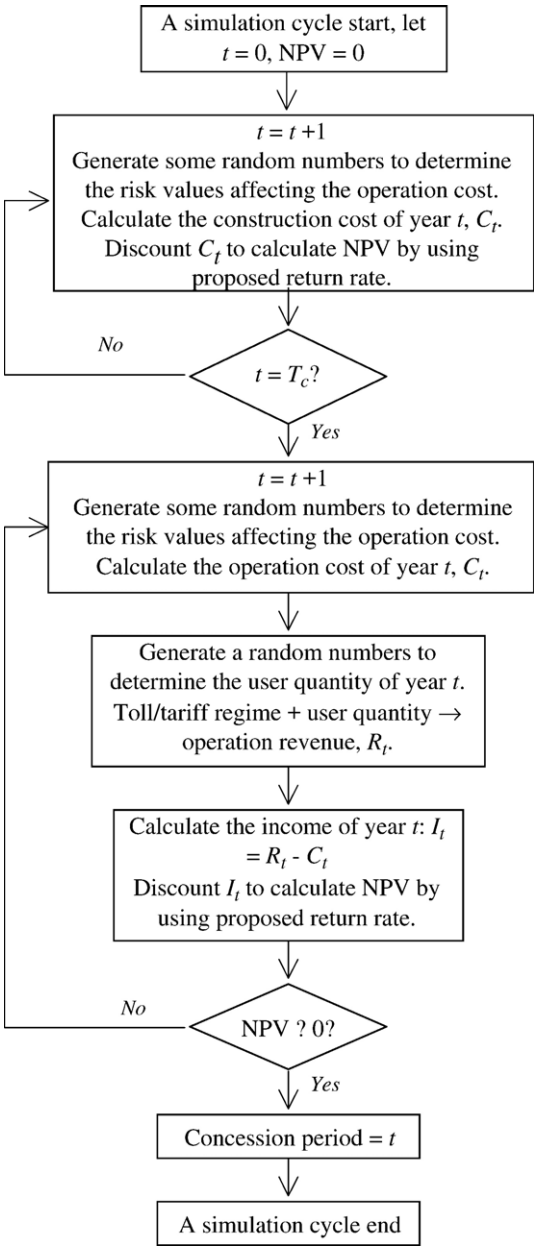

Fig. 1. Simulation flow diagram for determining the concession period.

2.1. Deterministic parameters

2.1.1. Construction period (T_c)

The concession period is composed of construction and operation periods. Under normal circumstances, the time required for completing the construction work is uncertain as project delay is common in practice. However, the construction period can be treated as a deterministic input in a concession scheme as the investor would enjoy a longer operation period by shortening the time for construction while the concession period remains the same [35]. By controlling the construction period, the identified risks may be converted into opportunities. Hence, the input data can be based simply on the most likely construction period as estimated by the public partner.