BOT Projects in Taiwan: Financial Modeling Risk, Term Structure of Net Cash Flows, and Project at Risk Analysis

YANG-CHENG LU, SOUSHAN WU, DAR-HSIN CHEN, AND YUN-YUNG LIN

YANG-CHENG LU is an associate professor in the department and institute of finance and the Finance Research Center at Ming Chuan University in Taipei.

SOUSHAN WU is a professor at the Institute of Business and Management at National Chiao Tung University.

DAR-HSIN CHEN is an assistant professor in the department of banking and finance at the College of Business at Tamkang University in Taipei.

YUN-YUNG LIN is an assistant professor in the department of banking and finance at the College of Business at Tamkang University.

Patterns of national infrastructure construction have moved toward privatization, private participation, and government-private partnerships. Such a liberalizing trend has resulted from a desire for more efficient resource allocation and more effective financing. The build-operate-transfer (BOT) model is one of the most important privatization schemes used for construction of a nation's infrastructure.

BOT has become popular because it improves the efficiency and effectiveness of project implementation. Such efficiency and effectiveness results from the incentive system created by the BOT model. The BOT model can be defined as follows:

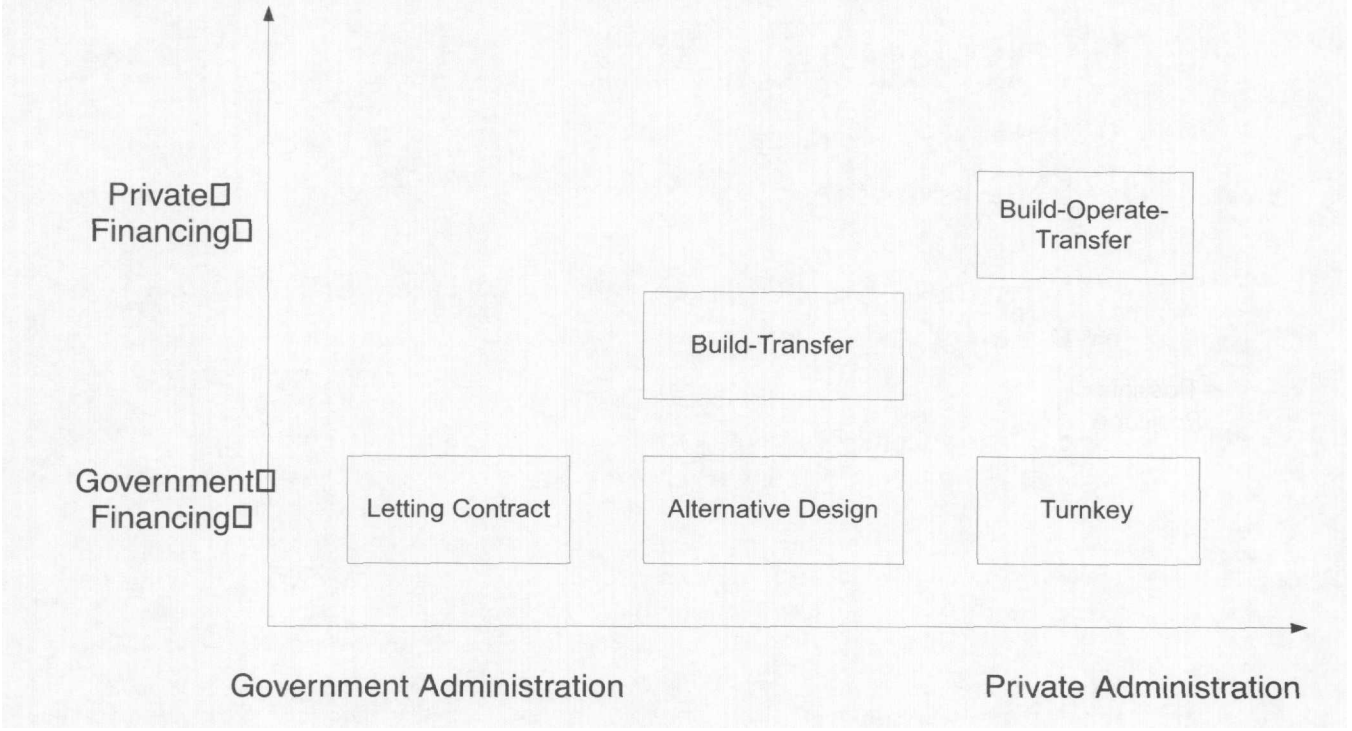
> Private entities receive a franchise (the incentive system) to finance, build, and operate the project for a fixed period of time, after which ownership reverts to the host government (or some local or regional public authority administered by the host government). Ownership reversion is planned to occur only after the private-sector entities have received the return of, and a satisfactory return on, the capital they have invested in the project. In return for the ownership reversion, the host government might be asked to furnish some (limited) credit support for project borrowings.

The BOT structure is especially attractive to host governments due to the ownership reversion feature. It is becoming commonplace for nations that intend to expand their infrastructure. In contrast to traditional infrastructure construction models such as letting contracts, alternative design, turnkey, and build-transfer (BT), the BOT model has a higher degree of private financing and management. Exhibit 1 depicts the characteristics and positioning for the BOT model in terms of private financing and administration. It shows that the BOT model has the highest degree of privatization and offers the best incentives.

Basically, the BOT model consists of risk/return negotiations among governments, the project company, and the bank syndicate as shown in Exhibit 2. In the bidding stage of a BOT project, the government usually proposes an appropriate bidding procedure. The project consortia with their bank syndicates would have to prepare detailed proposals to bid for the project. After one of the consortia has won the franchise, the government has the responsibility to communicate with the project sponsors and organize possible privilege loans if it is necessary. The project sponsors negotiate with the government and the bank syndicate to develop a mutually satisfactory project structure. The bank syndicate then tailors a loan to the structure of the project. Substantial negotiations are required for a fair risk/benefit sharing scheme.

EXHIBIT 1

Positioning of BOT Model — Financing and Administration Dimension



It is worth noting that the success of a risk/return sharing scheme depends on the financial soundness of the BOT proposal. The better the financial planning, the higher the possibility that the BOT project will succeed. Good financial planning is a critical factor for a successful BOT project.

Aspects of BOT Financial Proposal

A basic BOT financial proposal should include scope definition, financing and legal assumptions, construction cost and schedule, sources of financing and estimated cost of capital, future cash inflow forecasts, future capital and refurbishment requirements, a financial and economic model, NPV/IRR analysis, and scenario/sensitivity analysis. Short [1998] designs a proposal development process for a BOT project finance model and points out the importance of viability analysis for a sound financing plan. Finnerty [1996] suggests that the NPV and IRR evaluation methods for a BOT project should be based on a discounted cash flow analysis.

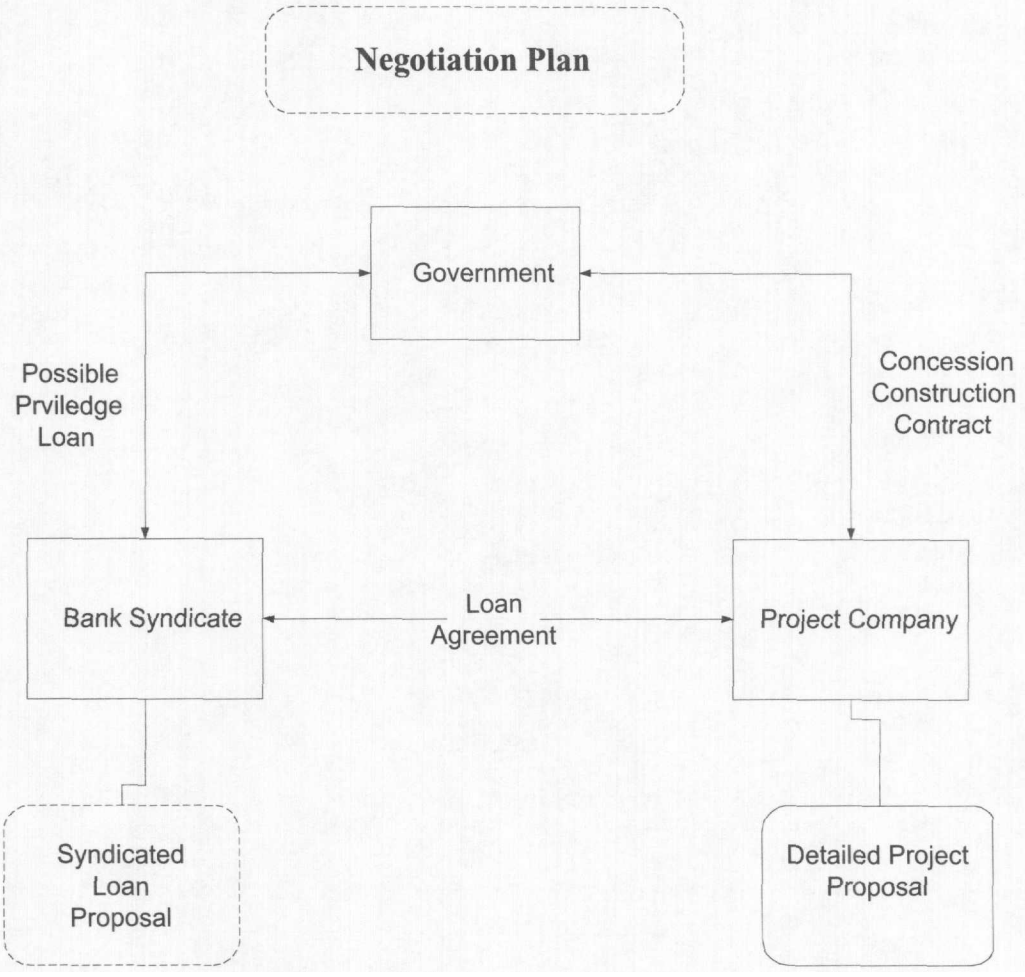
There has been little discussion, however, about how to use the simulation methodology in the financial scenario analysis of a BOT project. This purpose of this article therefore is to suggest a project at risk (PaR) analysis based on a simulation technique using the value at risk (VaR) methodology. A term structure of net cash flow curve also is developed to analyze the economic characteristics of BOT financial plans.

In this article, we describe the dimensions of a BOT project. We then propose a project at risk model with a term-structure-of-net-cash-flow analysis for the purpose of analyzing the financial characteristics of a BOT project. Finally, we discuss the applications and summarize.

BOT EXPERIENCES IN TAIWAN

The current proposed BOT projects in Taiwan and their responsible parties, project periods, and amounts are briefly summarized in Exhibit 3. Based on statistics released by the Council of Economic Planning and Development of the Government (CEPD), Taiwan in the next quarter century will invest nearly US$40 billion in the infrastructure projects, of which US$10 billion is expected to be financed internationally. These projects also include the largest BOT project ever, the North/South High-

EXHIBIT 2
Trilateral Negotiation Scheme for BOT Model



Speed Rail Project. By carrying out all these projects, the Taiwan government is committing to move the country into another stage for the next century.

Current BOT projects in Taiwan can be classified into three categories: construction-stage projects, bidding-stage projects, and planning-stage projects. These projects include high-speed rail, mass transit, highways, cable cars, airport terminals, harbors, bridges, office buildings, gyms, resorts, shopping centers, incinerators, parks, and land developments.

Although there is a continuing increase in plans for BOT projects, delay of the largest BOT project, the North/South High Speed Rail, indicates that financial projections may have underestimated the project's risk exposure. Overoptimistic financial estimates can result in failure to raise necessary project financing. In this case, the syndicate banks could not evaluate the financial risk exposure from the traditional financial projection models and therefore could not develop satisfactory credit proposals to get internal approval to make the loans. Thus, a project financial model with sufficient risk consideration is worth further study in Taiwan.

DIMENSIONS FOR BOT PROJECT FINANCING

The financial proposal development process normally begins before the request for proposal (RFP) is

EXHIBIT 3

Summary of BOT Projects in Taiwan

Projects	Authority	Central Authority: CEPD Project Periods	(in million of US dollars) Total Investment
1. Construction Stage			
(1) Taiwan North/South High Speed Rail	Bureau of Taiwan High Speed Rail Road Ministry of Transportation	1998-2033	12,331
(2) Taipei-CKS Mass Rapid Transit Ministry of Transportation	Bureau of Taiwan High Speed Rail Road	1996-2006	1,714
(3) Yueh-Mei Theme Park	Taiwan Sugar Co. Ltd. Ministry of Economic Affairs	1991-2003	511
(4) Taichung Large-Size Shopping Center	Taiwan Sugar Co. Ltd. Ministry of Economic Affairs	1998-2008	857
(5) Pier 73 of Harbor Kaohsiung	Port of Kaohsiung Taiwan Provincial Government	1995-1999	37
(6) Container Facility of Pier 79-81 in Harbor Kaohsiung	Port of Kaohsiung Taiwan Provincial Government	1995-1999	71
(7) Container Facility of Pier 78 in Harbor Kaohsiung	Port of Kaohsiung Taiwan Provincial Government	1995-1999	29
(8) Taipei International Financial Building	Bureau of Finance Taipei City Government	1998-2002	1,029
(9) Cooperation with Kwei-Yu Co. to Produce Steel and Related Products	Taichung Harbour Bureau Taiwan Provincial Government	1996-2001	1,320
2. Bidding Stage			
(10) The First Stage of Incinerator	Engineering Office of EPA	1997-2002	571
(11) Highway (Toucheng-Hualien)	Ministry of Transportation	1993-2009	5,106
(12) Highway (Fengyuan-Wufeng)	Ministry of Transportation	1997-2004	1,326
3. Planning Stage			
(13) Kaohsiung Railway Underground Project	Railway Underground Project Ministry of Transportation	1998-2008	3,517
(14) Gi-Bay Resort Hotel Ministry of Transportation	Tourism Bureau	1997-2001	9
(15) International Big Penghu Resort Hotel	Tourism Bureau Ministry of Transportation	1997-2005	40
(16) Highway (Wufeng-Puli)	Ministry of Transportation	1996-2005	1,030`
(17) Daipeng National Scenery Park	Tourism Bureau Ministry of Transportation	1998-2001	2
(18) The Second Stage of Incinerator	Engineering Office of EPA	1998-2003	606
(19) Standard Plant Rebuild of Hsinchu Scientific Park	National Science Council	1998-2000	15
(20) Large Modern Taiwan Province Gym	The Department of Education Taiwan Provincial Government	1993-1997	50
(21) The Second Stage of Harbor Tanshui	Keelung Harbor Bureau Taiwan Provincial Government	1998-2013	649
(22) The First Development Project of Kaohsiung Mass Rapid Transit Rapid Transit	Department of Kaohsiung Mass	1990-2005	5,577

EXHIBIT 3 (CONTINUED)

Projects		Authority	Central Authority: CEPD Project Periods	(in million of US dollars) Total Investment
(23)	Modern Kaohsiung Gym	Bureau of Education Kaohsiung Municipal Government	1998-2001	93
(24)	Taipei Large Indoor Gym	Bureau of Education Taipei City Government	1997-2002	654
(25)	Chingmen Theme Park	Taipei City Government	1997-2001	363
(26)	Lintou Resort Hotel	Tourism Bureau Ministry of Transportation	1997-2001	33
(27)	Tanchiang Bridge	Taiwan Provincial Government	2001-2005	207
(28)	Cooperation with Kwei-Yu Co. to Construct Pier 96-98	Taichung Harbour Bureau Taiwan Provincial Government	1998-2004	73
(29)	The Second Stage of Taipei Air Cargo Terminal	Civil Aeronautic Administration Ministry of Transportation	1999-2001	143
(30)	Tanhai New Town Beach Resort	Construction and Planning Administration Ministry of the Interior Affairs	-	-
(31)	Nankang Exhibit & Land Development	Ministry of Economic Affairs	1998-2003	-
(32)	Taichung, Tainan Railway Underground Projects	Department of Transportation Taiwan Provincial Government	-	-
(33)	Taipingshan Forrest Park	Taiwan Forestry Bureau	1998-2001	40
(34)	Ali Forrest and Railway Park	Taiwan Forestry Bureau	1998-2008	1,743
(35)	Aowanta Forrest Park	Taiwan Forestry Bureau	1998-2001	17
(36)	Cooperation with Hai-Du Co. to Construct Coal Pier	Port of Taichung Taiwan Provincial Government	1999-2012	62
(37)	Yangmingshan National Park-Peitou Cable Car	Taipei City Government	-	33
	Total Amount			39,862

announced when a BOT project is under consideration. Following the issue of an RFP, a detailed financial proposal is prepared by a team pursuing the project with the following dimensions:

- Scope definition
- Financing and legal assumptions
- Construction cost and schedule
- Sources of financing and estimated cost of capital
- Future cash inflow estimation
- Future capital/refurbishment requirements
- Financial and economic model
- NPV/IRR analysis
- Scenario/Sensitivity analysis

At the first stage of the proposal development process, overall parameters are defined for the project and the way it will be financed. The construction costs, completion schedule, source of financing, and cost of capital have to be estimated as part of the construction period financial plan. Based on financial estimates for the construction period, the sponsors can develop the operating-and-transfer-period financial plan, which measures future net cash inflow and capital and refurbishment require-

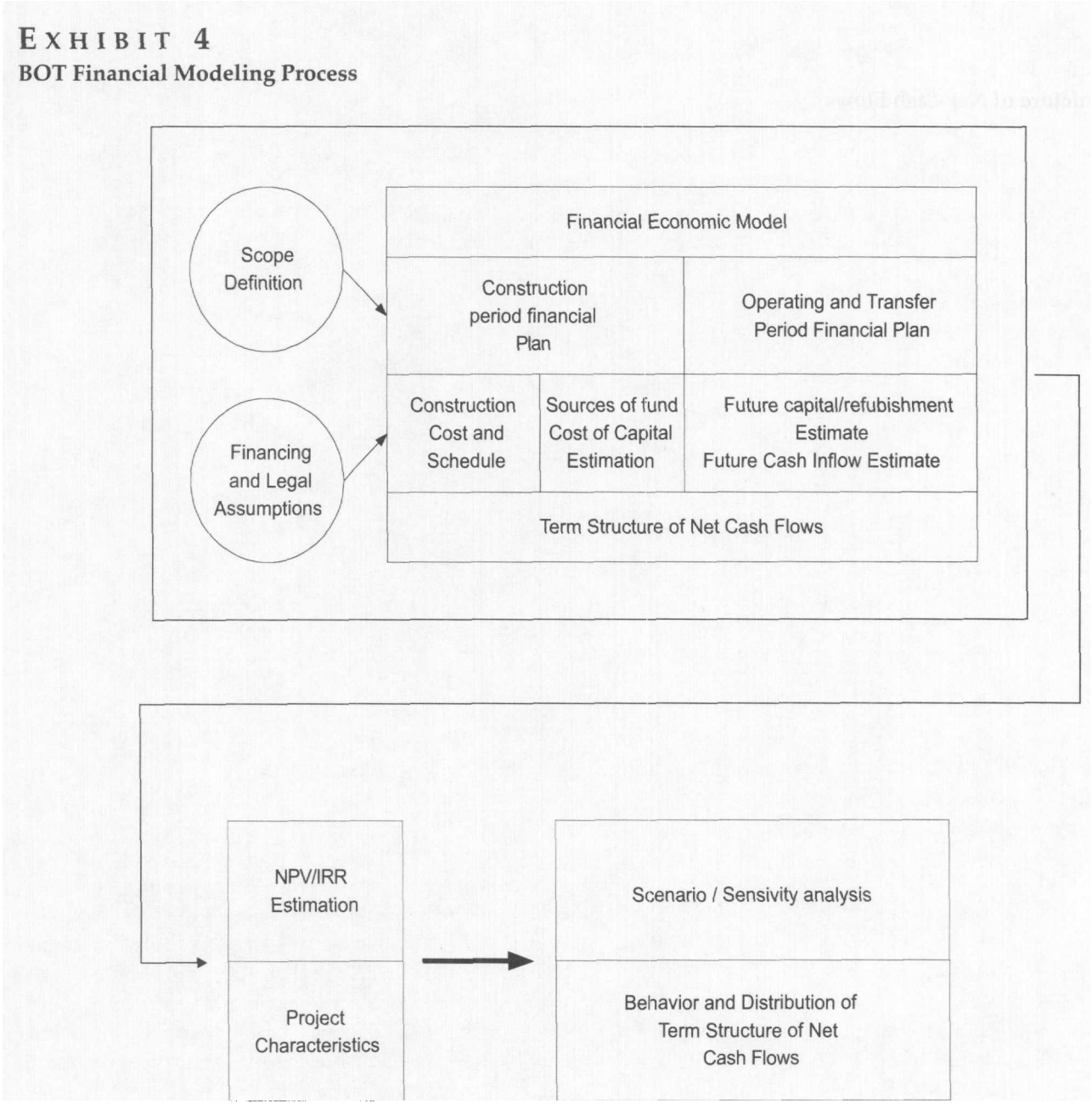
ments. The construction and the operating-and-transfer-period financial plans comprise the financial and economic model of a BOT project. The NPV and IRR analysis, based on the financial and economic model, provides decision support.

All of the components in the BOT financial model are included in a simulation and sensitivity analysis. The behavior and distributions of net cash flow patterns can be calculated in the scenario simulation and serve as a benchmark for decision making. These BOT project financing dimensions for the can be used as a basis for the financial proposal. The BOT financial modeling process shown in Exhibit 4 can be used as a guideline for preparation of a BOT financing proposal.

TERM STRUCTURE OF NET CASH FLOWS AND PROJECT AT RISK ANALYSIS

Following the BOT financial modeling process discussed in the previous section, a term-structure-of-net-

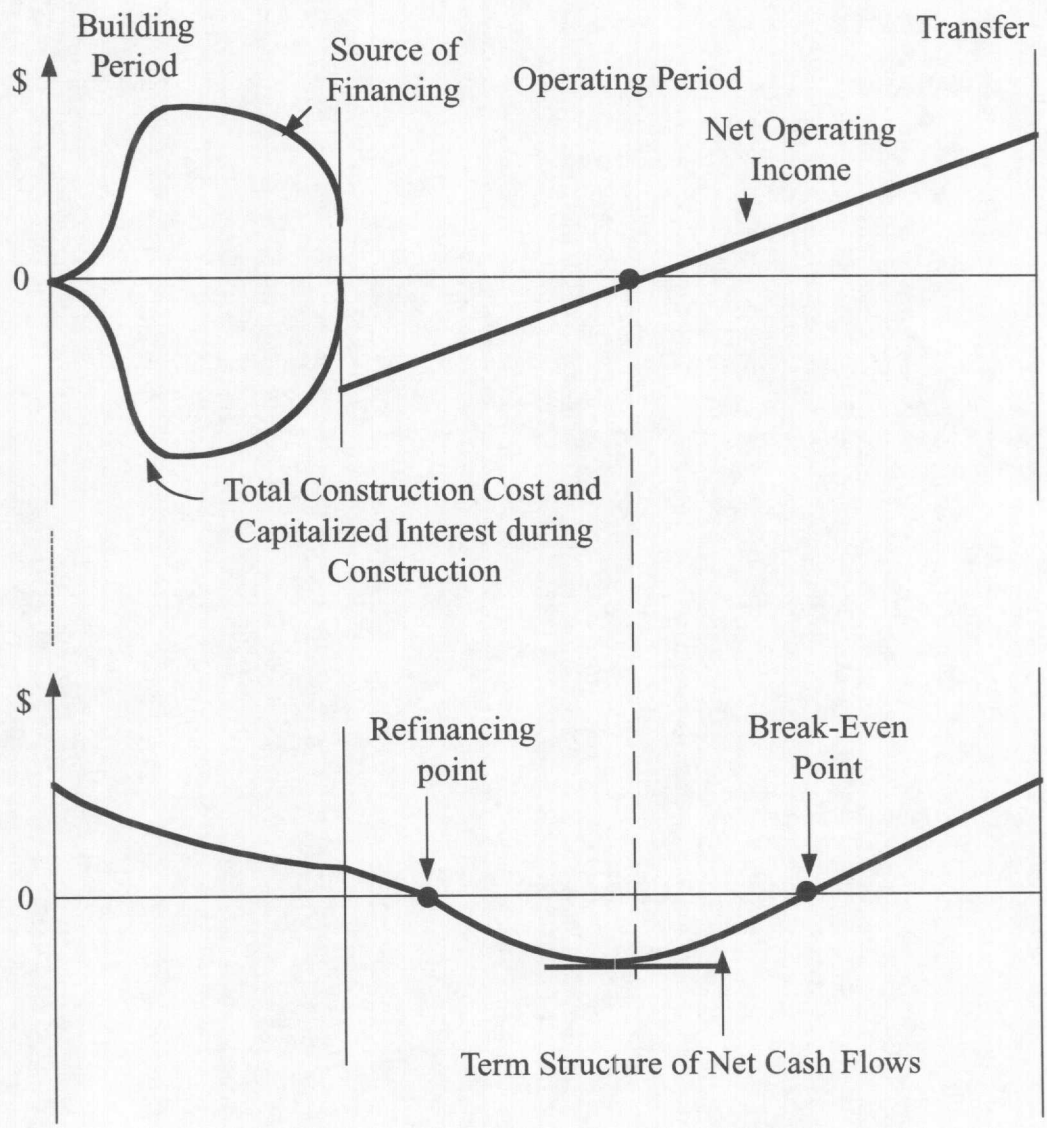
EXHIBIT 4
BOT Financial Modeling Process



cash-flow curve can be developed based on construction and operating costs, the sources of funding, and operating income, as described in Exhibit 5. The term-structure-of-net-cash-flow model portrays the project economics of the BOT model and characterizes the critical time points for refinancing the whole project.

Generally the term structure of net cash flows can be estimated from the financial modeling and would have *potential estimation bias* if the parameters of the project environment change. Hence the term structure of net cash flows should be treated as a stochastic process. Conceptually, there is a probability distribution for the term structure of net cash flows at each time point during the project. However, it is difficult to predetermine the functional forms for this distribution. A possible way of estimating the distributions of the term structure of net cash flows is through a Monte Carlo simulation. The distribution of the term structure of net cash flows first can be simulated through possible changes in the input parameters (characterized in the financing and legal assumptions). The first simulation results can be further employed to fit the following term structure of net cash flows model:

EXHIBIT 5
Term Structure of Net Cash Flows



$$\alpha_t = SF_t + CC_t + NOI_t$$

$$dC_t = (\mu - \alpha_t)C_t d_t + \beta\sigma^r C_t dZ_t$$

$$dZ_t = \varepsilon_t \sqrt{dt}$$

where C_t denotes the net cash flows at time t. μ and σ denotes the mean and volatility parameters for C_t. α_t is the time varying mean reversion parameter for the stochastic process that can be constructed from source of financing SF_t, construction cost, capitalized interest CC_t, and net operating income NOI_t. β and r are shape parameters for the term-structure-of-net-cash-flow curve and ε_t is a random noise term.

Basically the model above is a one-factor stochastic process widely applied in describing the term structure of interest rates. Numerous studies have employed similar estimation methods for yield curve fitting, as shown, for example, in Jarrow [1996] and Rebonato [1996]. Once the parameters are appropriately estimated, further simulation analyses can be performed easily and the NPV and IRR can be computed based on the term structure of net cash flows.

The possible NPVs for a BOT project would be a probability distribution as depicted in Exhibit 6 if the term structure of net cash flows is a stochastic process. The sponsors of a BOT project would confront a wide range of possible NPV outcomes under different scenarios. Therefore, an important concern for the sponsors in the planning and bidding stage is the possibility of project NPV under adverse conditions. We can quantify the possible losses, define them as PaR (see Exhibit 6), and employ PaR as a decision-support criterion when evaluating BOT projects. The economic definition of PaR would be: potential risk exposure measured in dollars for a BOT project under the worst imaginable circumstances. The methodology for PaR is similar to that for VaR analysis. Further applications of the PaR model are discussed in the next section.

TERM STRUCTURE APPLICATIONS OF NET CASH FLOWS AND PROJECT AT RISK ANALYSIS

The term structure of net cash flows curve can be used for risk scenario analysis. Risks pertaining to a BOT project is classified into the following categories:

1. Political Risks
- Legal Change
- Changes in Tax Regulation
- Inconsistency of Government Policies

2. Economic Risks
- Interest Rate Risk
- Foreign Exchange Rate Risk
- Influential Economic Events

EXHIBIT 6
NPV Distribution of a BOT Project

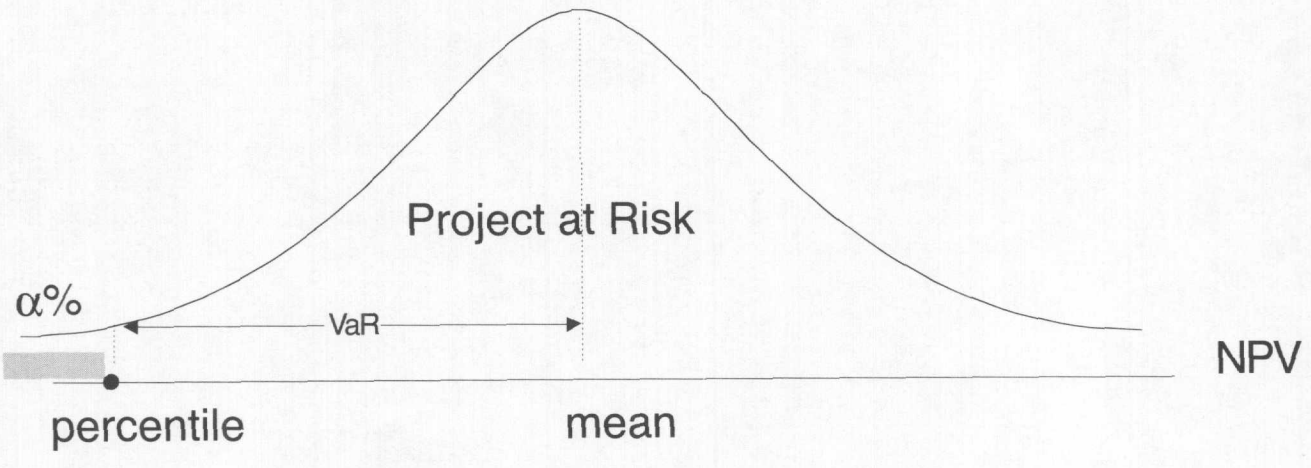
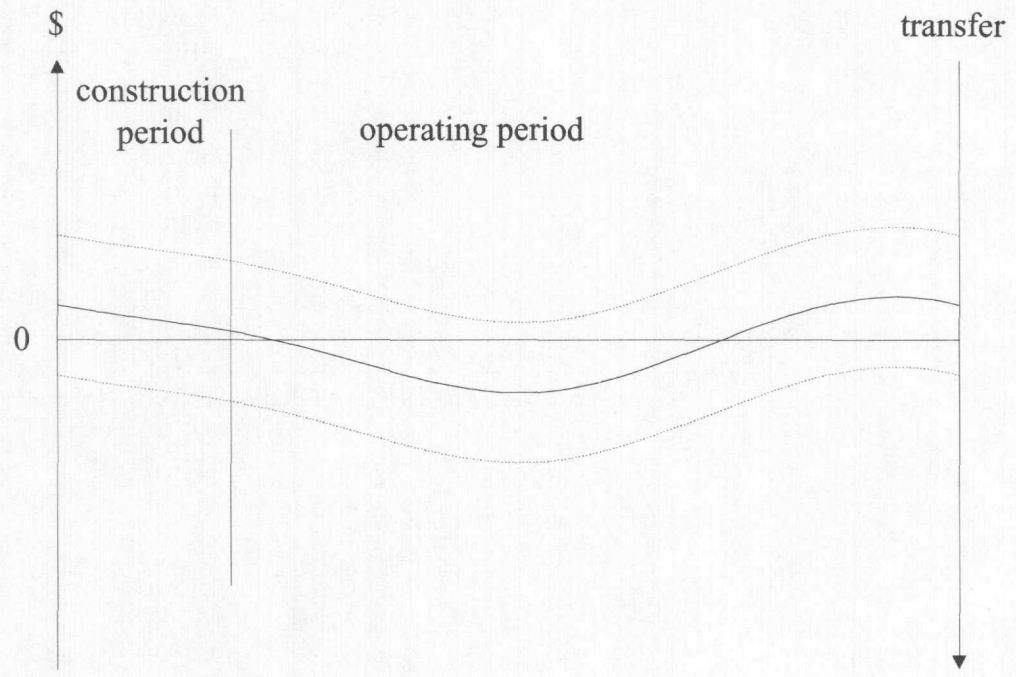


EXHIBIT 7
Simulated Bond of Term Structure of New Cash Flows from Scenario Analysis



3. Project Risks
- Building Period
    1. Construction Cost Overrun Risk
    2. Construction Delay Risk
    3. Construction Design Alteration Risk
- Operation Period
    1. Operating Income Underperformance Risk
    2. Operating Cost Overspending Risk

The above risks could be employed as input parameters for the term-structure-of-net-cash-flow model to perform the scenario/sensitivity analysis for the BOT project. A simulated band for the term structure of net cash flows can be derived from the scenario analysis, where the confidence interval of the net cash flow at each time point can be acquired. Exhibit 7 depicts the simulated band for the term structure of net cash flows.

The PaR analysis at each point in time also can be evaluated as part of the scenario analysis. It characterizes the potential risk exposures at each time point and provides further information as the BOT project proceeds. PaR evaluation can be performed at any time during the a BOT project to account for any change in the parameters. Exhibit 8 offers an integrated analysis combining the term structure of net cash flows and PaR evaluation.

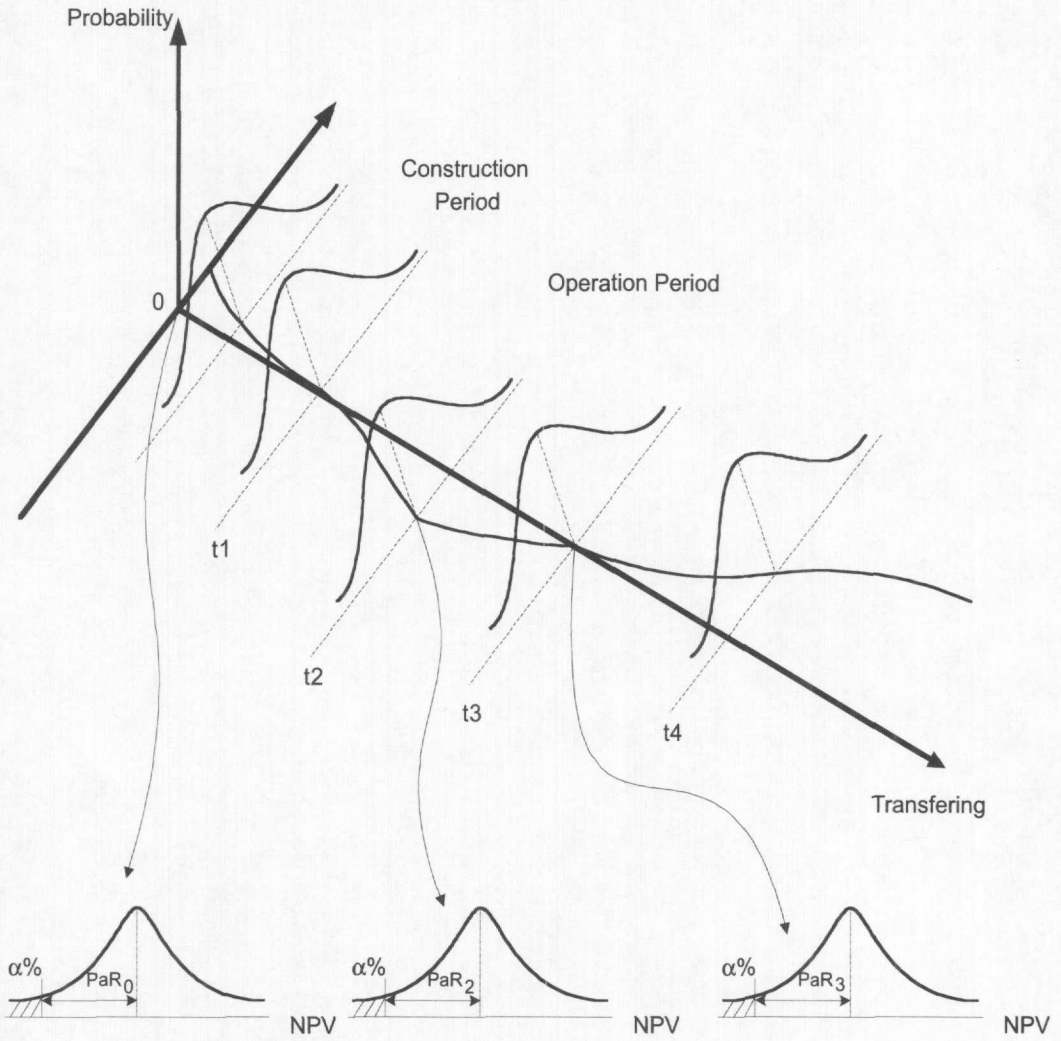
CONCLUSIONS

The BOT model is a trilateral negotiation game with complex interrelationships. The critical success factor for a BOT project is the efficient and effective allocation of project risks and returns among the government, the project sponsors, and the bank syndicate. Negotiations among the three parties can be effective if there is an objective tool for bargaining. This article proposes a quantitative model satisfying the need to analyze a BOT project.

Starting from the inputs of environmental parameters, a theoretical term structure of net cash flows can be obtained from a Monte Carlo simulation. The term structure of net cash flows then can be used to evaluate the cash flow dynamics. The PaR measure reflecting the potential risk exposure of the project is also derived. The PaR analysis can be performed at any time during a BOT project existence for risk management. This article presents a more quantitative and objective model — that is, the term structure of net cash flows and PaR analysis. There are more issues related to the BOT project finance that deserve our further investigation.

EXHIBIT 8

Integrated Analysis Combining Term Structure of Net Cash Flows and Project at Risk Evaluation



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