Automated Approach to Negotiations of BOT Contracts with the Consideration of Project Risk

Fen-May Liou[1] and Chih-Pin Huang[2]

Abstract: The terms of concession including tariff and concession period are often discussed intensively during negotiations of build-operate-transfer (BOT) contracts. Based on prior studies on negotiation terms and risk of BOT contracts, this paper incorporates risk attributes of the BOT project into the formulation of a contractual-negotiation model. The proposed model allows the government and the sponsor to reach a consensus on the terms should the financial return as well as the risk of the project be determined. The pro forma cash flow of a BOT project is developed and used to generate the probability distribution of net present values (NPV) from the owner's viewpoint by using Monte Carlo simulation. High- and low-risk scenarios are obtained to determine whether the contractual-negotiation models vary in accordance with risk levels. Results show that, given the expected NPV, the sponsor should be offered more favorable concessional terms for projects with high risk than that with low risk. We suggest that the government and industry practitioners embody the risk attributes of the project in the automated contractual-negotiation model.

DOI: 10.1061/(ASCE)0733-9364(2008)134:1(18)

CE Database subject headings: Build/operate/transfer; Monte Carlo method; Regression models; Automation; Contracts; Project management.

Introduction

Build-operate-transfer (BOT) schemes—commonly referred to as private participation (PP) or public-private partnerships (PPPs) which are a collective terms for BOT, build, operate and own (BOO), build, operate, own, and transfer (BOOT), build, transfer, and operate (BTO), build and transfer (BT), reconstruction, operate, and transfer (ROT), and operate and transfer (OT) etc.—are subject to concession agreement (Kumaraswamy and Morris 2002). A BOT project is implemented in line with a governmental grant, involving a concession company that provides the financing, construction, operation, and maintenance of an infrastructure project; ownership is then transferred to the government after a specified concession period (Tiong 1995a). Adopted in many industrialized countries, BOT schemes attempt to finance new infrastructure projects via private sector participation (Malik 1999; Senturk et al. 2004). BOT schemes in many large infrastructure projects such as roads, expressways, railways, bridges, ports, and power plants, are constructed or operated by private firms under a procurement system. Many studies indicate that government-sponsored BOT schemes encourage the private sector to participate in public infrastructure projects (Tiong 1990; Dias and Ioannou 1995; Liddle 1997).

The terms of a concession agreement, including tariff and concession period of the project, are often discussed intensively during negotiations. While the preliminary version of contractual terms is normally grounded on pro forma financial statements conducted during the feasibility study or the appraisal stage of the BOT project, change in any one of the terms will most likely alter the cash flow and deviate from the expected project return. The degree of deviations of project return from its expectative value will depend on probability distribution of the project return, i.e., the project risk. To facilitate the contractual negotiation, Ngee et al. (1997) introduced an automated mechanism that allows the government and sponsor to reach a consensus on the combination of concession period, tariff scheme, and rate of return of a BOT project. Alternatively, Shen et al. (2002) developed a quantitative BOT concession model for determining a proper concession period that can protect the interests of both the government concerned and private investors. The concession model was further extended to take project risk into consideration (Shen and Wu 2005). While the study of Ngee et al. (1997) is based on sets of manual assumed data with no consideration of the risk associated with the underlying project, the build-operate-transfer concession model (BOTCcM) does not present possible combinations between concession period and other financial variables. Based on the previous studies, this study examines how the tariff, duration of concession period, and borrowing interest rate are related at high- and low-risk levels in order to develop a risk-fit-in automated BOT contractual-negotiation model.

The rest of this paper is organized as follows. The following section reviews literature for critical negotiation factors of BOT projects. Next, we present the methodology and simulation procedure used in the present study for conducting the empirical research. The electronic toll collection (ETC) system project in Taiwan was used as the case study. Sampling data are selected

[1]Assistant Professor, Graduate Institute of Business Management, Yuanpei Univ., 306 Yuanpei St., Hsin Chu, Taiwan 300, R.O.C. (corresponding author). E-mail: mayliou@so-net.net.tw

[2]Graduate Student, Graduate Institute of Business Management, Yuanpei Univ., 306 Yuanpei St., Hsin Chu, Taiwan 300, R.O.C. E-mail: pin.huang@xuite.net

Note. Discussion open until June 1, 2008. Separate discussions must be submitted for individual papers. To extend the closing date by one month, a written request must be filed with the ASCE Managing Editor. The manuscript for this paper was submitted for review and possible publication on January 22, 2007; approved on April 19, 2007. This paper is part of the ***Journal of Construction Engineering and Management***, Vol. 134, No. 1, January 1, 2008. ©ASCE, ISSN 0733-9364/2008/1-18–24/$25.00.

from data inputs in high- and low-risk scenarios developed by Monte Carlo simulation. Multiple regression analysis is subsequently conducted to demonstrate the impact of the risk features on the automated contractual-negotiation model. Results are also summarized and discussed. Conclusions are finally drawn in the last section.

Critical Negotiation Factors of BOT Project

Using a questionnaire survey, Li et al. (2005) examined the relative importance of 18 potential critical success factors (CSFs) for private participation construction projects in the United Kingdom. They found that the three most important factors are a strong and good private consortium, appropriate risk allocation, and available financial market. Tiong (1990) divided the phases of a BOT project into preinvestment, implementation, construction, operation, and transfer. Project sponsors function in multiple roles during the concession period: (1) as consultants performing a feasibility study during the preinvestment phase and as engineering design during implementation; (2) as project sponsors to negotiate favorable concession agreements from the government and as project promoters to raise equity and secure loans during implementation; (3) as contractors to construct the facility, normally on a fixed price turnkey basis, during construction; (4) as operator and owner of the facility, using the project revenue to repay the loans during operations; and (5) as project sponsors to transfer ownership to the government after a specified concession period. In summary, the BOT sponsor takes all financial risks during project preparation and throughout the project cycle. While conducting survey research, Tiong (1996) identified six CSFs for private contractors in competitive tending and negotiation in a BOT project, e.g., entrepreneurship and leadership, correct project identification, strength of consortium, technical solution advantage, financial package differentiation, and differentiation in guarantees. Furthermore, an attractive financial package is designated to significantly affect the successful implementation of a competitive BOT tender during final negotiations (Tiong 1995b). An attractive financial package is based on principles of low cost, credibility, minimal financial risks to the government, and minimal burden on debt-servicing capacity of project revenue. Using survey research, Tiong and Alum (1997) examined both the government and promoter by adopting 13 financial and contractual elements as criteria. According to their results, the government and promoter prioritized the three most important elements during negotiations as the initial level of tariff, future tariff increases, and financial commitments by bankers of the promoters. Moreover, the government and promoters prioritize tariff as the most important element during final negotiations of financial and contractual concerns.

Ngee et al. (1997) introduced an automated mechanism in a multiple regression model using the tariff and duration of the concession period as explained variables for the project return. In their study, the automated contractual-negotiation model was developed with 35 input samples generated by adopting incremental (manual) changes in the tariff (2% each time) and concession period (from 10 to 14 years). After conducting linear and nonlinear regressions, respectively, they concluded that the nonlinear model outperformed the linear one in terms of variation (of rate of return) explained ($R^2=99.9\%$). Project risk is not considered while formulating the automated model. Alternatively, Shen et al. (2002) reviewed variables affecting the concession period in a BOT contract and proposed a quantitive concession model (BOTCcM) to determine the period duration that incorporates both the investor's and the government's interests. Shen and Wu (2005) further found that various risks existing in the process of implementing a BOT project have significant impacts on project cash flow. They subsequently incorporated project risks, drawn by Monte Carlo simulations, into the BOTCcM. In a BOTCcM, the concession period is the only factor that has to be determined, which implies that all other BOT factors are predetermined. The BOTCcM does not provide for alternative combinations of concession period and other BOT financial variables.

Project Evaluation and Risk

The approach of a project evaluation grounded on cash flows is to generate a "best estimate" (usually a single value such as mode, average, or a conservative estimate) based on the available data and use it as an input (i.e., the project variable) in the evaluation model (Savvakis 1994). The investment rule asserts that a project is acceptable if the evaluation indicator estimated by the cash-flow model is beyond a given hurdle rate (or value). However, since the evaluation model is formulated based on a set of single certain values, a range of other probable outcomes for each project variable are not included in the analysis. Based on the single value as input, the calculated evaluation indicator is also presented as a certainty. Recognizing the fact that there is risk associated with the investment scheme, the project evaluation usually conducts sensitivity and scenario analyses tests as supplements. The sensitivity analysis examines the degree of impact brought by changes in underlying assumptions (the project variables) on the evaluation indicator, whereas the scenario analysis examines a number of different likely scenarios (such as pessimistic, average, and optimistic scenarios) involving a simultaneous change of values for a number of key project variables (Ross et al. 2007). The Monte Carlo simulation further provides a dynamic analysis to project evaluation by building up random scenarios which describe the uncertainty surrounding the key project variables as probability distributions and to calculate in a consistent manner its possible impact on the expected return of the project (Savvakis 1994). The output of a risk analysis is therefore a probability distribution of all possible expected returns, offering the prospective investor a complete return (or risk) profile of the project showing all the possible outcomes that could result from the investment decision. Malini (1999) used the Monte Carlo simulation model to analyze the risk of BOT municipal bridge projects and concluded that the simulation model accurately estimates the financial risk of BOT projects. Variables used as simulators consist of tariff structure, tariff revision schedule, extent of the municipal grant, and duration of the concession period.

Research Methodology

In the present study, cash flow analysis forms the basis for project evaluation while the Monte Carlo simulation is used to generate the probability distribution (the financial risk) of the project return. Multiple regression is then performed to formulate prediction equations in order to model the negotiation terms of a BOT project.

Cash Flow Approach and Investment Decision Rule

Investment decision rules based on expected project cash inflow are used in the subsequent empirical study. The approach to investment decision making can be an analysis from the perspective of either the equity investors in a firm (the owner's view) or all stakeholders of the firm. The equity approach measures the return to equity by using the cash flows that are expected by equity investors, after meeting all debt obligations, while the return to the firm is calculated by using cash flows that are expected to accrue to all investors in the firm including debt and equity (Ross et al. 2007). The financial cost will affect the return to the firm only through the taxation item because interest expense is tax deductible while loans and interests are excluded from the cash flow. In order to investigate the effect of government-offered financial resources on project risk, the present study applies an equity approach to generate the cash flows of the project. In addition, net present value (NPV) used in the investment decision rule is applied as the evaluation indicator.

The NPV of a project refers to the sum of the present values of a stream of cash flow. If NPV is not less than 0, the project is accepted and vice versa. In addition, the possibility rate of negative NPV is a measurement of the degree of risk of the project (Savvakis 1994). The general equation for the NPV rule is as follows in Eq. (1)

$$\mathrm{NPV} = \mathrm{CF}_0 + \frac{\mathrm{CF}_1}{(1+k)} + \frac{\mathrm{CF}_2}{(1+k)^2} \cdots + \frac{\mathrm{CF}_n}{(1+k)^n} \tag{1}$$

where $\mathrm{CF}_0, \mathrm{CF}_1 \cdots, \mathrm{CF}_1$=cash inflow subtracting the cash outflow based on the annual net cash flows for the entire concession period; n=concession period; and k=discount rate=weighted average cost of capital (WACC). The WACC depends on the mix of debt and equity used to finance the project and is adopted to estimate the NPV.

Monte Carlo Simulation

"The Monte Carlo method is one of many methods for analyzing uncertainty propagation, where the goal is to determine how random variation, lack of knowledge, or error affects the sensitivity, performance, or reliability of the system that is being modeled" (Wittwer 2004). This method uses random numbers and probability to solve problems such as games of chance (Metropolis and Ulam 1949; Hoffman 1998). Specifically, Ulam et al. (1947) initially viewed the Monte Carlo method as an effective means of estimating probabilities of solitaire success and subsequently applied it to resolve neutron diffusion problems. The Monte Carlo simulation is a sampling method for iteratively evaluating a deterministic model using sets of random numbers as inputs, which are generated from probability distributions to stimulate the process of sampling from an actual population. This simulation method has subsequently been used by numerous industries to resolve deterministic problems by using random numbers. In particular, the risk analysis is performed using the Monte Carlo simulation along with an analysis of the uncertainty and risks in capital investment (Hertz 1964; Rubinstein 1981; Savvakis 1994).

The computer-based Monte Carlo simulation can typically involve 10,000 evaluations (Wittwer 2004). However, some computer software packages suggest fewer numbers of runs, such as 500 evaluations (e.g., RiskEase). Data generated from the simulation are represented as probability distributions. This simulation method iteratively analyzes sample values from an associated range. During risk analysis of an investment project, values from throughout the given range for each variable are used to estimate NPVs on an annual basis of the project life. Upon completion, a probability distribution for each year is obtained. Fig. 1 displays the process of the Monte Carlo simulation conducted in the present study.

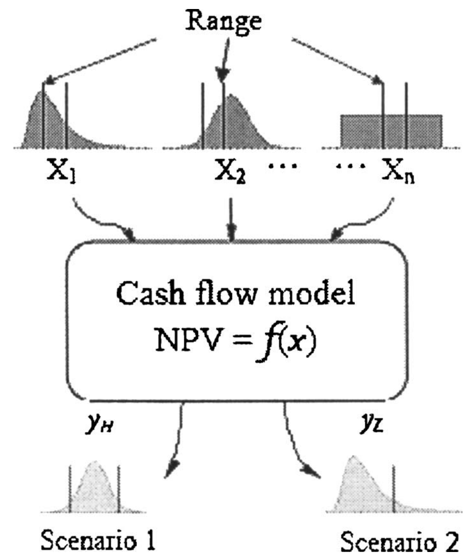

Fig. 1. Process of Monte Carlo simulation

Case Study

The ETC system project (the ETC project) in Taiwan is used as a case for the following empirical study. Data from the Ministry of Transportation and Communications of Taiwan are used to formulate the pro forma cash flow of the ETC project, based on which two scenarios are made at high- and low-risk levels from the Monte Carlo simulation. Sample inputs for regression models are randomly selected from the data sets generated during the process of simulation.

Project Profile and Financial Analysis

The ETC concessionaire is granted a concession period of 15 years and is responsible for the construction, operation, and maintenance of the ETC system during the concession period. Project sponsors are responsible for transferring the ownership to the government after the specified concession period. The construction started in 2004 while the operating period began in 2006, and lasts for 13 years. The parameter information of the ETC is shown in the Appendix. Table 1 displays the pro forma cash flow using the conventional spreadsheet computations on the cash flow of the ETC case, in which the cash flow is granted a concession period of 15 years. The cash outflow consists of initial investment, operating expenditures, tax, and financial payments. The cash inflows include tariff (based on driving-through frequency in the first 5 years and driving-through distance thereafter) and financial borrowing. The project does not have a residual value since the property is proposed to transfer to the government with no cost. In addition, the Taiwan government commits to providing concessional loans to the project. The tariff schemes, duration of concession period, and terms of the concessional loans are financial variables subject to negotiation between the two parties and approval from the host government.

Table 1. Cash Flow Statement of Taiwan ETC Project

Project cash flow	2004 Year 0	2005 Year 1	2006 Year 2	2007 Year 3	2008 Year 4	2009 Year 5	2010 Year 6	2011 Year 7	2012 Year 8	2013 Year 9	2014 Year 10	2015 Year 11	2016 Year 12	2017 Year 13	2018 Year 14	2019 Year 15
Cash inflow																
Tariff revenue	—	—	1,224	1,290	1,334	1,379	1,423	2,058	2,130	2,203	2,276	2,349	2,423	2,498	2,573	2,648
Revenue-onboard unit	—	—	2,780	28	28	28	29	29	29	30	30	30	30	31	31	31
Interest revenue	—	—	90	8	1	1	1	1	1	1	1	1	1	1	1	1
Borrowings	436	436	—	—	1,387	1,387	—	—	—	—	—	—	—	—	—	—
Total inflow	436	436	4,095	1,325	2,750	2,795	1,453	2,088	2,160	2,233	2,307	2,381	2,455	2,530	2,605	2,681
Cash Outflow																
Construction cost	727	727	—	—	2,312	2,312	—	—	—	—	—	—	—	—	—	—
Fixed cost	—	—	143	146	152	161	174	192	217	249	292	349	425	528	670	867
Regular expenditure	—	—	811	827	844	861	878	896	914	932	950	969	989	1,009	1,029	1,049
Cost for on board unit	—	—	2,780	28	28	28	29	29	29	30	30	30	30	31	31	31
Income tax	—	—	—	—	—	—	—	75	87	96	104	107	137	125	103	183
Loan Installments	—	—	—	—	—	—	521	521	521	521	521	521	521	—	—	—
Interest paid	14	28	28	28	73	119	102	85	68	51	34	17	—	—	—	—
Total outflow	742	756	3,763	1,037	3,414	3,479	1,692	1,778	1,799	1,821	1,844	1,866	1,921	1,436	1,473	1,626
Net cash flow	−305	−319	332	296	−659	−686	−251	290	325	355	376	387	353	837	772	550

Note: All figures in million of NT dollars.

The NPV is an appropriate indicator for financial feasibility since the case study considered here is characterized as a medium-term project investment. According to the cash flow in Table 1, the NPV is calculated using Eq. (1) and the owner's point of view is 291 million new Taiwan dollars (NT$), which is greater than zero indicating that the project is financially viable for the base case.

Monte Carlo Simulation Analysis

Evaluation risk software, RISKEASE, offers a simulation procedure to analyze project risk. It provides the probability distribution of NPVs as well as the probability of loss (NPVs <0) for the subject project but the data inputs randomly generated in the process of simulation are not available. Another simulation software, @RISK 4.5 further offers the randomly generated data inputs (the data sets) during the simulation. We first used RISKEASE to perform simulations in order to identify the range of key variables (including frequency-based tariff, distance-based tariff, borrowing interest rate, and duration of concession period) at each of the high- and low-risk levels. Each key variable is assumed a normal distribution. The low- and high-risk scenarios for probability of negative outcome of NPVs are defined as 0 and 75%, respectively, and each scenario individually simulates 14, 15, and 16 concession periods, resulting in six subscenarios (2 scenarios $\times 3$ years) in total. Six groups of ranges for each variable are obtained accordingly. Five hundred runs were made for each of the subscenario simulations. RISKEASE generates a set of statistics for each subscenario including expected value of NPV, standard deviation, minimum, maximum, coefficient of variation, probability of negative outcome, expected loss, expected gain, and expected loss ratio. Table 2 summarizes the risk analysis results. @RISK 4.5 is then used to individually take the associated parameters from the six subscenarios, with the assumed parameter ranges shown in Table 3. Six data sets generated during simulation for each of the six subscenarios are obtained.

Table 2. Risk Analysis Results for High- and Low-Risk Scenarios

Statistics analysis	0%	75%
(a) Concession period is 14 years		
Expected value of NPV	704	−214
Standard deviation	250	384
Minimum	−85	−1,285
Maximum	1,497	822
Coefficient of variation	0.29	−1.972
Probability of negative outcome (%)	0.40	69.20
Expected loss	0	284
Expected gain	704	70
Expected loss ratio (%)	0	80
(b) Concession period is 15 years		
Expected value of NPV	805	−300
Standard deviation	288	450
Minimum	−89	−1,382
Maximum	1,562	1,053
Coefficient of variation	0.358	−1.505
Probability of negative outcome (%)	0.2	74.60
Expected loss	0	370
Expected gain	805	71
Expected loss ratio (%)	0	84
(c) Concession period is 16 years		
Expected value of NPV	833	−245
Standard deviation	333	509
Minimum	25	−1,758
Maximum	1,859	1,215
Coefficient of variation	0.29	−1.972
Probability of negative outcome (%)	0.00	66.40
Expected loss	0	347
Expected gain	833	102
Expected loss ratio (%)	0	77

Note: All figures in millions of NT dollars.

Table 3. Ranges of Variable Inputs in Monte Carlo Simulation

		Scenarios on risk	
Concession years	Parameters	Low	High
14	Frequency based of tariff	3.5–4.0	3.2–4.0
	Distance based of tariff	0.078–0.1	0.062–0.1
	Borrowing interest rate (%)	4–7	7–10
15	Frequency based of tariff	3.5–4.0	3.2–4.0
	Distance based of tariff	0.076–0.1	0.055–0.1
	Borrowing interest rate (%)	4–7	7–10
16	Frequency based of tariff	3.5–4.0	3.2–4.0
	Distance based of tariff	0.074–0.1	0.056–0.1
	Borrowing interest rate (%)	4–7	7–10

Note: Frequency-based of tariff/per frequency; Distance-based of tariff/per kilometer; the currency unit is NT dollars.

Sampling Procedure

Systematic sampling was used to draw data inputs (sample data) for the regression model from the six data sets generated from simulations. We then randomly selected from each of the six subscenarios data sets (2 scenarios × 3 years) ten samples, generating a total of 60 (10 sample data × 6 subscenarios) samples to be used as inputs for the following regression model.

Multiple Regression Models

Statistical analysis software (SAS) was applied in multiple regression analysis to examine whether risks influence the associated parameters and NPVs. A risk parameter was used as a moderator representing the level of risk. Cross effects of the moderator were also examined. The regression model is shown as follows

$$\text{NPVs} = \beta_0 + \beta_1 T_1 + \beta_2 T_2 + \beta_3 R + \beta_4 C + \beta_5 D + \beta_6 DT_1 + \beta_7 DT_2 + \beta_8 DR + \beta_9 DC_1 + \varepsilon$$

where NPV=net present value, which is a function of T_1, T_2, R, C, and D; T_1=frequency-based tariff; T_2=distance-based tariff; R=borrowing interest rate; C=duration of concession period; D=risk parameter (dummy variable: 0=0% probability of getting a negative NPV, 1=75% probability of getting a negative NPV); β_0=constant term; $\beta_1, \beta_2, \ldots \beta_n$=coefficients of independent variables; and ε=random error.

Results show that the residuals of the model follow a normal distribution (Shapiro–Wilk test $p > 0.05$) and there is no multicollinearity among independent variables (condition index <30). Table 4 reveals that 99.67% of the variation of the project NPVs derived from various scenarios are presented by the independent variables in the regression model. The relationships between the project NPV with tariffs and concession period are positive, while those with the lending interest rate are negative. The main effect of the risk (D)($p < 0.05$) and the cross effects between risk with the distance-based tariff (DT_2) are both significant ($p < 0.001$). This finding indicates that the impacts of the variation of the tariff on the NPV differ at high risk from low-risk scenarios. Apparently, the development of an automated contractual-negotiation model depends on the project risk. The model developed for cases at low- and high-risk levels are, respectively, shown as follows (the distribution of residuals and the noncollinearity were both confirmed)

$$\text{NPV}_L = -1{,}103{,}461 + 131{,}268T_1 + 6{,}629{,}520T_2 - 1{,}129{,}743R$$
$$(-42.00^{***})(27.35^{***})(62.96^{***})(-13.71^{***})$$
$$+ 11{,}121C\ (12.19^{***}) \quad \text{if the project risk is low}$$

$$R^2 = 99.49\% \tag{2}$$

$$\text{NPV}_H = -987{,}549 + 129{,}111T_1 + 5{,}942{,}508T_2 - 834{,}389R$$
$$(-25.64^{***})(24.88^{***})(70.03^{***})(-5.94^{***})$$
$$+ 6{,}482C\ (4.42^{***}) \quad \text{if the project risk is high}$$

$$R^2 = 99.58\% \tag{3}$$

where the statistical significant level: $^{***}p < 0.01$; and the t value for each variable is shown in the corresponding parenthesis.

No matter whether the project risk is high or low, the four key financial variables depict a high portion of the variation of the project NPVs (Ngee et al. 1997). The impacts of tariffs and duration of concession period on the project NPV are positive while that of financial cost is negative. Comparing the two regression models, provided that $\text{NPV}_L = \text{NPV}_H$ and that the expected NPV is given, the input variables required in model (3) will be higher (while the borrowing interest rate, R will be lower since its coefficient is negative) than those in model (2) since the coefficients

Table 4. Regression Analysis Results

Variable	Parameter estimate	t value	p value
Intercept	−1,103,461	−32.29	0.0001[a]
T1	131,268	21.03	0.0001[a]
T2	6,629,520	48.41	0.0001[a]
R	−1,129,743	−10.54	0.0001[a]
C	11,121	9.37	0.0001[a]
D	115,911	2.46	0.0174[b]
DT1	−2,158	−0.28	0.7783
DT2	−687,012	−4.45	0.0001[a]
DR	295,354	1.85	0.0703
DC	−4,639	−2.71	0.0092[c]
	R^2=99.67%		

[a] $p < 0.001$.
[b] $p < 0.05$.
[c] $p < 0.01$.

in the latter [model (2)] are larger than those in the former [model (3)]. To be specific, the project sponsor will require more favorable terms from the government in order to compensate for the higher project risk it is going to bear. Additionally, provided that the automated contractual-negotiation model is different in a project with high risk from that with low risk, the sponsor of the BOT project should comprehend the risk attributes of the project before assessing the appropriate bargaining mechanism. Certainly, to facilitate the automated contractual-negotiation model, the project sponsor and the host government have to reach consensus on the type of distribution and the possible range of each key financial variable affecting the cash flows and the project return.

Conclusions

The tariff and concession period of a BOT project are the most important variables at the negotiation stage of a BOT project. While the initial version of contractual terms is normally based on pro forma financial statements conducted during the feasibility study or the appraisal stage, a change in terms will most likely alter the financial parameters. Ngee et al. (1997) introduced and justified the usefulness of an automated approach based on nonlinear regression modeling to BOT negotiations. However, their model, developed on the basis of incremental (manual) data inputs, is not intended to assess the risk of the BOT project in the negotiation model. Shen and Wu (2005) incorporate various risks into a BOT model used to determine a concession period that best protects the investor's and the government's interests. Yet, the model does not provide possible combinations of concession period and other financial variables.

Using the ETC project in Taiwan, this study incorporates risk attributes into the process of model formulation to identify possible combinations of financial terms in a BOT project. To examine whether the project risk affects the relationship between NPV with financial variables, we compare a risk-free scenario (as Ngee et al. 1997 did) with the third quartile of probability of negative expected NPV (defined as high risk). The results shown that the degree of project risk alters the impact of tariff on the project NPV (Shen and Wu 2005). Thus a two-stage approach to develop a risk-fit-in contractual-negotiation model is recommended. At the first stage, a Monte Carlo simulation is conducted based on ranges and distributions of variables agreed to by both parties to draw the degree of project risk and generate a group of data sets. The sample data embodying the project risk are randomly selected from the data sets and used as inputs for developing the regression model, i.e., the risk-fit-in negotiation mechanism, at the second stage. The proposed approach facilitates the process of negotiation between the sponsor and the host government to reach a consensus according to the risk features of the BOT project.

The Monte Carlo simulation is only one of the methodologies for risk analysis. Other risk analysis approaches may be used to build the risk-fit-in automatic approach to smooth the progress of the negotiation stage of BOT projects.

Acknowledgments

The writers would like to thank two anonymous reviewers and the editor of the Journal of Construction Engineering and Management for their helpful comments on earlier drafts of this manuscript. This study was partially supported by National Science Council, Taiwan (Grant No. NSC-95-2416-H-264-010).

Appendix: Financial Parameters of ETC Project in Taiwan

Debt/equity ratio=60/40

Concession period=15 years

Borrowing interest rate=6.5%

Business income tax rate=25%

Deposit interest rate=2%

Inflation rate=2%

Weighted average cost of capital (WACC)=debt/(debt +equity) * borrowing interest rate * $(1-t)$+equity/(debt+equity) * cost of equity=10.13%

Grace period=6 years

Start/end year of grace period=April 2004/2009

Operating period=13 years

Start year of operating period=February 2006

Construction period=4 years

Start year of construction period for frequency-based=April 2004/February 2006

Start year of construction period for distance-based=February 2008/February 2010

Debt repayment period=7 years

Start year of debt repayment period=2010

Frequency-based of tariff=3.5 (NTD/frequency)

Distance-based of tariff=0.087(NTD/km)

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