The Risk Analysis of BOT Projects

***Borliang Chen*[1], *H. C. Shiong*[2]**

ABSTRACT

The debt ratio is a crucial issue for the financial feasibility of BOT projects. Both the project initiators and the debt providers will consider the project nature and conduct a detailed financial analysis to determine the debt ratio. Most of cases, they will set up some hurdle rates for the profitability indices of the BOT projects to ensure the projects' success. Six most common profitability indices are NPV, IRR, DSCR, TIE, ROA, and ROE. A Project Financial Evaluation Model (PFEM) is established to calculate the project's profitability indices and then to determine the optimal capital structure.

PFEM uses the linear programming approach to calculate the debt ratio and equity ratio in the model. Hence, PFEM may evaluate the range of the hurdle rates of profitability indices on the debt ratio of the project in a sensitivity analysis as well. A completed sensitivity analysis includes dual price analysis, slack analysis, and some other sensitivity analysis.

A Turkey water power plant project is used as an empirical study of PFEM model. The results show that the range of the optimal capital structure is between 26.69%~33.04% with the given hurdle rates of profitability indices. In case of maximizing the object function, such as NPV, IRR, and ROE, the hurdle rate of ROE is the critical resource in the optimization analysis. On the other hand, in case of maximizing the object function, such as DSCR, TIE, and ROA, the hurdle rate of ROA is the critical resources in the optimization analysis.

Keywords: profitability indices, hurdle rate, BOT, optimal capital structure, linear programming

INTRODUCTION

The financial analysis is essential in feasibility analysis of BOT projects. Bakatjan et al(2003) and Zhang (2005) proposed a financial feasibility analysis model for BOT projects. A revision of above mentioned models is derived to calculate the profitability indices of the BOT projects. Six most common profitability indices are NPV, IRR, DSCR, TIE, ROA, and ROE. A Project Financial Evaluation Model (PFEM) is established to calculate the project's profitability indices. Then, we start a further study to determine the optimal capital structure with these profitability indices. The optimum capital structure of a BOT project is always a major concern to both loan providers and stock holders. The optimal capital structure is the

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[1] *Associate Professor, Department of Civil Engineering, National United University, Miaoli, Taiwan 360.*

[2] *Lecturer, Department of Civil Engineering, National United University, Miaoli, Taiwan 360.*

ratio between debt and equity which makes the project value become optimum. Some studies show that the debt ratio, a ratio between debt and total investment, or the equity ratio, a ratio between equity and total investment are critical financial variables.

The hurdle rates of profitability indices are given as criteria for determination of project feasibility. In additional, the hurdle rates of profitability indices would affect the optimal capital structure dramatically. Bakatjan (2003) recommends a linear programming approach to determine the optimal capital structure. Right selection of optimal capital structure could improve the financial feasibility of BOT projects. That is right value of debt ratio could enhance the value of profitability indices of the BOT projects. It also provides a foundation of agreement negotiation among the agency, loan providers, and the project company.

MODELING

Regressions analysis and linear programming are required in the analysis of optimal capital structure of BOT projects. We conduct the regression between the equity ratio and every profitability indices. These regressions provide as objective functions or constraint functions in linear programming analysis.

- The regression analysis

The regression analysis is to establish the relationship between independent variable, X, and dependent variable, Y.

$$y = f(x) = \beta_0 + \beta_1 x \qquad (1)$$

It is a simple regression in equation (1). We apply the simple regression to establish the linear relationship between equity ratio and profitability indices. The following is an illustration of the profitability index IRR and the equity ratio γ.

$$IRR = Y = a*\gamma + b \qquad (2)$$

- The analysis of linear programming

The standard form of linear programming model, sometimes referred to as the canonical form, is written as

$$\begin{aligned} &\text{Min } Z' = B1Y1 + B2Y2 + \ldots\ldots + BmYm \\ &\text{s.t.} \\ &A11Y1 + A12Y2 + \ldots\ldots + Am1Ym \geqq C1 \\ &A12Y1 + A22Y2 + \ldots\ldots + Am2Ym \geqq C2 \\ &\quad \vdots \\ &A1nY1 + A2nY2 + \ldots\ldots + AmnYm \geqq Cn \end{aligned} \qquad (3)$$

Ci (i=1, n) in equation (3) are resources aviable for this project. In the analysis of this paper, constrain functions are profitability indices and the values of Ci are the hurdle rates of the profitability indices. In equation (3), we show the case of finding the minimum objective function. And, the equation (4) is the case of finding the maximum objective function.

$$
\begin{aligned}
&\text{Max } Z = C1X1 + C2X2 + \ldots\ldots + CnXn \\
&\text{s.t.} \\
&A11X1 + A12X2 + \ldots\ldots + A1nXn \leqq B1 \\
&A21X1 + A22X2 + \ldots\ldots + A2nXn \leqq B2 \\
&\quad \vdots \qquad\qquad\qquad \vdots \\
&Am1X1 + Am2X2 + \ldots\ldots + AmnXn \leqq Bm \text{ ;}
\end{aligned} \tag{4}
$$

Bi (i=1,m) are the hurdle rate of profitability indices. This study aims to analyze the effects of the setting on the hurdle rates of profitability indices on the solution of the equity ratio γ. With the calculated equity ratio, we can then calculate the optimal capital structure (OCS) as in the following equation (5).

$$OCS = \frac{\gamma}{1-\gamma} \tag{5}$$

The commercial computer package LINGO is used for the sensitivity analysis of linear programming.

EMPIRICAL STUDY

The case of a water power plant at Turkey is to illustrate as an empirical study of this paper. The PFEM is used to generate the profitability indices with various equity ratios. PFEM is a revision of Bakatjan (2003) models.

Input parameters

Input parameters of the BOT project of water power plant are shown as Table 1.

Table1 、Financial parameters of case study

Parameters	Value	Remarks
1. Construction Cost		
Cost of Civil Work	$95,370,000	
Cost of E&M	$26,333,000	
Interface Cost	$3,092,000	10% of the cost of civil works, 5% of E&M cost
Additional Cost	$7,770,000	
Total (BC)	$132,565,000	
2. Construction progress		
First year	$16,571,000	Construction progress =12.5%
Second year	$36,455,000	Construction progress =27.5%
Third year	$39,770,000	Construction progress =30.0%
Fourth year	$39,770,000	Construction progress =30.0%
Total (BC)	$132,565,000	
3. Average unit price of electricity （Uav）	4.75 Cents/KW.h	。
4. Annual operation & maintainers cost	$790,000	3% of E&M cost
5. Loan conditions		

Loan interest rate(r)	10%	
Repayment period	10 years	
Grace period	4 years	
Operation period	20 years	
Inflation rate (θk)	4.1%	

With the PFEM models, we conduct a series of simulation to obtain the profitability indices of the power plant project with various equity ratios. The equity ratio varies from 0% to 100%.

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Results

In the analysis, we adopt γ=0%~60%. The equity ratio is shown in linear relation in this range. This makes the simple regression becomes plausible. The R^2 of regressions are very well and shown in table (2).

Table2、Regression of the profitability indices with the equity ratio

Index	Regression equation	R^2
NPV	Y = -74.18992488 * γ + 2990.168574	1
IRR	Y = -0.0003607832573 * γ+ 0.1552685255	0.94504
DSCR	Y = 0.02928263752 *γ + 1.051130822	0.94394
TIE	Y = 0.07777466672 *γ + 2.347641524	0.94394
ROA	Y = 0.0007367723496 * γ+ 0.04033733386	0.99919
ROE	Y = -0.0007554072272 *γ + 0.1699576679	0.94066

The hurdle rates of profitability indices are set in table (3). The equations in table (3) are to serve as objective functions or constrain functions in linear programming analysis. The hurdle rates of profitability indices are given in advance. These values are subjects to change depend on the needs of participants of BOT projects.

Table3、The hurdle rate of the profitability indices

Index	Regression equation	Hurdle Rate
NPV	Y = -74.18992488 *γ + 2990.168574	≧0
IRR	Y = -0.0003607832573 *γ+ 0.1552685255	≧14%
DSCR	Y = 0.02928263752 *γ + 1.051130822	≧1.5
TIE	Y = 0.07777466672 * γ + 2.347641524	≧2
ROA	Y = 0.0007367723496 * γ + 0.04033733386	≧6%
ROE	Y = -0.0007554072272 *γ + 0.1699576679	≧14.5%

To minimize the objective function is considered first. Minimizing the object functions represents that the minimum profitability index the BOT project could obtain in economy sense. With different objective functions, the equity ratios are calculated and at the meantime the critical hurdle rates of profitability indices are located. The results are shown in

Table (4). There are two values of equity ratio in this analysis, which are 33.04% and 26.69%. The critical hurdle rates of profitability indices are ROE and ROA.

Table4、The optimal equity ratios by minimizing the profitability indices

Object Function Min	objective value	Value γ	Dual Price≠0	
Min NPV	539.0304	33.03869	-98211.83	ROE
Min IRR	0.1433487	33.03869	-0.4776010	ROE
Min DSCR	1.832613	26.68757	-39.74448	ROA
Min TIE	4.423259	26.68757	-105.5613	ROA
Min ROA	0.06	26.68757	-1	ROA
Min ROE	0.145	33.03869	-1	ROE

To maximize the objective function is considered next. Maximizing the object functions represents that the maximum profitability index the BOT project could obtain in economy sense. With different objective functions, the equity ratios are calculated and at the meantime the critical hurdle rates of profitability indices are located. The results are shown in Table (5). There are two values of equity ratio in this analysis, which are 33.04% and 26.69%. The critical hurdle rates of profitability indices are ROE and ROA. We find an interesting phenomena that no matter the maximum or minimum the objective function the results are very the same.

Table5、The optimal equity ratios by maximizing the profitability indices

Object Function Max	objective value	Value γ	Dual Price≠0	
Max NPV	1010.22	26.688	-100695	ROA
Max IRR	0.146	26.688	-0.490	ROA
Max DSCR	2.019	33.039	-38.764	ROE
Max TIE	4.917	33.039	-102.957	ROE
Max ROA	0.065	33.039	-0.9753	ROE
Max ROE	0.150	26.688	-1.0253	ROA

Finally, we conduct the sensitivity analysis of linear programming by using the LINGO software. Similar results are found that the hurdle rates of ROA and ROE are critical in determining the value of objective function and the corresponding equity ratios.

Table6、The sensitivity analysis of optimal equity ratios by minimizing the profitability indices

Object Function Min	Dual Price≠0	Critical Index	Current RHS	Allowable Increase	Allowable Decrease
Min NPV	-98211.83	AROE	-0.024958	0.004798	0.005488
Min IRR	-0.4776010	AROE	-0.024958	0.004798	0.005488
Min DSCR	-39.74448	AROA	0.019663	0.004679	0.008369

Min TIE	-105.5613	AROA	0.019663	0.004679	0.008369
Min ROA	-1	AROA	0.019663	0.004679	0.008369
Min ROE	-1	AROE	-0.024958	0.004798	0.005488

The results are rearranged to calculate the optimal capital structure of the project by equation (5).

Table7、The optimal capital structure by minimizing the profitability indices

Object Function Min	Equity Ratio	Optimal Capital Structure	Critical Index
Min NPV	33.03869	0.4934	ROE
Min IRR	33.03869	0.4934	ROE
Min DSCR	26.68757	0.3640	ROA
Min TIE	26.68757	0.3640	ROA
Min ROA	26.68757	0.3640	ROA
Min ROE	33.03869	0.4934	ROE

CONCLUSIONS

It is better to find the equity ratio with maximizing the objective function. The project company requires to maximum profit of the project. However, the equity ratio calculated with minimizing the objective function could be regarded as the minimum profit of the projects. Therefore, the results of this approach are more conservative to loan providers and the project company. Hence, there are two ways to solve for the equity ratio. The equity ratio is 26.89% in maximizing the objective function. The equity ratio becomes 33.04% in minimizing the objective function. It would be better using the minimizing the object function in economy sense. And, these results are more conservative to participants of the project.

The regressions for equity ratios with the profitability indices show the high goodness of fit. R^2 of the regressions is more than 0.9. This implies that the equity ratio is a good explanation variable to predict the profitability indices.

A sensitivity analysis is conducted to study the sensitivity of the hurdle rates of profitability indices. The dual price of minimum IRR is -0.4776. In case that the hurdle rate of ROA is greater than 0, it will not affect the results. Hence, ROA is not sensitive in this analysis. The hurdle rate of ROE is critical in this study. With the setting of the hurdle rates of profitability indices in Table (3), the hurdle rate of ROE ≥ 14.5% determines the value of the equity ratio=33.04% and the optimal capital structure=0.4934 of the project.

In general, the financial analysis of BOT projects would choose the capital structure as 3/7=0.4286. With the analysis in this paper, it is concluded that this project should have 33.04% of total funding. This means that the project company should raise more funds from the stock holders. 3% of total funds is equal to 3%*$132,565,000=3,976,950. This analysis recommend that the stock holders should invest 4 more million US$ for this project.

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