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Optimal Financing Mix of Financially Non-Viable Private-Participation Investment Project with Initial Subsidy

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Governments with limited fiscal budgets tend to encourage private sector participation in building economic and social infrastructure to meet the economic growth or social welfare through Private-participation (PPI) schemes. However, since large projects may be financially non-viable despite their net economic benefits for the society, host governments may choose to subsidize a portion of the initial cost to create financial feasibility for private participation so as to realize the expected net economic benefits.

The private partners in a pure private-financed PPI scheme are expected to finance the original investment cost and recover it, with an acceptable return to compensate the project risk, from operating benefits under terms and conditions given in the concession agreement. The financial structure, that is, the financing mix between equity and debt, of the project determines the cost of capital and the value of the underlying project. An optimal financial structure minimizes the cost of capital and in turn, maximizes the project worth.

Scientific problem – the government's role in PPI-led projects changes the traditional capital structure model in financial management, which includes only the financing mix of owners' equity and debt. It is necessary to develop a model into which the government's financial support is incorporated to identify the optimal financial structure of PPI projects.

This paper develops a linear programming model based on discounted cash flow to determine the optimal financing mix of the project given governmental initial subsidy for non-financially viable PPI projects. The model takes a two-stage approach: first, a debt-free cash flow is developed to determine the government's initial subsidy; then, the optimal financing mix is determined based on the government's subsidy. We apply the proposed model to the Taiwan West Corridor High-Speed Railway project as an example. The results provide guidance for public-private negotiations.

Scientific novelty – a linear programming model built on discounted cash flow is proposed to determine the optimal capital structure for non-financially viable PPI projects with government subsidy.

The aim of this research – to develop a model into which the government's role in PPI projects is incorporated to determine the optimal capital structure. The results provide guidance to the public-private negotiations.

The object of the research – non-financially viable PPI projects, taking Taiwan West Corridor High-Speed Railway Project as the example.

The method of the research – a linear programming model built on discounted cash flow is used to find the optimal solution for multi-objective decisions.

Keywords: *PPI, subsidy, optimal capital structure, discounted cash-flow model, linear programming.*

Introduction

Private-participation investment (PPI), alternatively named public-private partnerships (PPPs) or build-operate -transfer (BOT) schemes are public- infrastructure projects that employ a particular form of structured financing from private sector (Adefulu, 1999; Skietrys *et al*., 2008; Wibowo, 2006). PPI schemes involve private participation in various forms including BOT, build, operate and own (BOO), build, operate, own and transfer (BOOT), build, transfer and operate (BTO), build and transfer (BT), reconstruct, operate and transfer (ROT), and operate and transfer (OT). Governments with limited fiscal budgets tend to encourage private sector participation in building infrastructure to meet the economic growth or social

welfare needs through PPI arrangements. Currently, PPI schemes can be found in 130 low- and middle-income countries covering projects in the energy, telecommunications, transport, and water and sewerage sectors. Investment commitments to infrastructure projects with private participation have been increasing in both developed and developing countries (Engel *et al.,* 2006; The World Bank, 2011).

Whether funds originate from public or private sectors, governments play a dominant role in such projects, to ensure that the projects comply with their efficiency requirements for use of national resources. The economic feasibility of any project is more critical than its financial feasibility (UNIDO, 1996). For projects that are economically feasible but financially non-viable, governments typically offer financial assistance in the form of guarantees, subsidies and other forms of aid (Kumaraswamy & Zhang, 2001; Wibowo & Kochendorfer, 2005) to enhance their financial viability (UNIDO, 1996; OECD, 2007; Asian Development Bank, 2008). For example, after the enhancement of the Private Capital Inducement Promotion Act in 1994, the Korean government's subsidy contributed 25.5 percent of the 3,400 billion won BOT projects, of which equity investment and debt financing comprised 53.6 percent and 20.9 percent respectively, in 2002 (UM, Dinghem, 2005). Similarly, in Taiwan, the Act for Promotion of Private Participation in Infrastructure Projects authorizes the government to provide subsidies of up to half of BOT project's initial investment. Prior BOT guidelines and research have rationalized the need for government subsidies to increase financial feasibility (Kumaraswamy & Zhang, 2001; Wibowo & Kochendorfer, 2005; Zheng & Tiong, 2011), proposed evaluation approach for projects with construction cost subsidy (Chen & Subprasom, 2007), or studied the forms of government assistance and subsidy (Adefulu, 1999). However, neither PPI related guidelines nor research articles have provided suggestions concerning how the project's optimal capital structure is determined given financial support from the government.

The private partners in a pure private-financed PPI scheme are expected to finance the original investment cost and recover it, with an acceptable return to compensate the project risk, from operating benefits under terms and conditions given in the concession agreement. The financial structure, (i.e., the financing mix between equity and debt) of the project determines the cost of capital and the value of the underlying projects. An optimal financial structure minimizes the cost of capital and in turn, maximizes the project worth.

However, the government's role in PPI-led projects changes the traditional capital structure model in financial management, which includes only the financing mix of owners' equity and debt. This research aims to incorporate the government's role into the financial model to identify the optimal financing mix for PPI projects with initial subsidy. Provided that all other financial terms and conditions are given, two parameters in the financing mix have to be determined: the minimum subsidy for financial viability and the debt ratio that maximizes the project value. These objectives are subject to project feasibility and credibility, which is an optimization problem with constraints.

This paper proposes a linear programming model combined with sensitivity analysis based on discounted cash flow to determine the optimal financing mix of the project given governmental initial subsidy for non-financially viable PPI projects. The model takes a two-stage approach: first, a debt-free cash flow is developed to determine the government's initial subsidy; then, the optimal financing mix is determined given the government's subsidy. We apply the proposed approach to the Taiwan West Corridor High-Speed Railway project as an example. At the first stage, a debt-free cash flow based on a set of assumed financial variables is developed as the base case. Sensitivity analysis is used subsequently to generate samples consisting of various sets of the financial variables and the associated outcomes. These samples are used in the first linear programming model to determine the minimum subsidy requirement that satisfies financial viability. At the second stage, a new cash flow given the government subsidy is developed. Samples generated from the sensitivity analysis from the base case are used to formulate the second programming model to determine the optimal financing mix that maximizes the project value. The results provide guidance for public-private negotiations.

The Rationale for subsidized PPI schemes

Infrastructure is traditionally provided by the government for free public use so the concept of ''user pays'' takes time to be fully accepted by the general public, particularly when the service provided by the private sector, which does not get government subsidies typically costs more than that provided by governmental agencies, which do (Kumaraswamy & Zhang, 2001). Large-scale BOT projects often require large sunk investments that take a long time to recover. In addition to the problems of sunk costs, such projects are generally more closely associated with cost overruns, uncertain economic viability, and social and environmental risks than with high profitability.

Direct or indirect government subsidies are commonly used to reduce the downside of the financial failure of a high-risk investment to make projects attractive (White, 2001). Typical subsidies include preferential tax treatment, investment grants, equity or subordinated debt contributions for which governments do not expect commercial returns, land grants, public financing of social and environmental mitigation measures, and application of state controls that restrict competition (Adefulu, 1999).

Forms of assistances or subsidies that governments offer to PPI projects that lack self-liquidation capabilities commonly take one of four forms: (1) minimum revenue guarantee (Ashuri *et al.,* 2012) or indirect guarantees with which government-run businesses sign off-take agreements with private businesses to ensure minimum purchase of their production if revenue falls under a certain level; (2) funding based on existing asset yields, such as the

Bangkok Second-Stage Expressway Project, where the Thai government proportionally distributes tolls collected from the first-stage expressway to the concession company (UNIDO, 1996); (3) providing land and bearing construction costs for access roads, such as the initial development of Hong Kong Disneyland, nearly half of the land for which was provided by the PRC government (Esty, 2001); (4) take-or-pay agreements, such as in the Sydney Harbour Tunnel Project, wherein the Australian government signed a take-or-pay agreement with the concession company to guarantee minimum traffic for the tunnel (UNIDO, 1996). These government subsidies improved financial viability of their projects, enabling them to realize the projects' economic benefits through private participation.

Zheng & Tiong (2010) study the Wastewater Treatment Project in Taiwan as case study and indicate that government's credit worthiness and subsidies are key factors that ensure the success of subsidized BOT projects. However, lower subsidies than required might be not sufficient to encourage private sector participation in the BOT project while higher subsidies might discourage private investors and financiers from seeking management efficiency (Mouraviev *et al.*, 2012). Liou *et al*., (2012) propose a model that accesses the relationship between project viability with project risk and government subsidy. The question is when and how much the subsidy should be.

Cost and benefit analysis is widely used to assess the feasibility of development projects (Diez, 1992; White House Office of Management and Budgeting, 1992; Asian Development Bank, 1997; Harburger, 1997; Overseas Development Administration, 1997; Belli *et al.,* 1998; European Commission, 2002; 2006; Canadian Treasury Board, 2007). Economic cost and benefit analysis and financial analysis, both of which use net present value (NPV) and internal rate of return (IRR) to indicate the viability of the project, are conceptually different. Financial analysis, which takes the viewpoint of the project owner, accounts for accounting revenues, expenditures, and expenses on the financial cash flow. Alternatively, economic analysis recognizes external benefit and cost generated by the project but excluding transfer payments that do not involve resource deployment, such as taxes and duties, interest expenses, and subsidies (Diez, 1992; Asian Development Bank, 1997; Belli *et al.*; 1998; European Commission, 2006; Canadian Treasury Board, 2007). The economic benefit and cost of a project may be markedly different from its financial benefit and cost. For example, the financial benefit of a transportation project is tariff revenues collected from the users, but its economic benefit consists of cost savings enjoyed by the beneficiaries. Since financing activities are transfer payments and are excluded from the economic benefit and cost, the financing plan of a project can be examined independently, given that the economic feasibility is satisfied.

Take toll road project as an example (Table 1). In the tax-financing scheme, the government is responsible for the investment and operating expenditures/expenses to generate economic benefits (EB) to road users on one hand. On the other hand, the government receives net toll earnings (NTE), which is toll fees collected from users, netting from operating expenses, and additional tax revenues ($\Delta GDP \times T$) generated from the increased gross domestic products (GDP) driven by the new road. The project is economically viable if EB > (I + operating expenses). If $NTE+\Delta GDP \times T-I < 0$, this financial loss becomes fiscal deficit. Alternatively, if this project is implemented with a PPI scheme given the initial cost and toll fees unchanged, the private investor makes the initial investment and receives NTE while the government is expected to receive $\Delta GDP \times T$ and bear the administration cost. If NTE<I, the PPI scheme is not feasible. Note that EB to be generated by the project are independent from the financing scheme. Therefore, if the government wants to realize the EB, offering partial subsidy (S) to lower the initial cost is one of the solutions to encourage the private participation. Next, the financing mix (E+D) can be determined given the subsidy.

Table 1

Economic and financial benefit and cost of toll road project

	Tax-based financing scheme		PPI scheme with subsidy		
	Cost	Benefit	Cost	Financing mix	Benefit
Government	I	NTE + $\Delta GDP \times T$	PPIAC + **S**		$\Delta GDP \times T$
Investor	–	–	I – **S**	E + D	NTE
Users	Toll fees	EB	Toll fees		EB

Note: I = initial project cost; NTE = net earnings from tolls = Toll fees paid by the users – operating expenses; ΔGDP = increased gross domestic products driven by the new infrastructure; PPIAC = government's administration cost for managing PPI; T = tax rate; EB = economic benefits; E = equity; D = debt; S = government subsidy.

The capital structure of PPI projects

A PPI-led project is usually legally framed by contracts between the public and private partners, which aim not only to specify the scope of the project but also to address and minimize project risks. The implementation and financing schedule of the project are one of the essential factors to develop this legal framework (Meidute, Paliulis, 2011).

Both corporate and project finance draws capital from equity and debt. Modigliani & Miller (1958; 1963) demonstrates that, in a perfect world, financial leverage is unrelated to firm value. However, it is widely believed that in a world with imperfections, such as, bankruptcy costs,

agency cost, and benefits from leverage-induced tax shields, associated with drawing debts, an optimal capital structure for the project may exist (Jensen & Meckling, 1976; Brennen & Schwartz, 1978; Masulis, 1980). Specifically, the amount of debt and equity affect the cost of capital and, therefore, the project's financial viability.

The traditional capital structure models identify an optimal financing mix between equity and debt (i.e., a debt ratio) that maximizes firm value. Shah and Thakor (1987) indicated that the debt ratio of project financing, a non-recourse loan structure that relies primarily on the project's cash flow for repayment, is positively related to risk because of the information asymmetry between equity investors and bondholders. However, PPI projects are usually required to be transparent, so the information asymmetry problem is decreased. Because the high risk of an off-balance-sheet financing structure, the debt ratio that maximizes project return tends to be lower than the debt capacity of the project, and it is even lower if the objective is to maximize the project value (Dias & Ioannou, 1995). These findings indicate that the financing features of PPI projects differ from those of general private projects.

The financial model of a PPI project is comprised of three functions: cost, revenue and decision criteria (Kakimoto & Senneviratne, 2000). Some prior studies incorporated key factors into regression models to provide quick information for BOT negotiation (Ngee *et al.*, 1997; Tiong & Alum, 1997; Shen *et al.,* 2002; Liou & Huang, 2008). Other studies have examined the debt capacity of the BOT projects. Bakatjan *et al.*, (2003) used a hydropower plant in Turkey as an example to develop a model that designates IRR and debt service coverage ratio, an indicator of bankruptcy, as the objective functions and incorporates the tax benefit and bankruptcy risk associated with debts. Wibowo (2006) used the WACC approach to examine the effects of minimum revenue guarantee, direct subsidies, and preferential loans on BOT projects, concluding that all types of governmental subsidies increase the rate of return on equity and decrease the risk of equity, thereby increasing project NPV. Most recently, Iyer, Sagheer (2012) used genetic-algorithm based model to identify a set of optimal solutions for the decision variables including grant (to the government), debt, and equity at the bidding stage.

Model development

Linear programming, also called linear optimization, is widely used to determine how to achieve the best outcome (the objective function, such as maximum profit or lowest cost), subject to some list of requirements (the inequality constraints) (Carleton, 1969; Candler & Boehlje, 1971; Myers, 1972; Tchangani, 2010). This methodology is popular in capital budgeting decisions (Park, Sharpe-Bette, 1990) and has been demonstrated useful in formulating optimal capital structure model for BOT projects (Bakatjan *et al*., 2003).

The traditional capital structure model examines the optimal financing mix between equity and debt (Panel A in Figure 1), while the government-subsidized PPI project is comprised of three financing sources: equity, debt, and government subsidy. For government-subsidized BOT projects, the government subsidy level must be determined before the optimal debt ratio can be determined (Panel B in Figure 1).

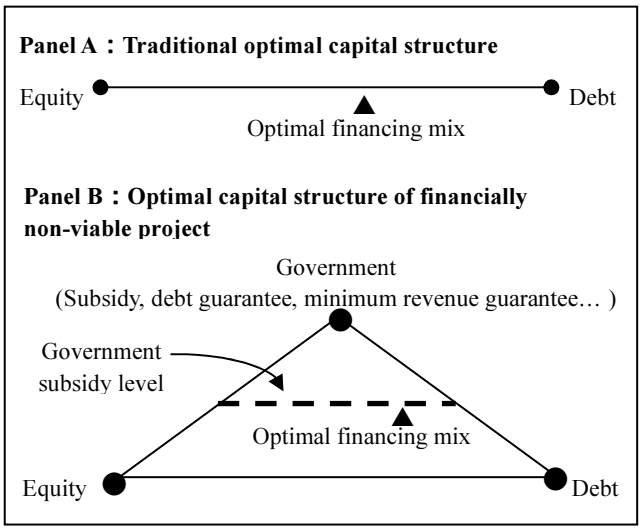

Figure 1. Optimal capital structure

The commonly used criteria for project feasibility and credibility include NPV, IRR, debt service coverage ratio (DSCR), times interest earnings (TIE), return on assets (ROA), return on equity (ROE), and profitability index (PI). Table 2 provides the notations for the variables in the criteria functions.

The first linear programming model, which determines the minimum subsidy requirement, consists of an objective function of minimizing PI and five constraints of financial viability. In the second linear programming model to identify the optimal debt ratio given the government subsidy, the objective function is maximizing PI subject to seven inequality constraints of financial feasibility and credibility.

1. **Net present value (NPV):** accept the project when NPV is not less than 0.

$$NPV = C_0 - \sum_{j=1}^{c_p} \frac{BCAE_j \times e \times (1-g)}{(1+r)^j} + \sum_{m=1}^{O_p} \frac{PBIT_m - TAX_m - ADI_m}{(1+r)^{m+c_p}} \quad (1)$$

2. **Internal rate of return (IRR)**: accept the project when IRR is not less than the cost of capital (i.e., the discount rate, *r*).

$$NPV = C_0 - \sum_{j=1}^{c_p} \frac{BCAE_j \times e \times (1-g)}{(1+IRR)^j} + \sum_{m=1}^{O_p} \frac{PBIT_m - TAX_m - ADI_m}{(1+IRR)^{m+c_p}} = 0$$

$$j = 1, 2, \cdots, C_p, \quad m = 1, 2, \cdots, O_p \quad (2)$$

3. **Average debt service coverage ratio** (ADSCR): A debt service coverage ratio (DSCR) greater than 1.5 is acceptable to banks (Bakatjan et al, 2003).

$$DSCR_m = \frac{PBIT_m}{ADI_m}; \quad ADSCR = \frac{\sum_{m=1}^{L_N} DSCR_m}{L_N}, \quad m = 1, 2, \cdots, L_N \quad (3)$$

4. **Self-liqudation ratio** (SLR). A SLR greater than 1 signifies the initial investment cost can be recovered from operation revenues.

$$SLR = \frac{\sum_{m=1}^{O_p} \frac{PBIT_m}{(1+r)^m}}{\sum_{j=1}^{C_p} BCAE_j \times (1+r)^{(C_p - j)}}, \; j = 1,2,\cdots,C_p \; ; m = 1,2,\cdots,O_p \quad (4)$$

5. **Average times interest earnings** (ATIE). TIE measures the project's ability to meet its short-term financial obligations. In Taiwan, the Council for Economic Planning and Development (1997) suggests that a TIE greater than 2.0 is preferred.

$$TIE_m = \frac{PBIT_m}{INT_m} \; ; ATIE = \frac{\sum_{m=1}^{L_N} TIE_m}{L_N}, \; m = 1,2,\cdots,L_N \quad (5)$$

6. **Average return on assets** (AROA).

$$ROA_m = \frac{PBIT_m - TAX_m - ADI_m}{TPC}, m = 1,2,\cdots,O_P$$

$$AROA = \frac{\sum_{m=1}^{O_p} ROA_m}{O_p}, m = 1,2,\cdots,O_P \quad (6)$$

7. **Average return on equity** (AROE).

$$ROE_m = \frac{PBIT_m - TAX_m - ADI_m}{\sum_{j=1}^{C_p} E_j}, \; j=1,2,\cdots,C_p \; ; \; m = 1,2,\cdots,O_P$$

$$AROE = \frac{\sum_{m=1}^{O_p} ROE_m}{O_p}, \; m = 1,2,\cdots,O_P \quad (7)$$

8. **Profitability index** (PI). PI is estimated as NPV divided by total investment.

$$PI = \frac{NPV}{TPC} \quad (8)$$

Table 2

Descriptions of variables used in the functions

Variables	Description	Variables	Description
ADI_m	Principle and interest payment at year *m*	O_p	End year of operation period
$BCAE_j$	Construction cost at year *j*	$PBIT_m$	Profit before interest and tax at year *m*
C_0	Subsidy at year 0	TPC	Total investment
C_p	End year of construction period	TAX_m	Tax payment at year *m*
g	Government subsidy on construction cost ratio	r	Discount rate or cost of capital
ROA_m	Return on assets at year *m*	ROE_m	Return on equity at year *m*
INT_j	Interest expense at time *j*	E_j	Owners' equity at year *j*
e	Equity / (Equity + Debt)	L_N	Debt repayment period

Taiwan High-Speed Rail Project

Taiwan High-Speed Rail (THSR) is the first and largest PPI project in Taiwan. Since the THSR became operational in 2007, its ridership has fallen approximately 30 percent below expected levels, and its revenue has remained far lower than originally estimated. THSR had a debt ratio of 81 percent upon completion of construction in 2006 (THSR 2006 annual report). During the construction period, while THSR shareholders were inclined to provide additional capital to finance cost overruns, the Ministry of Transportation (MOT) of Taiwan and several state-controlled enterprises hold 39.5 percent in shares, most of which are preferred stocks with preferential terms on dividend payments. In addition, more than 75 percent of the syndication loans came from government deposits in the banks (Sun, 2000). THSR's earnings remain insufficient to pay its loans' principal and interest, so THSR has requested assistance from the government and has negotiated with banks for loan extensions. After intensive negotiation, the MOT appointed an individual professional manager as the Chairman of THSR Corporation to replace the one who represented the sponsor.

With the economic IRR greater than social cost of capital (AmDec-CECI, 1990), this project is economically viable, but it is highly vulnerable to economic slowdown, so it provides a good case for the present study: an economically viable project that requires government subsidy to reduce financial risk. In the present empirical study, we assume that the government, private investors and lenders all realized during its planning stage that the THSR Project was non-financially viable and that the government subsidized the project to enhance the feasibility of private investment.

The THSR concessionaire was granted a concession period of 30 years and is responsible for the construction, operation, and maintenance of the THSR Project during the concession period. Project sponsors are responsible for transferring ownership to the government after the specified concession period. Construction began in 1998, and the operating period began in 2007. The project's cash outflows include construction costs (NT$493 billion), operating and maintenance costs, taxes and financial payments, while the cash inflows are comprised of tariffs, government subsidies, and financial borrowing. The project does not have a residual value because the property is expected to be transferred to the government at no cost. Based on the pro forma cash flow, the self-liquidation ratio of the project is 0.65 (with a discount rate of 11%), showing that it is a financially non-viable project.

The programming model

To generate samples, the government subsidy ratio (G) varies from 0-90 percent in 5-percent steps, the debt ratio (D) varies from 0-50 percent in 5-percent steps and from 60 percent to 90 percent in 2- or 3-percent steps. This approach generated 494 samples with different combinations of G and D, which are used to examine the

relationship between G and D with the corresponding financial indicators individually. We found that, except for AROA, D and G cannot perfectly explain the variation in objective indicators (R^2 < 80 %). Therefore, quadratic regressions are used for the programming model.

$$FI_i = \alpha_{1i} + \beta_{1i}G + \gamma_{1i}G^2 + \varepsilon_{1i};$$

whereas FI_i denote NPV, IRR, ROE, AROE and PI individually in each of the five regression models.

Zero debt is assumed at the first stage with the government subsidy ratio varying from 0 to 90 percent in 2- or 3-precent steps, generating 26 samples. The results of the quadratic regression models show that G and G^2 significantly affects all objective indicators (p <0.001 and R^2 > 0.9), but the effect on each indicator diminishes after a peak (γ_{1i} > 0).

The two decision variables in the study are the minimum subsidy for the project viability and the debt ratio that maximizes project value. The most popular indicators for financial feasibility include NPV, IRR, ROE, and PI (Graham, Campbell, 2001), among which ROE ignores the time value of money, NPV favors large-scale projects, and IRR favors small-scale projects (Damodaran, 2010). To avoid bias from scale discrimination, PI, which measures NPV per dollar investment, is used as the objective function in the programming model.

The minimum subsidy. As PI is positively related to subsidy, the optimal subsidy is the subsidy that minimizes PI subject to all constraint functions. For a financially feasible project, PI is not less than 1 so the objective function is PI = 1. The programming model is as follows:

Objective function：

$$\text{Min PI} = 6.849 \times G^2 - 3.705 \times G + 0.818 \quad (9)$$

Subject to:

$$\text{NPV: } 236889 \times G - 131286 \geqq 0$$

$$\text{IRR: } 0.361 \times G^2 - 0.127 \times G + 0.110 \geqq 0.131$$

$$\text{AROE: } 2.222 \times G^2 - 1.202 \times G + 0.266 \geqq 0.07$$

$$\text{PI: } 6.849 \times G^2 - 3.705 \times G + 0.818 \geqq 1.00$$

$$1.00 \leqq G \geqq 0.00$$

Note that WACC is 13.1 percent; the average ROE in the transportation sector for the last 20 years is 7 percent.

The Lagrange multiplier associated with K-T (Kuhn-Tucker) conditions can transform a quadratic programming model with inequalities to a set of simultaneous equations. The LINGO software provides the optimal solution for a quadratic programming model. The minimum subsidy ratio for the financial feasibility of the case is 58.6 percent.

The optimal debt ratio. At the second stage, given a subsidy ratio at 58.6 percent, we develop cash flow to equity as the base case for the THSR Project; then we conduct sensitivity analysis by varying the debt ratio from 0 to 90 percent in 2- to 3-percent steps, generating 26 samples. The debt ratio shows a quadratic relationship with each of the objective indicators (R^2 > 0.9). Therefore, the quadratic regression models are used to assess the relationship between debt ratio with each of the financial criteria.

$$FI_i = \alpha_{2i} + \beta_{2i}D + \gamma_{2i}D^2 + \varepsilon_{2i};$$

whereas FI_i denote NPV, IRR, ADSCR, ATIE, AROA, AROE and PI individually in each of the seven regression models.

The results of the quadratic regression models show that D and D^2 significantly affect all objective indicators (p <0.001 and R^2 > 0.9), but the effect on each indicator diminishes after a peak (γ_{2i} > 0).

Banks' willingness to commit to loans is one of the success key factors for BOT projects (Tiong & Alum, 1997; Chan *et al.,* 2001, 2004). Loan providers determine the debt ratio subject to financial features and the risk associated with the projects (Dias & Ioannou, 1996; Yeo & Tiong, 2000; Wibowo & Kochendorfer, 2005; Wibowo, 2006). Therefore, the consists of constraints of credibility indicators, other than viability criteria, are included in the model. The objective and constraint functions in the programming model are shown below.

Objective function：

$$\text{Max PI} = -37.670 \times D^2 + 16.1 \times D - 0.64 \quad (10)$$

Subject to:

$$\text{NPV: } -17700 \times D^2 - 72594 \times D + 15991 \geqq 0$$

$$\text{IRR: } 0.09 \times D^2 - 0.32 \times D + 0.15 \geqq 0.131$$

$$\text{ADSCR: } 2.88 \times D^2 - 4.33 \times D + 1.70 \geqq 1.50$$

$$\text{ATIE: } 31.79 \times D^2 - 41.28 \times D + 12.88 \geqq 2.00$$

$$\text{AROA: } -0.12 \times D^2 - 0.19 \times D + 0.13 \geqq 0.05$$

$$\text{AROE: } -1.04 \times D^2 - 0.07 \times D + 0.29 \geqq 0.07$$

$$\text{PI: } -37.670 \times D^2 + 16.1 \times D - 0.64 \geqq 1.00$$

$$1.00 \leqq D \geqq 0.00$$

Given G=58.6%, the LINGO software identifies the optimal debt ratio at 16.5 percent. We replaced PI with NPV and repeat the procedure described above, receiving similar results.

Discussion and Conclusions

The government's financing role in the subsidized PPI projects changes the traditional optimal capital structure between equity and debt. This paper develops a two-stage quadratic programming model to identify the optimal amount of government subsidy and the optimal financing mix.

In the proposed two-stage linear programming model, the objective of the first stage is to minimize the subsidy subject to constraint functions that include NPV, IRR average ROE and PI. A minimum subsidy requirement is determined based on cash flow that is financed solely by equity. At the second stage, the cash flow to equity is developed and used to generate samples to model an

optimal debt ratio, given the subsidy determined at the first stage. We apply the two-stage programming model to the THSR Project and find a minimum subsidy that is more than half of the initial investment cost. The optimal debt ratio is 20 %, lower than those determined by traditional WACC and APV approaches (30 %). With these results, it is not surprising that most banks were hesitant to make commitments to this project at the preparation stage until the MOT of Taiwan offered equity capital and bank deposits. However, equity investment and loans from the government does not ease the Project's financial vulnerability to economic downturn. The over-loaded debt ratio (almost 98 %) has given the Project a serious cash flow problem during the operation period.

The negotiation of terms and conditions including, among other things, government's financial support and debt level of non-financially viable PPI project is an interactive process among all parties. The project may fail to proceed to implementation stage if any one of the parties cannot reach a consensus agreement (Meidute, Paliulis, 2011). As the subsidy level affect the optimal debt ratio of the project, it is crucial to determine an appropriate subsidy or any other kind of financial support program at the initiation and planning stages. The host government carries out the feasibility study for the project and proposes a financial support program at the initiation stage. The concessionaire might not be able to reach the expected optimal financing mix at latter stage if the optimal debt ratio is not acceptable to the financial institutions. Therefore, it is very important that the potential private investors and financial institutions are invited to participate in the feasibility study at the initiation and planning stages. Should the subsidy level and the optimal debt ratio be not acceptable to any one of the PPI parties, either the financial support program or the project have to be readjusted (Figure 2).

The two-stage programming model developed in the current paper effectively identifies the minimum subsidy needed and the optimal debt ratio. The results provide a guidance for public-private negotiations. The two-stage programming model developed in the current paper effectively identifies the minimum subsidy needed and the optimal debt ratio. The results provide a guidance for public- private negotiations.

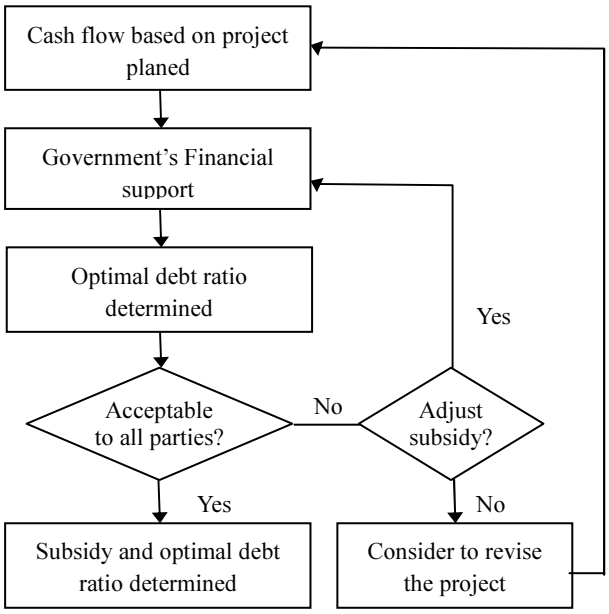

Figure 2. The decision process

Other than economic and social infrastructure projects, many PPI projects (especially in Taiwan) aim to increase revenues from the ancillary business (e.g., land development along the lines in a transportation project or restaurants and accessory stores in a tourism project). However, the ancillary business in a PPI project typically provides competitive products or services, which usually have a higher risk than the main business of the project. How ancillary business can affect the project risk remains to be explored.

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Finansiškai neperspektyvaus Privačių investicijų projekto ir Pradinės subsidijos optimalus finansinis derinys

Santrauka

Ribotą fiskalinį biudžetą turinčios vyriausybės yra linkusios skatinti privataus sektoriaus dalyvavimą kuriant ekonominę ir socialinę infrastruktūrą, taip siekdamos ekonominio augimo arba socialinės gerovės per Privačių investicijų (PPI) schemas. Tačiau, nors dideli projektai, nepaisant jų grynosios ekonominės naudos šalies visuomenei, gali būti finansiškai neperspektyvūs, šalių vyriausybės gali pasirinkti subsidijuoti dalį pradinių išlaidų, norėdamos sukurti finansines galimybes privačiam dalyvavimui tam, kad įgyvendintų numatytą grynąją ekonominę naudą. Ankstesnės PPI gairės ir tyrimas racionalizavo poreikį vyriausybės subsidijoms. Norėdamos padidinti finansines galimybes, pasiūlė įvertinimo metodą projektams, turintiems statybos kaštų subsidiją arba ištyrė vyriausybės pagalbos ir subsidijos formas. Tačiau nei su PPI susijusios gairės, nei tyrimo straipsniai nepateikė pasiūlymų kaip turi būti apibrėžta optimali projekto kapitalo struktūra, esant finansinei vyriausybės paramai.

PPI projektas dažniausiai yra teisiškai apribotas sutartimis tarp viešų ir privačių partnerių, kurių tikslas yra ne tik nustatyti projekto apimtį, bet taip pat ir nukreipti bei minimizuoti projekto riziką. Projekto įgyvendinimo ir finansavimo grafikai yra vienas iš esminių veiksnių, tobulinant šią teisinę schemą. Vyriausybės vaidmuo PPI projektuose pakeičia tradicinį kapitalo struktūros modelį į finansinį valdymą, kuris apima tik finansinį savininkų kapitalo ir skolų derinį. Nors ankstesnis tyrimas ir sukūrė derybų modelius su koncesiniais kintamaisiais finansiškai perspektyviems projektams, vis dar reikia ištirti, kaip vyriausybės subsidija ir kapitalo struktūra yra apibrėžiama finansiškai neperspektyviems projektams. Būtina sukurti modelį, kaip įtraukti vyriausybę tam, kad būtų galima nustatyti optimalią PPI projektų finansinę struktūrą. Kyla klausimas kada ir kiek turėtų būti subsidijuojama.

Ekonominių kaštų ir naudos analizė bei finansinė analizė, kurios abi naudoja grynąją dabartinę vertę (NPV) ir vidinės apyvartos normą (IRR) norėdamos parodyti projekto perspektyvumą, yra konceptualiai skirtingos. Finansinė analizė, kuri remiasi projekto savininko požiūriu, paaiškina įplaukas, sąnaudas ir išlaidas kaštų sraute. Alternatyviai, ekonominė analizė atpažįsta išorės naudą ir kaštus, kuriuos sukuria projektas, išskyrus mokėjimo pavedimus, kurie neapima resursų išdėstymo, pvz.: mokesčiai ir rinkliavos, palūkanų išmokėjimai ir subsidijos. Kadangi finansinė veikla yra mokėjimo pavedimai, išbraukti iš ekonominės naudos ir kaštų, projekto finansavimo planą galima tirti atskirai, jei tam yra ekonominės galimybės.

Tradiciškai vyriausybė suteikia infrastruktūrą nemokamai viešam naudojimui, todėl reikia laiko, kad koncepciją „vartotojas moka“, visiškai priimtų visuomenė, ypač kai paslauga, kurią teikia privatus sektorius, kuris negauna vyriausybės subsidijų, dažniausiai kainuoja daugiau, negu ta pati paslauga, kurią teikia subsidijas gaunančios vyriausybinės įstaigos. Didelio masto BOT projektams dažnai reikia didelių „nuskandintų“ investicijų, kurioms atgauti reikia daug laiko. Tokie projektai dažniausiai yra labiau susiję su kaštų viršijimais, neaiškiu ekonominiu perspektyvumu ir socialinėmis bei aplinkos rizikomis, nei su dideliu pelningumu. Tiesioginės arba netiesioginės vyriausybės subsidijos dažniausiai yra panaudojamos norint sumažinti finansines, labai rizikingų investicijų nesėkmes, siekiant paversti projektus patraukliais.

Tikimasi, kad privatūs partneriai visiškai privačiai finansuojamoje PPI schemoje finansuos pradinius investavimo kaštus ir juos kompensuos su priimtinomis įplaukomis, kad kompensuotų projekto riziką iš einamojo pelno, esant koncesijos susitarime nurodytiems terminams ir sąlygoms. Projekto finansinė struktūra, tai yra finansinis derinys tarp kapitalo ir skolos, apibrėžia kapitalo kaštus ir pagrindinės PPI schemos vertę. Optimali finansinė struktūra minimizuoja kapitalo kaštus ir maksimizuoja projekto vertę. Tradiciniai kapitalo struktūros modeliai nustato optimalų finansavimo derinį tarp kapitalo ir skolos (t. y. skolos koeficientą), kuris maksimizuoja pastovią vertę, kai vyriausybės subsidijuojamus PPI projektus sudaro trys finansavimo šaltiniai: kapitalas, skola, ir vyriausybės subsidija. Vyriausybės subsidijuojamų BOT projektų atveju, vyriausybės subsidijos lygis turi būti nustatytas prieš nustatant skolos koeficientą. Jei visi kiti finansiniai terminai ir sąlygos yra duoti, reikia nustatyti du parametrus finansavimo derinyje: minimalią subsidiją finansiniam perspektyvumui ir skolos koeficientą, kuris maksimizuoja projekto vertę. Tai optimizavimo problema su suvaržymais. Linijinis programavimas yra populiarus priimant kapitalo paskirstymo sprendimus ir pasirodė naudingas formuojant optimalų kapitalo struktūros modelį BOT projektams. Šiame darbe tobulinami linijinio programavimo modeliai, kurie derinami su jautrumo analize, pagrįsta diskontuotais grynųjų pinigų srautais, siekiant nustatyti optimalų projekto finansavimo derinį esant pradinei vyriausybės subsidijai finansiškai neperspektyviems PPI projektams. Modelis naudoja dviejų etapų metodą. Pirmame etape, grynųjų pinigų srautas be skolų, pagrįstas daugybe tariamų finansinių kintamųjų, yra suformuojamas kaip pagrindinis pavyzdys. Paskui panaudojama jautrumo analizė, siekiant sugeneruoti pavyzdžius, kurias sudaro įvairios finansinių kintamųjų sekos ir susiję rezultatai. Šie pavyzdžiai naudojami pirmame linijinio programavimo modelyje, norint nustatyti minimalią subsidiją, kurios reikia finansinei perspektyvai. Antrame etape sukuriamas naujas grynųjų pinigų srautas, esant vyriausybės subsidijai. Iš pagrindinio pavyzdžio, jautrumo analizės sugeneruoti pavyzdžiai, yra panaudojami suformuoti antrą programavimo modelį, siekiant nustatyti optimalų finansavimo derinį, kuris maksimizuoja projekto vertę. Pasiūlytą modelį kaip pavyzdį mes taikome *Taivanio vakarų koridoriaus greitaeigio geležinkelio projektui* (plg. *Taiwan West Corridor High-Speed Railway Project).*

Taivanio *greitaeigis geležinkelis* (Taiwan High-Speed Rail - THSR) yra pirmasis ir didžiausias BOT projektas Taivanyje. Turėdamas ekonominę IRR, didesnę už socialinius kapitalo kaštus, šis projektas yra ekonomiškai perspektyvus, tačiau labai pažeidžiamas dėl ekonomikos lėtėjimo. Todėl jis yra tinkamas pavyzdys šiam tyrimui: ekonomiškai perspektyvus projektas, kuriam reikia vyriausybės subsidijos, kad sumažintų finansinę riziką. THSR projektui mes taikome dviejų etapų programavimo modelį.

Dažniausiai naudojami projekto įvykdymo ir patikimumo kriterijai apima NPV, IRR, skolos padengimo koeficientą (DSCR), procentinių pajamų dažnumą (TIE), aktyvų rentabilumą (ROA), kapitalo rentabilumą (ROE) ir rentabilumo indeksą (PI). Norint išvengti padėties diskriminavimo šališkumo, PI yra naudojamas kaip tikslinė funkcija programavimo modeliuose. Pirmame etape tikslinė funkcija minimizuoja PI objektą, kad suprojektuotų įgyvendinimą, kurį parodo teigiamas NPV, už kapitalo kaštus aukštesnė IRR, vidutinis kapitalo rentabilumas (AROE), kurio reikalauja kapitalo savininkai, ir ne mažesnis už 1 PI. Sakoma, kad skola yra nulinė, esant vyriausybės subsidijos koeficientui, kintančiam nuo 0 iki 90 procentų etapais, kas 2 – 3 procentai, generuojant 26 pavyzdžius. Modelis nustato minimalią subsidiją, kuri yra daugiau nei pusė pradinių investavimo kaštų. Antrame etape, linijinio programavimo tikslas yra maksimizuoti PI objektą ne tik projekto įvykdymui, bet ir patikimumui (finansinių institucijų požiūriu), kuriuos parodo vidutinis skolos padengimo koeficientas ir vidutinis procentinių pajamų dažnumas. Kai subsidijos koeficientas yra 58.6 procentai, mes sukuriame grynųjų pinigų srautą kapitalui, kaip pagrindinį pavyzdį ir atliekame jautrumo analizę, keisdami skolos koeficientą nuo 0 iki 90 procentų, etapais, kas 2 - 3 procentai. Šis etapas sugeneruoja kitus 26 pavyzdžius. Modelis parodo, kad optimalus skolos koeficientas yra 20 % mažesnis, nei nustatyta tradiciniais WACC ir APV metodais (30%). Mes pakeitėme PI į NPV ir pakartojome prieš tai aprašytą procedūrą, gaudami panašius rezultatus.

Nenuostabu, kad turėdami tokius rezultatus dauguma bankų nesiryžo imtis įsipareigojimų, kol šis projektas buvo ruošiamas ir kol Taivanio transporto ministerija nepasiūlė akcinio kapitalo ir banko depozitų. Tačiau, kapitalo investicijos ir vyriausybės paskolos nesumažina projekto finansinio pažeidžiamumo esant ekonominiam nuosmukiui. Didelis skolos koeficientas (beveik 98%) rodo projektui rimtą, grynųjų pinigų srauto problemą veikimo laikotarpiu. Daug išsamesnis finansinės paramos reikalavimų ir perspektyvaus skolos koeficiento tyrimas gali padėti sumažinti projekto finansinės krizės, kurią patyrė THSR, tikimybę. Derybos dėl terminų ir sąlygų, įskaitant ir finansiškai neperspektyvaus PPI projekto vyriausybės finansinę paramą ir skolos lygį, yra interaktyvus visų dalyvaujančių šalių procesas. Jei kuri nors šalis negali pasiekti susitarimo, projektas žlunga diegimo metu. Kadangi subsidijos lygis daro įtaką projekto optimaliam skolos koeficientui, būtina nustatyti atitinkamą subsidiją arba kitokios rūšies finansinės paramos programą iš pradžių ir planavimo metu. Praktiškai, vyriausybė atlieka projekto įgyvendinimo tyrimą ir siūlo finansinės paramos programą pradiniame etape. Koncesininkas gali nesugebėti pasiekti laukiamo optimalaus finansavimo derinio pradiniame etape, jei optimalus skolos koeficientas nėra tinkamas finansinėms institucijoms. Todėl labai svarbu, kad potencialūs privatūs investuotojai ir finansinės institucijos, būtų pakviesti dalyvauti įgyvendinimo tyrime pradiniame ir planavimo etape Jei subsidijos lygis ir optimalus skolos koeficientas nėra tinkami kuriai nors PPI šaliai, tai finansinės paramos programa arba projektas turi būti pataisyti. Šiame darbe pateiktas dviejų etapų programavimo modelis efektyviai nustato minimalią reikalingą subsidiją ir optimalų skolos koeficientą. Rezultatai pateikia gaires deryboms tarp visuomenės ir privataus kapitalo.

Daugelis PPI projektų siekia padidinti pajamas iš pagalbinio verslo (pvz., krašto plėtra kartu su trasomis transporto projekte, arba restoranai ir suvenyrų parduotuvės turizmo projekte). Tačiau, pagalbinis verslas PPI projekte, kaip paprastai būna, tiekia konkurencingus gaminius ar paslaugas, kurie dažniausiai yra rizikingesni už pagrindinį projekto verslą. Kaip pagalbinis verslas daro įtaką projekto rizikai, dar reikia ištirti.

Raktažodžiai: *PPI (privačios investicijos), subsidija, optimali kapitalo struktūra, diskontuoto grynųjų pinigų srauto modelis, linijinis programavimas.*

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