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Payment-based Annual Revenue Guarantee versus Period-extension-based Cumulative Revenue Guarantee in Build-Operation-Transfer Projects

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Abstract

This study proposes a method to compare revenue guarantee programs in a build-operation-transfer project. Two types of revenue guarantee programs are formulated: a payment-based annual revenue guarantee program and a period-extension-based cumulative revenue guarantee program. Monte Carlo simulation is used to model the real option approach. This method is applied to a toll road project in the Philippines wherein the expected payoffs of the government and the concessionaire are simulated over an evaluation period that includes the concession period. The condition under which the expected government return in one program is equal to that in the other program is shown. These programs are then evaluated by incorporating a project risk factor into the project return. The results show that for the analyzed project the cumulative revenue guarantee program is preferred to the annual revenue guarantee program. However, the optimal solution depends on the government's return-risk preference.

Keywords Public-private partnership, Build-Operate-Transfer, toll road, annual revenue guarantee, cumulative revenue guarantee, Philippines, real option approach

INTRODUCTION

Infrastructure investment and operation based on the public-private partnership (PPP) scheme have achieved worldwide popularity. The Build-Operate-Transfer (BOT) contract is one of the types of the PPP. The BOT contract is defined as "a kind of specialized concession in which a private firm or consortium finances and develops a new infrastructure project according to performance standards set by the government (*1*)." Toll road investment often involves the BOT contract.

One of the most critical risks in BOT-based toll road project is the uncertainty of travel demand. To deal with demand-oriented risk, governments have adopted revenue guarantee programs in some cases. Vasallo (*2*) describes the revenue guarantee program as having two variables: the trigger variable and the compensation mode. The trigger variable is defined as what initiates the guarantee. When a trigger variable exceeds a predetermined threshold, the guarantee is activated while the compensation is carried out. The trigger variable is grouped into three types: (i) annual revenue, (ii) cumulative revenue, and (iii) profits/internal rate of return (IRR). The compensation mode is defined as the manner of compensating the concessionaire when required. This compensation mode is grouped into three modes: (i) payment, (ii) toll, and (iii) period extension. Theoretically, nine combinations may be derived using two of the aforementioned variables, but the "annual revenue plus payment" program and the "cumulative revenue plus period extension" program are the most widely adopted. This study deals with these two programs. This paper refers to these programs as payment-based annual revenue guarantee (PARG) program and the period-extension-based cumulative revenue guarantee (PCRG) program respectively.

It is supposed that the government enters into a BOT contract with a concessionaire regarding investment in a toll road and its operation. The contract defines the share of project cost allocated to the government and the concessionaire. It also gives the concessionaire the right-to-operate over the toll road during the concession period while requiring the concessionaire to transfer its right to the government at the end of the concession period. It is assumed that the future traffic volume is forecasted by the government, but this volume is uncertain due to unknown factors. The PARG program is defined as a scheme whereby the contract predetermines the annual minimum revenue of the concessionaire. If the observed annual revenue proves to be lower than the predetermined minimum revenue in a given year, the gap between the observed revenue and the minimum revenue is refunded to the concessionaire in this year by the government. The decision concerning the refund is made every year by monitoring the annual revenue. On the other hand, the PCRG program is defined as a scheme whereby the contract allows the concessionaire to extend the concession period if a given condition is satisfied. The condition is typically that the cumulative revenue of the concessionaire does not reach the predetermined cumulative revenue in the last year of the concession period.

The PARG program was introduced in the 1990s and was applied in many countries, including Korea, Colombia, Chile, and Malaysia. However, it has recently been losing popularity because it often resulted in contingent liabilities for the government. In contrast, the PCRG program has been growing in popularity. For example, two bridges in Lisbon, the Severn Crossing in the UK, and the least present value of revenues (LPVR) auctions in Chile adopted the PCRG program (*2, 3*, *4*). The PCRG program does not require the government to pay monetary compensation to the concessionaire, even when it fails to earn the expected revenue; instead, the program requires the government to give the concessionaire the right to extend the concession period.

Although the two revenue guarantee programs have been widely implemented in BOT contracts, no method has been proposed to compare them in a given project. This may leads to the wrong choice of the revenue guarantee mechanism in the project. It might be said that the government should prefer the PCRG to the PARG in any case because the PCRG does not require the government to pay any monetary compensation. However, it should be noted that, under the PCRG program, the governments pay an opportunity cost even if they are not required to pay monetary compensation. The opportunity cost comprises the expected toll revenue that the government could earn through the concessionaire with the termination of the concession period. This may hold true even if the contract requires the government to change from a toll to a toll-free arrangement after the concession period; the user benefit stemming from a toll-free operation could be regarded as one of the major factors the government is required to maximize.

This paper aims to propose a method to compare the PARG with the PCRG in a given BOT project. It shows the condition under which the expected government payoff in the PCRG program is equal to that in the PARG program. It also suggests a suitable mechanism from a viewpoint of government risk-return preference. This paper uses the real option approach with Monte Carlo simulation in a case study. The case of a toll road project in the Philippines is used in the case study.

The paper is organized as follows. The motivation for and goals of this study are explained in the first section. Next, the methodology is described. The PARG and PCRG are formulated and the real option approach using the Monte Carlo simulation is explained. Then, the case study is presented. The simulation results are summarized and their implications discussed. Finally, the conclusion mentions further research issues.

METHOD

Model of the PARG Program

Consider a toll road project wherein the government enters into a BOT contract with a concessionaire. The contract defines the cost sharing between the two parties. The contract also gives to the concessionaire the right-to-operate over the toll road during the given concession period, whereas it requires the concessionaire to transfer its right to the government after the concession period ends. The PARG program requires the government to refund the compensation to the concessionaire on the basis of observed annual revenue and the predetermined minimum annual revenue. The annual compensation paid by the government is formulated as follows:

$$M_t = \begin{cases} 0 & \text{if } R_{ot} \geq R_{gt} \\ \alpha_t \left(R_{gt} - R_{ot}\right) & \text{if } R_{ot} < R_{gt} \end{cases}. \tag{1}$$

M_t denotes the annual compensation paid by the government in year t, R_{ot} denotes the observed annual revenue in year t, R_{gt} denotes the guaranteed annual revenue in year t, and α_t denotes the compensation rate in year t ($0 \leq \alpha_t \leq 1$). The guaranteed annual revenue is typically in proportion to the revenue forecast made by the government. This means $R_{gt} = \beta_t R_{ft}$, where β_t denotes the annual guarantee rate in year t varying from 0 to 1 and R_{ft} denotes the forecasted annual revenue in year t. α_t and β_t depend on the project scheme or government's policy. For example, the government may consider who prepared the revenue forecast for determining β_t because a private investor may bloat the forecast figure in order to get the government's acceptance to the project even if the project is not viable, in order to get government to commit the guarantee. This study assumes the simplest scheme with $\alpha_t = 1$ and β_t being constant throughout the period.

Then, the total government payoff throughout the evaluation period is formulated as follows:

$$\pi_G = -\gamma \sum_{t=T_0}^{T_e} C_t \exp[-r(t-T_0)] - \sum_{t=T_s}^{T_e} M_t \exp[-r(t-T_0)] + \sum_{t=T_e+1}^{T_z} (R_{ot} - C_t) \exp[-r(t-T_0)], \tag{2}$$

where π_G is the government's payoff during the evaluation period, C_t is the annual project cost in year t (construction cost in the first five years, and operation cost after that), T_0 is the first year of the evaluation period, T_s is the first year of the concession period, T_e is the last year of the concession period, T_z is the last year of the evaluation period, r is a discount rate for the government (risk-free rate), and γ is a given cost-sharing parameter. Note the evaluation period is longer than the concession period. The first term on the right hand of Eq. (2) indicates the upfront subsidy from the government. It is expected that the cost-sharing parameter γ is between 0 and 1. The second term means the total compensation paid by the government. The third term indicates the profit gained from the operation after the transfer from the concessionaire to the government. The revenue and cost are discounted using the discount rate to calculate the present value.

It should be noted that the concessionaire does not participate in the concession contract if its profit is negative. Thus, the following condition should be satisfied for a successful contract under the PARG program:

$$\pi_C = -(1-\gamma) \sum_{t=T_0}^{T_e} C_t \exp[-\bar{r}(t-T_0)] + \sum_{t=T_s}^{T_e} (R_{ot} + M_t) \exp[-\bar{r}(t-T_0)] \geq 0, \tag{3}$$

where π_C is the payoff of the concessionaire during the evaluation period. $\bar{r}$ is a discount rate for the concessionaire (risk-adjusted rate).

Model of the PCRG Program

The PCRG program allows the concessionaire to extend the concession period if its cumulative revenue does not reach the given guaranteed cumulative revenue (GCR) at the end of the predetermined concession period. There are three potential cases in this program. The first case is that the cumulative revenue reaches the given GCR before the end of the predetermined concession period (Case 1). In Case 1, the concessionaire operates until the end of the predetermined concession period and then transfers the operation to the government at the end of the predetermined concession period. The government operates the toll road during the post-concession period. Although, in practice, the concession is typically transferred as soon as the revenue reaches the given GCR, this paper assumes that the concessionaire keeps operating until the end of the concession period. This is because the possibility of early transfer cuts the upside expectation of the concessionaire, demotivating the concessionaire to participate in BOT projects, as pointed out by Vasallo (*2*). The second case is that the cumulative revenue does not reach the given GCR at the end of the predetermined concession period, but reaches the given GCR before the end of the evaluation period (Case 2). In Case 2, the operation will be transferred to the government when the cumulative revenue reaches the given revenue, even after an extension of the concession period. The final case is that the cumulative revenue does not reach the given GCR even at the end of the evaluation period (Case 3). In Case 3, the concessionaire keeps operating from the start year of the predetermined concession period until the end of the evaluation period.

Under the PCRG program, the total government payoff throughout the evaluation period is formulated as follows:

$$\pi_G = \begin{cases} -\gamma \sum_{t=T_0}^{T_e} C_t \exp[-r(t-T_0)] + \sum_{t=T_e+1}^{T_z} (R_{ot} - C_t) \exp[-r(t-T_0)] & \text{in Case 1} \\ -\gamma \sum_{t=T_0}^{T_x} C_t \exp[-r(t-T_0)] + \sum_{t=T_x+1}^{T_z} (R_{ot} - C_t) \exp[-r(t-T_0)] & \text{in Case 2} \\ -\gamma \sum_{t=T_0}^{T_z} C_t \exp[-r(t-T_0)] & \text{in Case 3} \end{cases} \quad , (4)$$

where T_x is the year when the cumulative revenue reaches the given GCR under the extension of concession period ($T_e < T_x < T_z$). This means that T_x satisfies the following:

$$\sum_{t=T_s}^{T_x-1} R_{ot} < \overline{R} \leq \sum_{t=T_s}^{T_x} R_{ot} \, , \tag{5}$$

where $\overline{R}$ is the given GCR. The first term on the right hand of Eq. (4) indicates the upfront subsidy from the government, and the second term is the profit gained from the operation during the post-concession period.

Again, it should be noted that the concessionaire does not participate in the concession contract if its profit is negative. Thus, the following condition should be satisfied for a successful contract under the PCRG program:

$$\pi_C = \begin{cases} -(1-\gamma) \sum_{t=T_0}^{T_e} C_t \exp[-\bar{r}(t-T_0)] + \sum_{t=T_s}^{T_e} R_{ot} \exp[-\bar{r}(t-T_0)] \geq 0 & \text{in Case 1} \\ -(1-\gamma) \sum_{t=T_0}^{T_x} C_t \exp[-\bar{r}(t-T_0)] + \sum_{t=T_s}^{T_x} R_{ot} \exp[-\bar{r}(t-T_0)] \geq 0 & \text{in Case 2} \\ -(1-\gamma) \sum_{t=T_0}^{T_z} C_t \exp[-\bar{r}(t-T_0)] + \sum_{t=T_s}^{T_z} R_{ot} \exp[-\bar{r}(t-T_0)] \geq 0 & \text{in Case 3} \end{cases} \tag{6}$$

Real Option Approach using Monte Carlo Simulation

In this section, the uncertainty of the annual toll road revenues is introduced into the above models. The Monte Carlo simulation is used to estimate the uncertain annual revenues. Then, the real option method is used to analyze the expected payoffs of the government and the concessionaire. This is because the real option approach can evaluate the non-linear payoffs in a project. It is expected that revenue guarantee programs, including the PARG and the PCRG, lead to non-linear payoffs in a project. This study follows the method proposed by Irwin (*5*), which is based on the real option approach using the Monte Carlo simulation. Irwin and Blank et al. applied this method to the evaluation of a hypothetical project under the PARG program (*5, 6*).

The method assumes that the observed annual revenue R_{ot} follows a geometric Brownian motion. This is formulated as follows:

$$R_{ot} = R_{ot-1} \left[\left(\mu - \frac{\sigma^2}{2} \right) + \sigma Z \right], \tag{7}$$

where μ is the annual rate at which the observed annual revenue is expected to grow, σ is the annual volatility of the observed annual revenue, and Z is a normally distributed random variable with a mean of 0 and a variance of 1. A set of computational simulation processes is composed of randomly drawing Z repeatedly from the normal distribution and then calculating R_{ot} sequentially from $t = T_0$ to $t = T_z$. Next, this set of computation simulation processes is repeated many times; in this study's case analysis, this is performed 10,000 times. Finally, the expected payoffs or the standard deviation of the payoffs is calculated on the basis of the simulated results of R_{ot}.

CASE STUDY

Project information and Analytical Assumptions

The method is applied to the case of the Calamba-Los Baños Expressway project, which is a potential candidate BOT project in the Philippines. This expressway would be a branch of an existing toll road, the South Luzon Expressway (SLEx), from Calamba to Los Baños via the Laguna de Bay area. According to CTI & MRI (*1*), this project aims to (i) support the tourism development of Los Baños and its nearby tourism spots; (ii) contribute to decongesting the national road; and (iii) serve as both an expressway and a flood control dike. Because the initial investment cost is very high against the expected revenue, it is generally expected that this project will show quite low profitability. Diaz (*7*) points out that the government is required to provide financial support to this project to ensure its successful management. This study uses cash flow data forecasted by the Japan Bank of International Cooperation shown in DPWH (*8*).

In the Philippines, PPP projects, including the one mentioned above, are regulated by the Build-Operation-Transfer Law, which was originally enacted to solve problems related to domestic electric power shortages in the 1990s. The Law empowers the government to take the initiative in project planning. It also requires a competitive bidding process, which should improve the performance and efficiency of project management. The Law regulates that 50% or less of the project cost can be paid through an upfront government subsidy. The project cost is defined as the initial investment cost plus the total operation cost during the concession period. This means that the cost-sharing parameter γ is equal to or less than 0.5.

The observed annual revenue of the first year of the evaluation period, namely R_{o1}, is assumed to follow the normal distribution with a mean of 51.60 million Philippine pesos (PHP) and a standard deviation of 13.4 million PHP. The mean is derived from the forecasted revenue in the first year (*8*), while the standard deviation follows Flybjerg et al. (*9*), who statistically revealed that the government would generate "natural error" in revenue forecasts in the first year. Next, the annual rate at which the observed annual revenue is expected to grow, μ in Eq. (7), is assumed equal to 9.3%, which is derived from DPWH (*8*), if the observed annual revenue is less than 173.2 million PHP; it is equal to 0 if the observed annual revenue is equal to or greater than 173.2 million PHP. This is because the revenue forecast shows that the annual revenue increases until it reaches 173.2 million PHP and plateaus after it reaches 173.2 million PHP. The annual volatility of the observed annual revenue, σ in Eq. (7), is assumed equal to 8.6%. This is calculated according to a logarithmic cash flow returns approach (*10*). The discount rate for the government, r, is assumed to be 4.4%, which is derived from the interest rate of bonds issued by the Philippines government as of April 2011. The discount rate for the concessionaire, $\bar{r}$, is assumed to be 7.5% on the basis of the empirical data in Diaz (*7*).

The revenue demand forecast was carried out in 2003, assuming the operation of the toll road started in 2010, and the concession period runs from 2010 to 2040. Thus, this analysis also assumes that the start year of the evaluation period, T_0, is 2003; the initial year of the predetermined concession period, T_s, is 2010; and the final year of the predetermined concession period, T_e, is 2040. Finally, the final year of the evaluation period, T_z, is assumed to be 2050. This means that the maximum extended period in the PCRG program is ten years.

Results

Table 1 shows the numerical example in one of the 10,000 cases. It includes the government's annual payoffs under the PARG program and the PCRG program by their component. This simulation case assumes that the cost-sharing parameter γ is equal to 0.3, the annual guarantee rate β is equal to 0.8, and the GCR is equal to 1,800 million PHP respectively. Note this case belongs to the Case 2 in Eq. (4). First, it shows the government annual payoffs under the PARG are the same as those under the PCRG program in 2004 to 2011. This is simply because this period is the construction stage. Second, under the PARG program, the government's annual payoffs are negative during the concession period from 2010 to 2040. This is because the government pays the compensations to the concessionaire every year. Third, under the PARG program, the government's annual payoffs are positive in 2041 to 2050. This is because the government earns the revenue from the toll-road operation after the right-to-operate over the toll road is transferred from the concessionaire. Finally, under the PCRG program, the government earns the positive payoff in 2045 to 2050. This is because the government starts the toll-road operation in 2045 since the cumulative revenue reaches the GCR in 2044.

Next, Figure 1 shows the expected government payoff $E(\pi_G)$ and the expected concessionaire payoff $E(\pi_C)$ versus the annual guarantee rate β under different cost-sharing parameters γ in the PARG program. The dotted curves indicate the situation where the concessionaire earns negative profit, whereas the solid curves indicate the situation where the concessionaire earns positive profit. First, Figure 1 shows that under a given cost-sharing parameter γ, higher annual guarantee rate β means higher guaranteed annual revenue R_{gt}; this leads to a lower expected government payoff. This is because the government is required to pay more compensation to the concessionaire as the annual guarantee rate increases. Second, when the cost-sharing parameter γ is equal to 0.4 or less, the project is financially unprofitable at any annual guarantee rate. It means that when the government pays 40% or less of the project cost, the concessionaire cannot earn positive profit even if the government guarantees 100% of annual revenue during the concession period. When the cost-sharing parameter γ is equal to 0.5, the project is financially viable if the annual guarantee rate is equal to or more than 0.75. It means that when the government pays 50% or the project cost, the concessionaire can earn positive profit if the government guarantees 75% or more of annual revenue during the concession period. When the cost-sharing parameter γ is equal to 0.6, the project is financially viable at any annual guarantee rate. It means when the government pays 60% of the project cost, the concessionaire can earn positive profit even if the government gives no guarantee in terms of annual revenue during the concession period. It should be noted that, in the context of the Philippines, the cost-sharing parameter γ cannot be over 0.5 because

TABLE 1 Numerical Example of a Simulation Case (in million PHP)

	PARG					PCRG			
Year	1st term in Eq. (2)	2nd term in Eq. (2)	3rd term in Eq. (2)	Expected government payoff	Expected government payoff (discounted)	1st term in Eq. (4)	2nd term in Eq. (4)	Expected government payoff	Expected government payoff (discounted)
2004	-2.85			-2.85	-2.73	-2.85		-2.85	-2.73
2005	-62.08			-62.08	-56.85	-62.08		-62.08	-56.85
2006	-115.96			-115.96	-101.62	-115.96		-115.96	-101.62
2007	-136.49			-136.49	-114.46	-136.49		-136.49	-114.46
2008	-162.87			-162.87	-130.70	-162.87		-162.87	-130.70
2009	-162.87			-162.87	-125.08	-162.87		-162.87	-125.08
2010	-95.42	-1.07		-96.49	-70.91	-95.42		-95.42	-70.12
2011	-0.99	-5.30		-6.29	-4.43	-0.99		-0.99	-0.70
2012	-0.99	-14.00		-15.00	-10.09	-0.99		-0.99	-0.67
2013	-0.99	-23.31		-24.30	-15.65	-0.99		-0.99	-0.64
2014	-0.99	-26.23		-27.22	-16.78	-0.99		-0.99	-0.61
2015	-0.99	-22.26		-23.25	-13.71	-0.99		-0.99	-0.59
2016	-0.99	-8.07		-9.06	-5.12	-0.99		-0.99	-0.56
2017	-0.99	-6.07		-7.07	-3.82	-0.99		-0.99	-0.54
2018	-0.99	-15.42		-16.42	-8.48	-0.99		-0.99	-0.51
2019	-0.99	-15.69		-16.69	-8.25	-0.99		-0.99	-0.49
2020	-0.99	-13.18		-14.17	-6.71	-0.99		-0.99	-0.47
2021	-0.99	0.00		-0.99	-0.45	-0.99		-0.99	-0.45
2022	-0.99	0.00		-0.99	-0.43	-0.99		-0.99	-0.43
2023	-0.99	0.00		-0.99	-0.41	-0.99		-0.99	-0.41
2024	-0.99	0.00		-0.99	-0.39	-0.99		-0.99	-0.39
2025	-0.99	0.00		-0.99	-0.38	-0.99		-0.99	-0.38
2026	-0.99	0.00		-0.99	-0.36	-0.99		-0.99	-0.36
2027	-0.99	0.00		-0.99	-0.35	-0.99		-0.99	-0.35
2028	-0.99	0.00		-0.99	-0.33	-0.99		-0.99	-0.33
2029	-0.99	0.00		-0.99	-0.32	-0.99		-0.99	-0.32
2030	-0.99	0.00		-0.99	-0.30	-0.99		-0.99	-0.30
2031	-0.99	0.00		-0.99	-0.29	-0.99		-0.99	-0.29
2032	-0.99	0.00		-0.99	-0.28	-0.99		-0.99	-0.28
2033	-0.99	0.00		-0.99	-0.27	-0.99		-0.99	-0.27
2034	-0.99	0.00		-0.99	-0.25	-0.99		-0.99	-0.25
2035	-0.99	-7.43		-8.42	-2.06	-0.99		-0.99	-0.24
2036	-0.99	0.00		-0.99	-0.23	-0.99		-0.99	-0.23
2037	-0.99	0.00		-0.99	-0.22	-0.99		-0.99	-0.22
2038	-0.99	0.00		-0.99	-0.21	-0.99		-0.99	-0.21
2039	-0.99	0.00		-0.99	-0.20	-0.99		-0.99	-0.20
2040	-0.99	0.00		-0.99	-0.19	-0.99		-0.99	-0.19
2041	-0.99		186.80	185.80	34.91	-0.99		-0.99	-0.19
2042	-0.99		188.77	187.77	33.76	-0.99		-0.99	-0.18
2043	-0.99		181.59	180.59	31.07	-0.99		-0.99	-0.17
2044	-0.99		171.02	170.03	27.99	-0.99		-0.99	-0.16
2045	-0.99		182.84	181.85	28.65	-0.99	182.84	181.85	28.65
2046	-0.99		183.14	182.15	27.46	-0.99	183.14	182.15	27.46
2047	-0.99		179.02	178.02	25.69	-0.99	179.02	178.02	25.69
2048	-0.99		182.15	181.16	25.01	-0.99	182.15	181.16	25.01
2049	-0.99		178.21	177.21	23.41	-0.99	178.21	177.21	23.41
2050	-0.99		178.02	177.03	22.38	-0.99	178.02	177.03	22.38

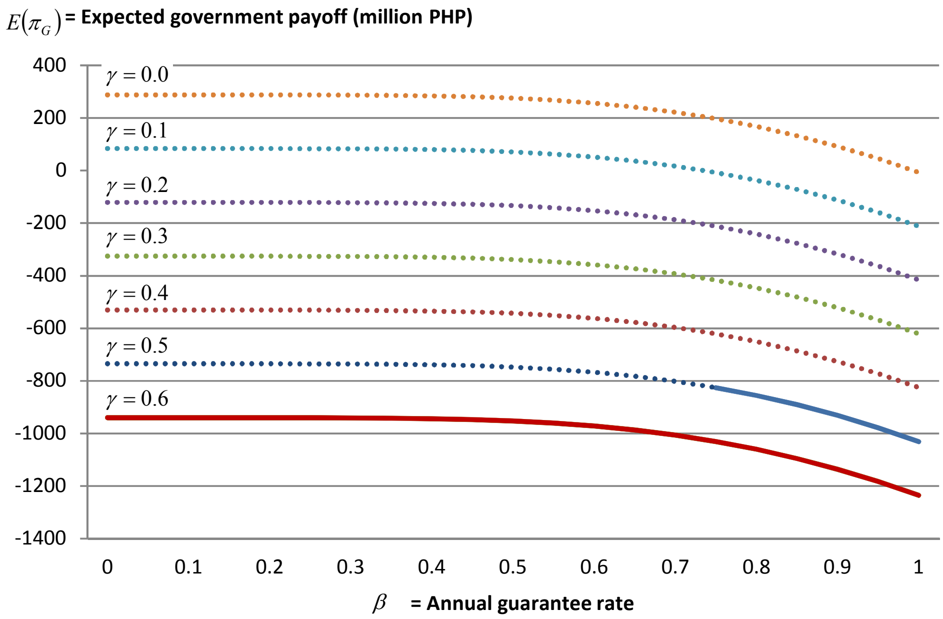

FIGURE 1 Expected government payoff versus annual guarantee rate under different cost-sharing parameters in the PARG program.

Note: The dotted curves indicate the situation where the concessionaire earns negative profit, whereas the solid curves indicate the situation where the concessionaire earns positive profit.

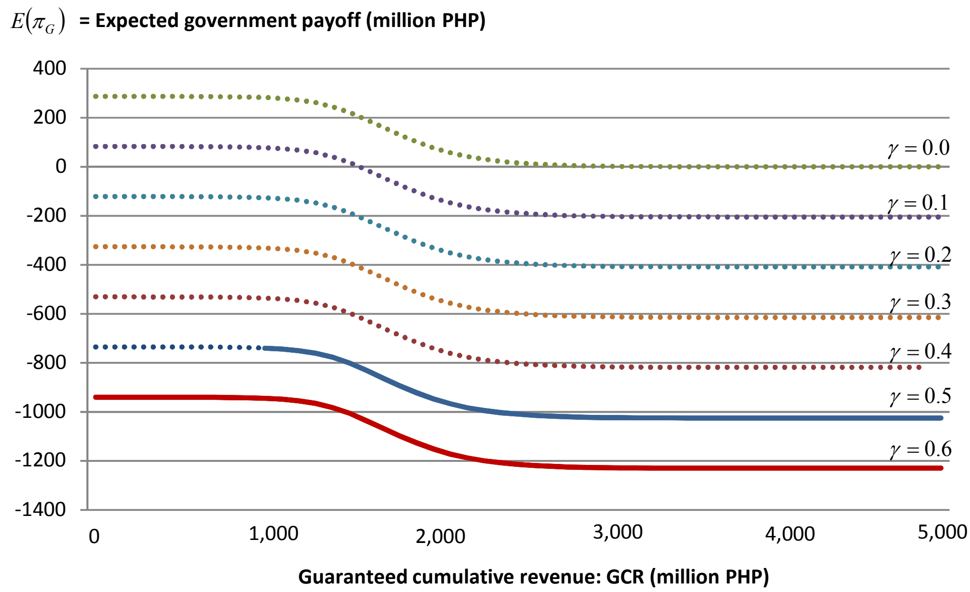

FIGURE 2 Expected government payoff versus guaranteed cumulative revenue (GCR) under different cost-sharing parameters in the PCRG program.

Note: The dotted curves indicate the situation where the concessionaire earns negative profit, whereas the solid curves indicate the situation where the concessionaire earns positive profit.

of the regulation by the Philippine BOT Law as mentioned above. Finally, as the cost-sharing parameter γ increases, the expected government payoff decreases. This is simply because the government should pay more of the project cost as the cost-sharing parameter γ increases. The expected government payoff is negative when the project is financially viable. This may support the results shown by Diaz (*7*).

Figure 2 shows the expected government payoff $E(\pi_G)$ versus the guaranteed cumulative revenue (GCR) $\overline{R}$ under different cost-sharing parameters γ. First, Figure 2 shows the expected government payoff is constant under the given cost-sharing parameter when the GCR is less than around 1,000 million PHP for any cost-sharing parameters γ. This is because the concessionaire reaches the GCR before the end of the predetermined concession period (Case 1). Under the given cost-sharing parameter, the expected government payoff is also constant when the GCR is more than roughly 2,800 million PHP for any cost-sharing parameters

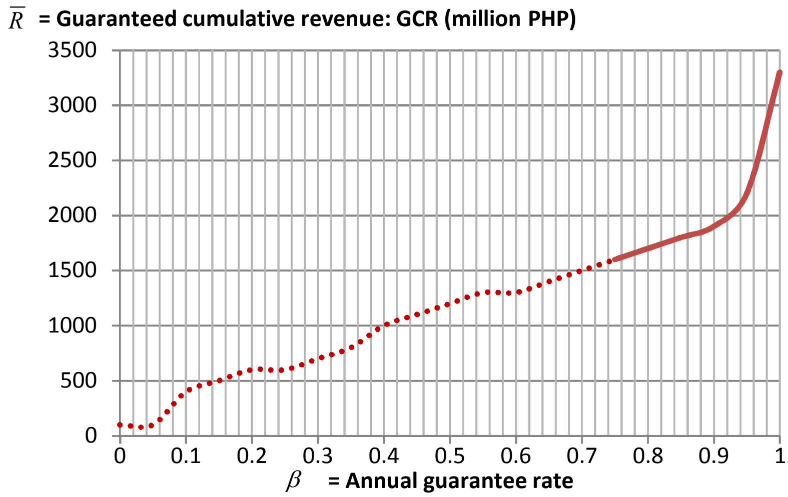

FIGURE 3 The curve of combinations of the annual guarantee rates and GCRs that lead to the same expected government payoff in the case of $\gamma = 0.5$

Note: The dotted part of the curve indicates that the project is not financially viable in either the PARG program or the PCRG program, whereas the solid part of the curve indicates that the project is financially viable in both the PARG and PCRG programs.

γ. This is because the concessionaire cannot reach the GCR at the end of the evaluation period (Case 3); this leads to zero profit from the toll operation during the post-concession period. Second, when the cost-sharing parameter γ is equal to 0.4 or less, the project is financially unviable at any GCR. It means that when the government pays 40% or less of the project cost, the concessionaire cannot earn positive profit even if the government gives a 5,000 million PHP guarantee limit. When the cost-sharing parameter γ is equal to 0.5, the project is financially viable if the GCR is equal to or more than approximately 1,000 million PHP. This means that when the government pays 50% of the project cost, the concessionaire can earn positive profit if the government gives a limit more than 1,000 million PHP. When the cost-sharing parameter γ is equal to 0.6, the project is financially viable at any GCR. This means that when the government pays 60% of the project cost, the concessionaire can earn positive profit even if the government has established no guarantee limit. Finally, as the cost-sharing parameter γ increases, the expected government payoff decreases. This is because the government should pay more of the project cost as the cost-sharing parameter increases. The expected government payoff is negative when the project is financially viable. Again, this may support the results shown by Diaz (*7*).

Figure 3 shows a curve that indicates the combinations of the annual guarantee rates β and the guaranteed cumulative revenues (GCRs) $\overline{R}$ that lead to the same expected government payoff in the case that the given cost-sharing parameter γ is equal to 0.5. Note that the curve shows the approximated results because the simulation inputs the discrete β and $\overline{R}$ for analytical simplicity. The dotted part of the curve indicates that the project is not financially viable in either the PARG program or the PCRG program, whereas the solid part of the curve indicates that the project is financially viable in both the PARG and PCRG programs. The financial viability of the project is positive only when the annual guarantee rate β is greater than 0.75, or GCR is greater than approximately 1,500 million PHP. The slope of the curve becomes steeper when the annual guarantee rate β is greater than 0.90. This means that the marginal increase of the annual guarantee rate β results in more expected government payoff than the marginal increase of the GCR.

DISCUSSION

Under the PARG program, the increase of annual guarantee rate causes more government compensation, which results in a lower government payoff. Under the PCRG program, the increase of GCR causes shorter government operation, which also results in a lower government payoff. Thus, the expected government payoff in the PARG program is equivalent to that in the PCRG program under a specific condition. In the above case study, this condition occurs when the annual guarantee rate β is higher than 0.75 when the cost-sharing parameter γ is equal to 0.5. This condition is derived from the analysis of financial viability of the project.

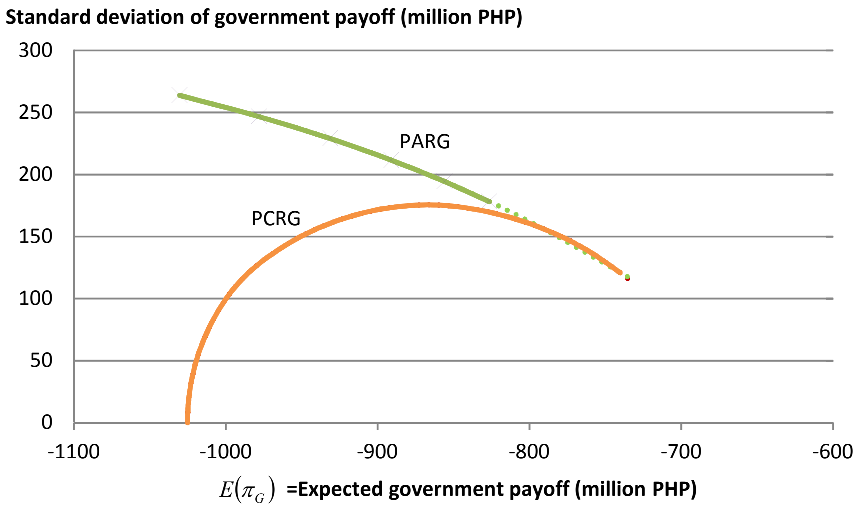

FIGURE 4 The expected government payoff versus the standard deviation of government payoff under the PARG and PCRG program in the case of $\gamma = 0.5$.

Note: The dotted curve indicates the situation where the concessionaire earns negative profit, whereas the solid curve indicates the situation where the concessionaire earns positive profit.

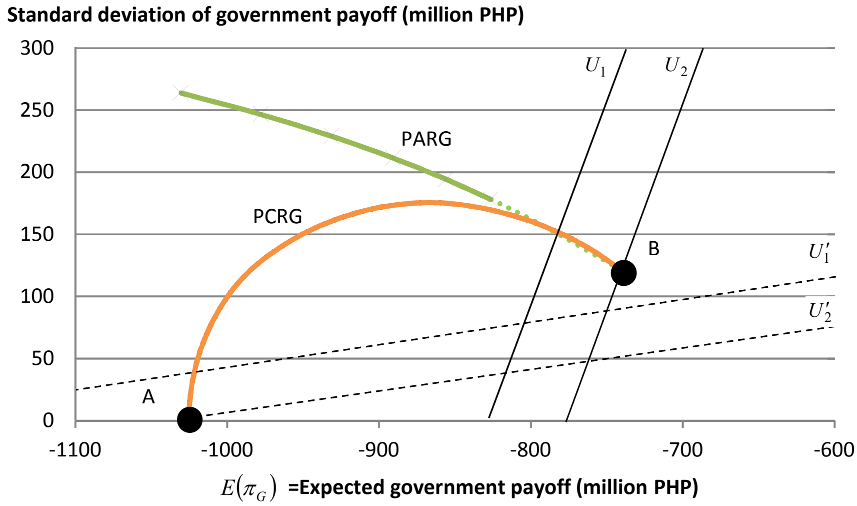

FIGURE 5 Return-risk relationships with positive financial viability and government iso-utility curves.

This means that the two programs are equivalent with respect to the expected government payoff under the project-viability condition. In order to examine which program is preferable, it may be necessary to introduce other criteria than the expected government payoff. One possible idea is to account for the government's risk in addition to its expected payoff. In general, it is considered that the government prefers the program with a higher payoff and a lower risk. Let us assume that the government's risk is defined as the standard deviation of the government payoffs. Then, the standard deviation of the simulated government payoffs can be calculated empirically in the above case study. Figure 4 shows the expected government payoff versus the standard deviation of the government payoff under the PARG program and the PCRG program in the case of γ =0.5. The dotted curve indicates the financially unviable case, whereas the solid curve indicates the financially viable case. In Figure 4, the J-shaped curve that peaks at about –880 million PHP is the result of the PCRG program, whereas the downward linear-like curve is the results of the PARG program.

The curve in the PARG program is situated higher than the curve in the PCRG program. This means that under the given expected government payoff and the given cost-sharing parameter, the PCRG program has lower risk than the PARG program. The analysis also indicates that the simple reduction of risk does not necessarily mean that government expected payoff will increase.

The optimal solution is apparently dependent on the preference or utility function of the government. Suppose the government determines the cost-sharing parameter γ to find the optimal solution. Figure 5 shows two hypothetical cases where the iso-utility curves of the government and the curves of return-risk relationship with positive financial viability are drawn. The first case is one in which the slope of the iso-utility curves—U_1, U_2—is higher. Conversely, the second case is one in which the slope of the iso-utility curves—U_1', U_2'—is lower. The slope implies the marginal substitution of the return (expected government payoff) to the risk (standard deviation of government payoff). It should be noted that $U_1 < U_2$, whereas $U_1' < U_2'$. This shows Point B is most preferable program in the first case, whereas Point A is the most preferable program in the second case. However, in this case analysis, the PCRG program is always preferred to the PARG program because the PCRG program has a lower risk and a higher expected payoff at the optimal solution than the PARG program does.

CONCLUSIONS

This study proposed a method to compare the PARG program with the PCRG program in a given BOT project using the real option approach with Monte Carlo simulation and applied to the case of a toll road in the Philippines. The annual guarantee rate in the PARG program and the GCR in the PCRG program that led to the same expected government payoff were calculated. The results showed the condition of the annual guarantee rate in the PARG program and the guaranteed cumulative revenue in PCRG program in which the two programs are equivalent with respect to the expected revenue. Then, these programs were evaluated with respect to project return and risk of the government. For the analyzed project, the results showed that the PCRG program would be preferred to the PARG program. However, the optimal solution depends on the utility function of the government. It is indicated that the simple reduction of risk does not necessarily mean that government expected payoff will increase. It is expected that this method contributes to the proper decisions made by the governments with respect to the choice of a revenue guarantee mechanism in BOT projects.

Although this study has implications for BOT projects using a revenue guarantee program, the following issues should be addressed in future research. First, the simulation was implemented with limited cases of discrete input with respect to the cost-sharing parameter, the annual guarantee rate, and the GCR. A simulation with more input values should be performed to achieve results that are more general and sophisticated. Second, other program evaluation criteria should be explored. Although this study assumed the government would choose a revenue guarantee program based on the risk and return from the project, in reality they should consider other factors such as the impact to social welfare. Third, although the simulation assumed a single discount rate for the concessionaire, it should vary among the revenue guarantee programs because the risk premium generally depends on the capital structure. More sophisticated simulation is required to incorporate the influence of the variation of the discount rates. Fourth, risks other than demand-oriented risk in a BOT project should be examined. They may include cost-oriented risks, political risks, and institutional risks. A program evaluation method under multiple risks should be also developed. Finally, further empirical study is needed on how the decision makers in government actually perceive the trading off of return, risk, and other factors such as the level of government participation.

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REFERENCES

1. CTI Engineering International Co., Ltd. and Mitsubishi Research Institute, Inc. *Preparatory Survey for Public-Private Partnership (PPP) Infrastructure Development Projects in the Republic of the Philippines*. Report prepared for the Japan International Cooperation Agency (JICA), National Economic Development Authority (NEDA), and Department of Public Works and Highways (DPWH), 2010.
2. Vassallo, J. M. Why Traffic Forecasts in PPP Contracts are Often Overestimated? In *EIB University Research Sponsorship Program*, EIB Luxembourg, 2007.
3. Lemos, T., D. Eaton, M. Betts, and L. Tadeu de Almeida. Risk Management in the Lusoponte Concession: A Case Study of the Two Bridges in Lisbon, Portugal. *International Journal of Project Management*, Vol. 22, 2004, pp. 63–73.
4. Wilkinson, R. Severn Crossings Tolls. *National Assembly for Wales Paper*, 2010, No.10/059.
5. Irwin, T. Public Money for Private Infrastructure: Deciding When to Offer Guarantees, Output-based Subsidies and Other Fiscal Support. *World Bank Working Paper*, 2003, No.10.
6. Blank, F. F., T. K. N. Baidya, and M. A. G. Dias. Real Options in Public Private Partnership: Case of a Toll Road Concession. Presented at the Real Options Group of the 15th Annual International Conference, Turku (Finland), June 2009.

7. Diaz, C. E. D. A Method for Determining the Viability of Public-Private Partnerships for Toll Road Projects in the Philippines. *Journal of the Eastern Asia Society for Transportation Studies*, Vol.8, 2010, pp. 174–186.
8. DPWH. *JBIC Special Assistance for Project Formation (SAPROF) for Road Network Capacity Expansion (Bypass) Project*, Vol. 1, 2003.
9. Flyvbjerg, B., M. Holm, and S. Buhl. How (In)accurate are Demand Forecasts in Public Works Projects? *Journal of American Planning Association*, Vol.71, No.2, 2005, pp. 131–146.
10. Mun, J. *Real Options Analysis: Tools and Techniques for Valuing Strategic Investments and Decisions*, 2nd edition. Hoboken, NJ: John Wiley & Sons, Inc., 2005.