ANALYSIS OF POLICY AND REGULATION ON BUILD-OPERATE-TRANSFER SCHEME: A CASE STUDY OF THE BAN PONG-KANCHANABURI MOTORWAY IN THAILAND

Kitti SUBPRASOM
Civil Engineer
Bureau of Planning
Department of Highways
Bangkok 10400 Thailand
Fax: +66-02-354-6559
E-mail: subprasom@yahoo.com

Anthony CHEN
Associate Professor
Department of Civil &
Environmental Engineering
Utah State University
Logan, UT 84322-4110 USA
Fax: +1-435-797-1185
E-mail: achen@cc.usu.edu

Abstract: The Build-Operate-Transfer (BOT) network design problem often involves three parties: the government, private sectors, and road users. Each of the parties has different objectives that often conflict with each other. This study develops the optimal pricing model for each party's perspective under travel demand uncertainty. Numerical studies are provided to illustrate the tradeoff among different objectives and the effects of regulation and policy on the BOT project. Regulation and policy are normally imposed by the government to ensure the BOT project satisfy certain requirements. The impact of imposing regulation and policy on profit, social welfare, spatial equity, and financial performance of a BOT project are explored using a case study of the Ban Pong-Kanchanaburi Motorway (BKM) in Thailand.

Key Words: BOT scheme, pricing strategy, policy and regulation

1. INTRODUCTION

In recent years, governments in many countries have begun privatizing transportation infrastructure sectors. Some of the forces driving this movement include a scarcity of public resources, an increase in the demand for better service, and a political trend toward the deregulation of infrastructures from public monopoly. Confronted with these forces, the government, especially in developing countries, has turned to the privatization of transportation infrastructures. Among the most common privatization approaches, the Build-Operate-Transfer (BOT) concession scheme has become the major trend for the privatization of transportation infrastructure projects. In the BOT approach, the government grants a private sector the rights to finance, develop, and operate a revenue producing toll road for a defined time period (i.e., concession period) after which the facility is transferred back to the government (Walker and Smith, 1995).

Different pricing strategies of a BOT project are found to serve a wide range of objectives (project performances). From the private sector's viewpoint, the main concern is profit maximization, while under the government's perspective, social welfare maximization for the society is of interest. However, there exists a spatial equity issue in the sense that the changes of the benefits of road users traveling between different origin-destination (O-D) pairs may be significantly different when imposing some pricing strategies. This could result in another kind of unfairness to the travelers and become a new obstruction on the implementation of a pricing policy due to public rejection. Therefore, another meaningful consideration is to minimize the inequality of benefits generated from the BOT project.

A BOT project is typically regulated by the government on key issues of the project performances and price of the service. The government can impose some regulations to modify the BOT project to satisfy certain requirements. Recognizing this viewpoint, this paper focuses on the regulation and policy alternatives on the BOT project development. For comparison, five cases are analyzed and compared: (1) BOT without regulations, (2) BOT with pricing control, (3) BOT with construction cost subsidy, (4) BOT with concession period extension, and (5) BOT with a combination of policy and regulation. Case 1 considers the optimal pricing scheme for each party without regulation. Case 2 examines the effect of pricing control on the level of toll charge. Because pricing control makes the BOT financially infeasible, case 3 considers subsidy on construction cost to the private sectors to make the BOT project viable. Case 4 examines another government subsidy policy by extending the concession period to increase the duration of toll collection. Finally, case 5 investigates a combination of construction cost subsidy and concession period extension.

2. PROJECT PERFORMANCES AND FINANCIAL FEASIBILITY EVALUATION

The BOT project represents a major capital investment for which project performances and financial analysis must be carried out during the planning stages. In this paper, the project performances refer to the objectives from different party perspectives that include profit, social welfare, and equality of road users' benefits. The goal of the financial analysis is to evaluate the financial viability of the BOT project. Regardless of the public's needs, a BOT project will not be financed unless the financial position of the project is sufficient to attract investment from the private sectors. For this reason, the project performances and financial evaluation is the cornerstone of the entire feasibility analysis of the BOT project.

The methodology used for the project performances and financial feasibility evaluation is shown in Figure 1 and can be summarized as follows.

Step 1. A BOT network design problem with one or more objectives under demand uncertainty, formulated as a stochastic bi-level programming problem, is solved by the simulation-optimization procedure (see Chen *et al*., 2001, 2003a, 2003b). This first part of the framework is the interaction between the toll structure and the road user's response such that the traffic volumes patronizing the BOT roads can be predicted. This interaction can be posed as a Stackelberg game (Fisk, 1984). In this game, the transportation planner is assumed to have knowledge on how the users would respond to a given pricing strategy. However, it is important to recognize that the pricing strategy set by the planner can only influence (not control) the route choice decision of the users.

Step 2. From the annual traffic characteristics and cost of the BOT project, the project performances and the cash flow are determined.

Step 3. Project performances and three criteria for financial evaluation (i.e., the net present value (NPV), the internal rate of return (IRR), and the breakeven year) are all considered in the decision process.

Step 4. If the project is financially feasible but other project performances such as social welfare and profit are not satisfied, the regulation or constraint on these outcomes may be imposed so that the toll structure will be modified to satisfy certain requirements.

Step 5. If the project is not financially feasible with the present configuration, certain policies from the government (e.g., construction cost subsidy, concession period extension,

etc.) may be considered to modify the project cash flow in order to make the project financially viable. The process of project evaluation is repeated until the financial indices and project performances are satisfied.
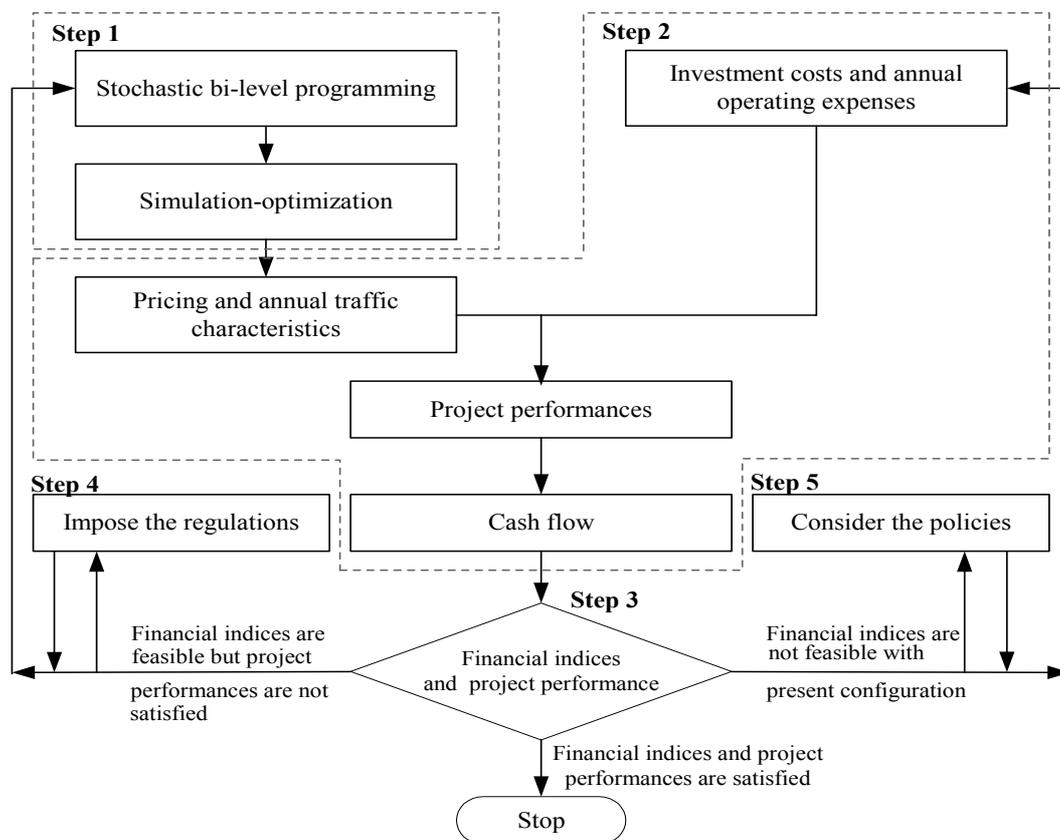

Figure 1. Project Performances and Financial Feasibility Evaluation Framework

The following sections provide the details of project performances and financial indices of BOT project.

2.1 Project Performances

Project performances refer to the objectives (goals) of the decision makers from different party viewpoints. In this paper three different perspectives are considered that include the private sectors, the government, and the road users. Three different pricing strategies from different perspectives are summarized in Table 1.

Table 1. A Comparison of Three Pricing Strategies

Pricing strategies	Perspectives	Objectives
Profit maximization	Private sectors	Maximize expected annual revenue
Social welfare maximization	Government	Maximize expected annual consumer surplus
Inequity minimization	Road users	Minimize expected Gini coefficient

2.1.1 Profit

For the private sectors, the main concern is profit when determining the viability of a BOT project. Profit is the difference between revenue and cost. The annual revenue of a BOT project is the number of road users (or traffic volumes) patronizing the BOT roads multiplied by the toll charge:

$$\psi^n = \sum_{a \in \overline{A}} \xi v_a^n x_a^n \,,$$ (1)

where ψ^n = annual revenue in year n; ξ = parameter which transforms the hourly link flow into the annual link flow; v_a^n = hourly flow on link a in year n; x_a^n = toll charge on link a in year n; and $\overline{A}$ = set of BOT links.

Cost of a BOT project is comprised of construction and maintenance-operating cost. The annual profit can be defined as:

$$\pi^n = \psi^n - C^n \,,$$ (2)

where π^n = annual profit in year n; and C^n = annual cost in year n.

2.1.2 Social Welfare

For the government, the main concern of a BOT project is the benefit defined in terms of social welfare added to society. The social welfare is defined as the difference between consumer surplus and cost of the BOT project (Yang and Meng, 2000). The annual consumer surplus in monetary terms is calculated as:

$$\vartheta^n = \frac{\xi}{\beta} \left\{ \sum_{w \in W} \int_0^{d_w^n} D_w^{-1}(\omega) d\omega - \sum_{a \in A \cup \overline{A}} v_a^n t_a^n \right\},$$ (3)

where ϑ^n = annual consumer surplus in year n; β = parameter that transforms the toll into an equivalent time value; A = set of links; W = set of origin-destination (O-D) pairs; $D_w^{-1}(.)$ = the inverse demand function of O-D pair w; d_w^n = demand between O-D pair w in year n; and t_a^n = travel time on link a in year n.

The annual social welfare can be defined as:

$$S^n = \vartheta^n - C^n \,,$$ (4)

where S^n = annual social welfare in year n; and C^n = annual cost in year n.

2.1.3 Inequality

For the road users, the main concern is the spatial equity of benefit distribution of the BOT project. The spatial equity impact can be described as the distribution of the benefits and

costs of the pricing scheme across the road users from different O-D pairs in the network. If the pricing scheme benefits only a small group of road users from some areas, while the rest of the population experiences a decline in benefits, the pricing scheme can be considered inequitable.

In this paper, the spatial distribution of the benefits and costs in the form of consumer surplus improvement of the BOT project is considered. The Gini coefficient that is commonly used as an income inequality measure is applied to evaluate the spatial equity impact of the BOT project development (Lorenz, 1905).

The annual Gini coefficient is calculated as:

$$G^n = \frac{\sum_{i=1}^{W}\sum_{j=1}^{W} d_i^n d_j^n \left| \hat{\vartheta}_i^n - \hat{\vartheta}_j^n \right|}{2(d^n)^2 \overline{\vartheta}^n},$$

(5)

where G^n = annual Gini coefficient in year n; $\overline{\vartheta}^n$ = average consumer surplus improvement in year n; $\hat{\vartheta}_i^n$ = consumer surplus improvement in year n for O-D pair i; d_i^n = travel demand of O-D pair i in a non-BOT case for year n; and $d^n = \sum_i d_i^n$ = total travel demand in the whole network for year n. The value of the Gini coefficient is between 0 and 1. The lower the Gini coefficient, the more equitable the BOT scheme.

2.2 Financial Feasibility

Financial feasibility for the BOT project development is based on the discounted cash flow (DCF) model, which is one of the most widely used techniques for financial evaluation. The DCF model brings together all the cash flow profiles of a project over the planning horizon (adjusted for time value of money), and combines them into a measure of NPV, IRR, and breakeven year.

2.2.1 Net Present Value

When an investment is made, the decision makers look forward to gaining benefits over the planning horizon against what might be gained if the money was invested elsewhere. The investor's required rate of return (RRR) for a capital investment is selected to reflect this opportunity cost of capital, and it is used to discount the estimated future cash flow to the present time. The net present value is the discounted value of the net return at the end of the planning horizon above what might have been gained by investing elsewhere at the RRR. In other words, it is the difference between the present value of the benefits (revenues) minus the present value of the costs of a project. In general, if the BOT project has a NPV greater than or equal to zero, it is considered feasible. If the NPV is greater than zero, the proposed project will earn a return on the investment greater than the RRR used as a discount rate.

2.2.2 Internal Rate of Return

The IRR has been proposed as an index of the desirability of project (Hendrickson and Au, 1989). In general, the higher the rate, the better the project. By definition, it is the discount rate at which the net present value of benefits equals the net present value of costs. This

method is usually applied by comparing the RRR to the IRR values. The IRR rule is to accept a project if its IRR > RRR and to reject a project if its IRR ≤ RRR.

2.2.3 Breakeven Year

The breakeven year represents the amount of time that it takes for the project revenue to recover its initial cost. The use of the breakeven year as a decision rule specifies that the BOT project with a breakeven year less than a specified number of years should be accepted. When comparing among the pricing strategies of the BOT project, the scheme with the quickest payback is preferred.

3. THE BAN PONG-KANCHANABURI MOTORWAY (BKM) PROJECT

3.1 General Background and Traffic Characteristics

In 1996, the Thai government reviewed the result of the Motorway Study conducted by the Japanese experts that was carried out on behalf of the Japan International Cooperation Agency (JICA) for the preparation of a master plan for the construction of inter-city motorways in Thailand. At present, some of the inter-city motorways have been constructed and opened for service such as the Bangkok-Chonburi (new route) and the Eastern Outer Bangkok Ring Road. In addition, there are sections under invitation for private sector joint investment such as the BKM project. Due to the present constraint of the national budget, the government has implemented an important policy on investment in the transportation infrastructure. The policy clearly states that the private sectors are invited to participate in the transportation infrastructure investment under the promotion and support of the government, so that the government's investment burden can be relieved. Consequently, part of the budget can be used for development in other parts of the country.

The BKM project, developed under the BOT scheme, has a total length of approximately 45 kilometers, starting from the city of Ban Pong, Ratchaburi province and extending to Kanchanaburi province, which already has a detailed design as shown on the project location map in Figure 2. A four-lane highway (two for each direction) with the capacity of 1900 PCU/h/lane will be built to connect the city of Ban Pong and the city of Tha Maka, and from the city of Tha Maka to the Kanchanaburi province.

For the traffic demand pattern, the base year of 2000 is used for developing the O-D trip matrices based on the existing travel pattern (from O-D surveys). The traffic characteristics of the base year network have been calibrated to reflect travel characteristics of the study area. The highway network in the design years includes the committed construction of the BKM project (Department of Highways, 2001). These design years for the analysis of the BKM project consist of 2009, 2019, 2029, and 2034.

Several basic transport planning data are required for the development of the traffic model, such as social economic planning data, traffic volume, and highway network characteristics. There are several important steps for the traffic model development: coding the planning data (population and employment according to the study area), modeling the present and future highway networks, developing the O-D trip matrices based on the existing travel pattern (from O-D surveys), assigning trips to the highway network, and finally the calibration process based on existing traffic data. Once the model has been calibrated to reflect the

existing travel characteristics of the study area, it can be used to forecast the future travel demand based on the socio-economic projections. The future travel demand projection is derived from the following equation:

$$T = POP * GPPC^E ,$$ (6)

where T = rate of traffic growth; POP = rate of population growth in the study area; $GPPC$ = rate of gross provincial product per capita growth; and E = elasticity factor of traffic growth to per capita income growth. The above equation shows the relationships between the traffic growth with respect to the growth rates of population and per capita income. The elasticity factor (E) is a power function that reflects the study area characteristics. An appropriate value of E has been derived based on the travel studies from the Traffic Engineering Division, Department of Highways (2001), population data, and gross provincial product (GPP) data. From the study, the following values of E are used: 1.67 for 2001-2006, 1.07 for 2007-2009, 0.75 for 2010-2019, 0.67 for 2020-2029, and 0.5 for the rest of the project life.
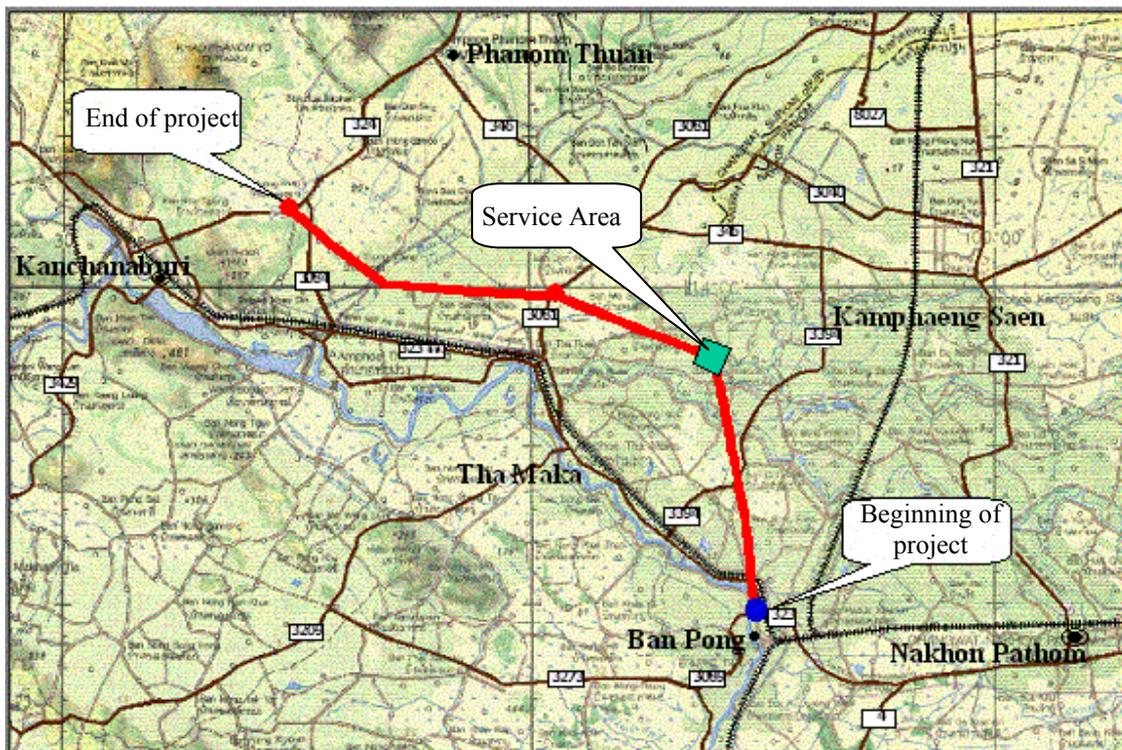

Figure 2. The BKM Project Location Map

Based on socio-economic projections, the increase of O-D travel demand will be as follows: increase 7.6% per year for 1999-2009, increase 3.8% per year for 2009-2019, increase 3.0% per year for 2019-2029, and increase 2.2% per year for 2029-2039. The trip matrices in the design years of 2009, 2019, 2029, and 2034, which are based on the base year trip matrix, have been projected according to the projection of socioeconomic planning parameters. The link characteristics and the trip matrices of the design years can be referred to Department of Highways (2001) and Subprasom (2004).

3.2 Costs of BKM Project and Value of Time of Road Users

The main part of the investment costs of the project is the construction cost. The construction cost of the BKM project is estimated from the quantities and the unit prices of work items using the information of the project area. Other cost items of the BKM project include maintenance cost, land acquisition cost, operating cost, and environment monitoring cost. The private sectors are responsible for all project costs except land acquisition and compensation costs, which are the responsibility of the government. The BKM project costs are summarized in Table 2 (Department of Highways, 2001).

Table 2. Summary of the BKM Project Costs

Project Cost	Million Baht	Million $US
Construction cost	5,541.92	138.55
Detailed design cost	96.98	2.42
Construction supervision cost	96.98	2.42
Land compensation cost	569.82	14.25
Property compensation cost	49.71	1.24
Tree compensation cost	2.24	0.06
Setting out right of way cost	14.70	0.37
Routine maintenance cost	24.70	0.62
Periodic maintenance cost (7th year and 22nd year)	153.38	3.83
Periodic maintenance cost (15th year)	190.30	4.76
Project operating cost	45.20	1.13
Environmental mitigation and monitoring cost	38.33	0.96

Note: 40 Baht equals 1 $US.

The data used to estimate the value of time (VOT) of road users was obtained from the National Statistic Office of Thailand and includes per capita income, hourly income per employed person, and average hourly income in the study area. It is assumed that the VOT for purposes other than business is 40% of the passenger's income, while the VOT is assumed to be equal to the passenger's income for business trips. The resulting VOT in the year 2000's value are as follows: 64.4 Baht per PCU-hour for 2000, 95.4 Baht per PCU-hour for 2009, 147.6 Baht per PCU-hour for 2019, 213.9 Baht per PCU-hour for 2029, and 252.8 Baht per PCU-hour for 2034 (Department of Highways, 2001).

3.3 Problem Setting

The pricing model for the BKM project is conducted for 30 years (concession period). The basic assumption for the analysis period is a 30-year term, starting in the beginning of 2005, with a design and construction period of 4 years, bringing it to the end of 2008. The service to motorists is available in the beginning of 2009 through the end of 2034. A 12% discount rate that the Department of Highways uses in their project evaluation is adopted for this case study.

A negative exponential demand function is used for annual O-D travel demand of the BKM project case study:

$$d_w^n(\varepsilon) = \bar{d}_w^n(\varepsilon)\exp(-\gamma c_w^n), \forall w \in W, \tag{7}$$

where $\bar{d}_w^n$ = the potential demand in year n; c_w^n = the average travel time, which includes equivalent time of toll for all travelers between O-D pair w in year n; ε = random variable associated with travel demand; and γ = a scaling parameter reflective of the sensitivity of demand to the full trip price. The potential O-D demands of design years are given in Department of Highways (2001) and Subprasom (2004). The value of γ is set to be 0.95 for all cases.

To handle travel demand uncertainty in the BOT network design problem, a stochastic simulation is used to simulate the uncertainty of travel demands based on probability distribution with pre-defined mean and variance. In this study, the Latin Hypercube Sampling technique is used to generate random traffic demand variates according to a predefined Normal distribution. The potential demand is chosen as the only key exogenous input variable to reflect the uncertainty of travel demand. Random samples of potential demand for each O-D pair in year n can be generated according to the following standard normal distribution:

$$\bar{d}_w^n = Mean(\bar{d}_w^n) \pm Z\sigma_w^n, \tag{8}$$

where Z = random variable generated from $N(0,1)$; and σ_w^n = standard deviation of potential demand between O-D pair w in year n.

The link travel time function used in the traffic assignment problem is the standard Bureau of Public Road (BPR) function, given below.

$$t_a^n(v_a^n) = t_a^0\left\{1.0 + 0.15\left(\frac{v_a^n}{c_a}\right)^4\right\}, \tag{9}$$

where t_a^0 = the free-flow travel time of link a; v_a^n = hourly link flow in year n; and c_a = capacity of link a.

4. NUMERICAL RESULTS

4.1 Optimal Pricing Schemes

This section presents the numerical results of the optimal pricing schemes for the BKM project without policy and regulation. It is expected that different pricing schemes yield different project performances. Since the capacity of the BKM project is already determined (i.e., 3,800 PCU/h), cost of project is fixed. Therefore, the term "performances" refer to the revenue, consumer surplus, and user's benefit inequality (Gini coefficient). Table 3 presents the optimal toll charge corresponding to the expected performances for each design year. The

numbers in brackets indicate the standard deviation of project performances. It is clear that all objectives conflict with each other and the tradeoff among the different objectives can be observed.

Table 3. Optimal Pricing of Different Pricing Schemes

Pricing strategy	Toll (Baht)	Revenue (million Baht)	Consumer Surplus (million Baht)	Gini
Year 2009				
Profit maximization	7.95	338.08 [3.34]	614.83 [5.94]	0.642 [0.095]
Welfare maximization	6.75	259.24 [2.05]	630.75 [6.00]	0.638 [0.088]
Inequality minimization	1.50	58.06 [0.92]	493.92 [4.87]	0.606 [0.080]
Year 2019				
Profit maximization	51.66	895.58 [151.74]	1,270.96 [112.37]	0.738 [0.124]
Welfare maximization	12.92	454.16 [5.69]	1,671.39 [179.54]	0.431 [0.077]
Inequality minimization	12.49	439.23 [5.46]	1,665.81 [175.40]	0.424 [0.071]
Year 2029				
Profit maximization	111.60	2,154.77 [271.04]	2,641.31 [250.56]	0.689 [0.099]
Welfare maximization	84.50	1,723.16 [219.18]	2,840.81 [279.09]	0.485 [0.078]
Inequality minimization	19.17	358.03 [2.83]	1,978.66 [130.50]	0.397 [0.066]
Year 2034				
Profit maximization	142.69	3,104.92 [314.77]	3,156.07 [294.07]	0.705 [0.118]
Welfare maximization	105.71	2,372.89 [230.51]	3,595.03 [326.03]	0.474 [0.072]
Inequality minimization	23.06	436.76 [3.27]	2,006.51 [202.05]	0.403 [0.070]

The key characteristics of each pricing scheme are different. The profit maximization scheme is found to impose the highest toll charge when compared with the other two schemes. Obviously, this characteristic of the pricing structure will not be suitable for social welfare maximization since it will overprice the trips. This is verified by the fact that the profit maximization scheme generated a relative lower consumer surplus. For the social welfare maximization scheme, the level of demand is an important factor. The optimal toll charge of this scheme must balance the induced and suppressed demand. The last objective is the spatial equity as measured by the Gini coefficient. The equity minimization scheme would try to distribute the users' benefit of the pricing scheme equally to all road users in the network. The toll charge under equity minimization is found to be very low, even with a high travel demand level. Toll charges of the social welfare maximization and profit maximization pricing scheme may be too high for the inequality minimization pricing scheme. The result explains the point about the characteristics of the social welfare maximization and equity minimization. The pricing scheme focuses on generating benefits for some particular O-D pairs (those O-D pairs that contribute most to the social welfare improvement). This will naturally create an equity problem due to its unequal treatment. On the other hand, the equity minimization scheme does not generate a substantially higher benefit for any particular O-D pair; therefore it reduces the unequal treatment. The relationships between profit and equity are found in a similar manner.

As mentioned previously, regardless of the project performances, the BOT roadway project will not be financed unless the financial position of the project is sufficient to attract private

sectors to invest in the BOT project. Figure 3 plots the stochastic cumulative profiles of the project's cash flow against time over the concession period for the profit maximizing scheme. These plots are comprised of the mean value of cumulative cash flow and the lower and upper bound values that give the 95 percent confident interval. The results also include the mean and standard deviation of NPV, IRR, and breakeven year. From the figure, there are three distinct phases. The first phase is the construction phase, which is characterized by the negative cumulative cash flow that results from the project disbursements on construction. At the end of this phase, the expected cumulative cash flow reaches its lowest point. The second phase encompasses the operation period when benefits increase until the expected cash flow line reaches the point where the expected cumulative cash flow is zero. This point is known as the expected breakeven year, which is 14.4 years. The last phase starts at the expected breakeven year and continues until the end of the concession period. The project cash flow in this phase goes upward due to the increasing revenue from toll collection of the BOT project.
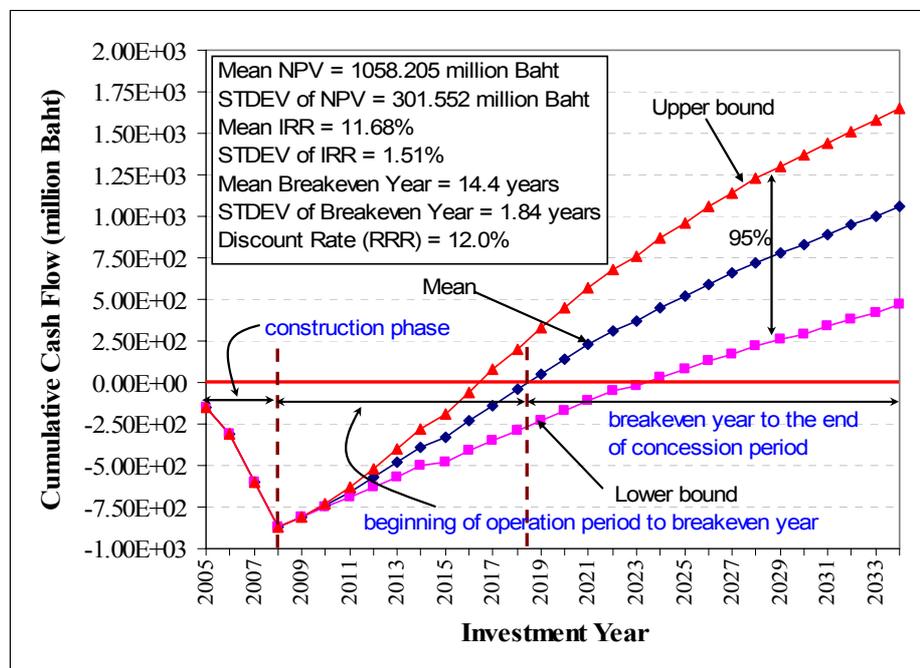

Figure 3. Stochastic Cumulative Cash Flow Profile for Profit Maximization

4.2 Pricing Control

It is a theoretical interest to analyze the effects of toll level on the performances and financial feasibility of the BOT project. For the BKM project, the Thai government had set regulation on the pricing structure. The base toll rate for the opening year 2009, based on the Ministry of Transport and Communication (MOTC) announcement No. 19 (Department of Highways, 2001), is 30 Baht. Once the initial toll rate has been established, toll rates are supposed to be increased every 3 years at an annual rate of 3%. Table 4 presents the effects of pricing regulation on the corresponding expected project performances in each design year. In addition, the percent differences in project performances compared with the optimal pricing scheme are also provided.

Table 4. Effects of Pricing Regulation to Project Performances

Design Year	2009	2019	2029	2034
Toll charge of pricing regulation (Baht)	30	40.32	54.18	62.81
Profit maximization				
Percent difference in toll charge	+277.36%	-21.95%	-51.45%	-55.98%
Expected annual revenue (million Baht)	154.63	858.08	1,027.18	1,302.20
Percent difference in revenue	-54.26%	-4.20%	-52.33%	-58.06%
Social welfare maximization				
Percent difference in toll charge	+344.44%	+212.07%	-35.88%	-40.58%
Expected annual consumer surplus (million Baht)	352.22	1,272.53	1,997.25	2,600.46
Percent difference in consumer surplus	-44.16%	-23.86%	-29.69%	-27.67%
Inequality minimization				
Percent difference in toll charge	+1900%	+222.82%	+182.63%	+172.38%
Expected Gini	0.735	0.642	0.595	0.63
Percent difference in Gini	+21.29%	+47.93%	+49.87%	+56.33%

Under the profit maximization strategy, toll charges in the design years 2019, 2029, and 2034 with pricing regulation are lower than the optimal pricing scheme. In the opening year 2009, however, the toll charge of regulated pricing is higher than non-regulated pricing. Since the demand of year 2009 is low, it is not necessary to impose a high price. A toll charge of 30 Baht is found to be too high for the opening year and could cause road users to choose the free roads instead of tolled links. From the government perspective, the optimal toll charge of this scheme must balance the induced and suppressed demand. If the toll charge is too low, it may cause an increase in travel demand; and traffic conditions on the BOT links may reach the highly congested level that results in a decrease in consumer surplus. Likewise, if too many trips are suppressed, it also causes a reduction in consumer surplus. From Table 4, it is found that the pricing structure in the years 2009 and 2019 are over the optimal pricing rate. On the other hand, toll charges are under the optimal pricing for the years 2029 and 2034. For the road user's benefit inequality minimization, the concept of minimizing spatial equity is to encourage a scheme with well distributed benefits to the road users of different areas. It can be observed that toll charges of regulated pricings of all design years are higher than the optimal pricing scheme. This pricing regulation results in an increase of the expected Gini coefficient that brings more inequality of benefits to the road users from different O-D pairs.

Figure 4 shows the effects of pricing regulation on the financial feasibility of the private sectors' perspective. As observed, cumulative cash flow under pricing regulations is inferior compared to the non-regulated case. One should note that the mean and standard deviation of the financial indicator in the figure is for pricing regulation. With pricing regulation, it yields an expected IRR of 6.40% with a standard deviation of 1.92%. As noted earlier, the RRR of the BKM project is 12%. Based on the investment rule, pricing regulation causes the BKM project to be infeasible in terms of expected IRR. The private sectors are not satisfied with this condition; therefore, the Thai government may need to propose other policies in order for the financial status of private sectors to become feasible.
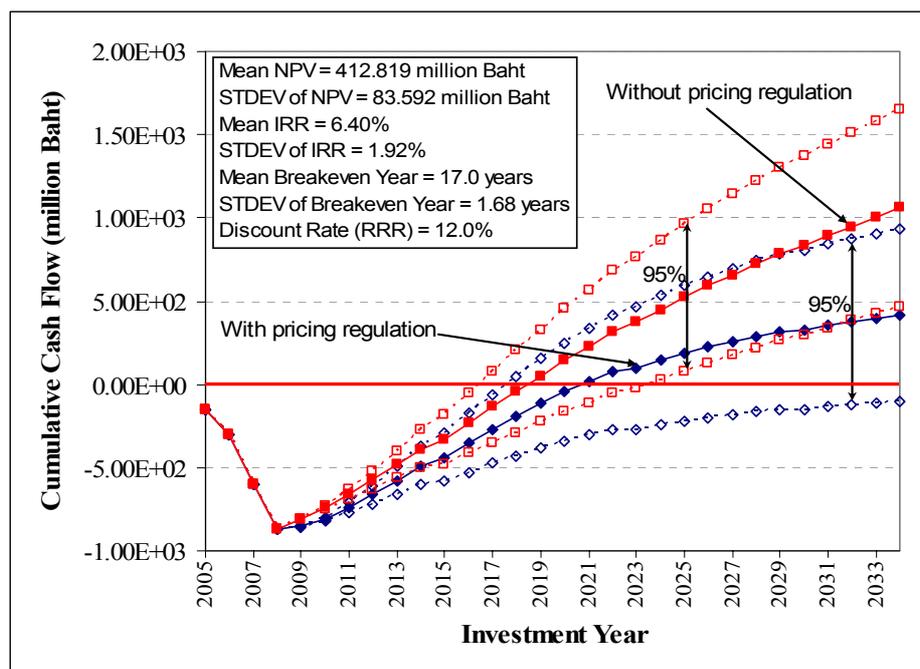
Figure 4. Effects of Pricing Regulation to Cumulative Cash Flow of Profit

4.3 Construction Cost Subsidy

Apart from the regulation on the pricing structure, the government may propose the policy to support the private sectors in order for them to obtain higher profit and for the economic performance of their cash flow to become feasible. One of the government support policies is construction cost subsidy.

In this section, we assume that the government continues to impose the pricing regulation. Since the financial performance of the private sectors in terms of the IRR is not feasible under the pricing control, the government needs to quantify the percentage grant of construction cost to make the expected IRR reach the minimum requirement (i.e., the RRR of 12.0%). It is necessary to point out that government support on the construction cost does not affect the pricing structure of a scheme because the government already fixed the toll charge regarding the pricing regulation of each design year. Likewise, it only affects the financial performances of the private sectors.

For this particular case, the government must grant at least 55% of the construction cost to make the expected IRR reach 12%. Figure 5 shows the cumulative cash flow profile of profit under the construction cost subsidy. At this amount of construction cost subsidy, the expected IRR increases to 12.18%. If the government grant is lower than 55% of the construction cost, the expected IRR is not financially viable. However, if a subsidy is higher than 55%, the expected IRR will exceed the minimum requirement whereby the private sector benefits over the government.
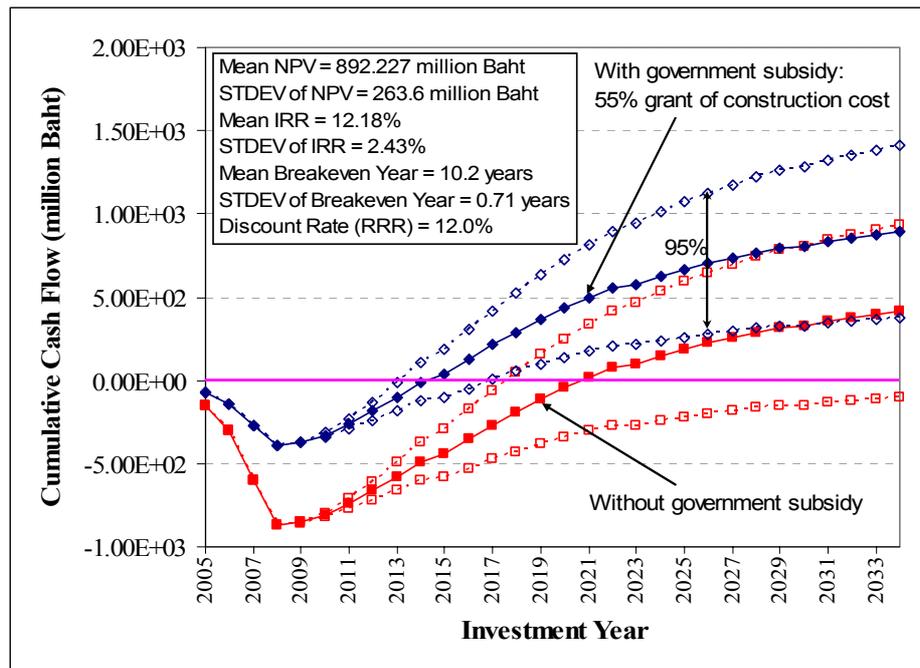
Figure 5. Effects of Construction Cost Subsidy to Cumulative Cash Flow of Profit

4.4 Concession Period Extension

An essential element of a BOT project is the duration of the concession period. The period of concession is normally set to allow the private sectors to build the project and operate it long enough to accomplish the economic goal. If the concession period is too long, the potential profits beyond that period must be so heavily discounted to the present value that they become negligible. A short concession period, however, may result in a high toll charge for the users (i.e., to recover the cost of the project and earn some profit), which could be unacceptable. In this section we assume that the Thai government regulates the toll charges of the BKM project to protect road users from the monopoly power of private sectors. Since the project IRR of the private sectors is not feasible under the pricing control, the government may propose a policy to allow the concession's length to be extended until the expected IRR of the BKM project reach the 12%. Because the analysis of this policy approach is beyond 30 years, certain assumptions are made. It is assumed that the O-D demand after year 2029 will increase 2.2% per year. The remaining costs of the BKM project after year 2034 include the routine maintenance cost and project operating cost. The value of time of the road users after year 2034 increases 3.4% annually. The toll charge under the pricing regulation after year 2034 increases every 3 years at 3% annually.

From the results, the optimal concession length must end at 2067. Figure 6 shows the relationship between the investment year and the project IRR. Obviously, the project IRR increases significantly from year 2034 to 2054. After that, the project IRR remains fairly steady due to the effect of discount factor of the cash flow. If the investment year is too long, profits of the BKM project are so heavily discounted to the present value that they are generally small and disregarded. At year 2067, however, the expected IRR of the BKM project is exactly 12% with a standard deviation of 1.01%. Therefore, the government must extend the concession period from 30 years to 63 years, whereby the private sectors fulfill the IRR obligation.
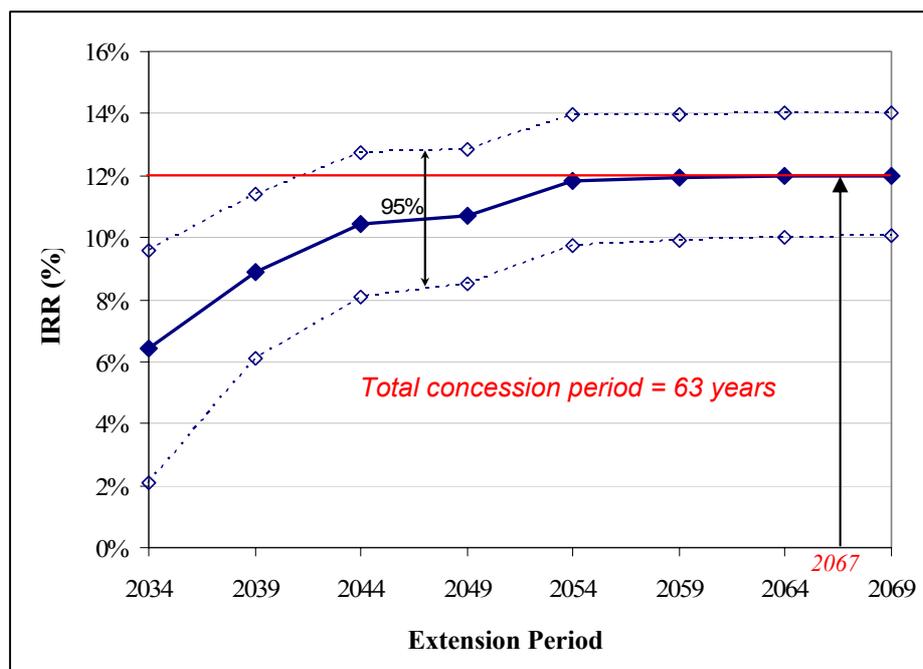
Figure 6. Effects of Concession Period Extension to the Project IRR

In summary, the policy of the concession period extension can ensure the private sectors accomplish the minimum rate of return (i.e., 12%).   The advantage of this approach is that for the government, it is not necessary to provide a grant or direct subsidy to the private sectors in which the concession period extension policy is suitable, especially when the government has a limited budget. On the contrary, from the private sectors viewpoint, the BOT project is not an attractive investment if the required investment period is too long to accomplish the economic goal.

4.5 Combination of Construction Cost Subsidy and Concession Period Extension

It is evident that the pricing regulation causes the financial infeasibility of the private sectors (i.e., expected IRR < 12%). The possible government-support policies of construction cost subsidy and concession period extension could make the private sectors to obtain a higher profit as well as the economic performance of their cash flow to become feasible. However, these policies are difficult to implement; the 55% grant of construction cost is considered an impossible budget for the government to accommodate. For the concession period extension policy, the private sectors feel that the BOT project is not an attractive investment, because of the length of time required to accomplish the return of investment.

The government, therefore, can do better by combining construction cost subsidy and concession period extension to make the policy feasible. In this section, it is assumed that the government allows the concession period to be extended by 10 years, in which the concession period will end in 2044 with total concession period of 40 years. With this condition, the government needs to quantify the percentage grant of construction cost to make the expected IRR reach the 12%. It is found that the government must grant only 13% of the construction cost which makes the expected IRR become 12.037%.

5. CONCLUDING REMARKS

This paper presented the analysis of policy and regulation in BOT project development applied to a real case study of the Ban Pong-Kanchanaburi Motorway project in Thailand. The BOT network design problem often involves three parties including, the private sectors, the government, and the road users, in which each of these parties has distinctive objectives. Numerical results were provided to demonstrate the conflict among the different objectives. Moreover, the results revealed the effects of regulation and various policies that were typically implemented on key issues of the project performances (profit, social welfare, and benefit's inequality) and financial feasibility of private sectors.

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