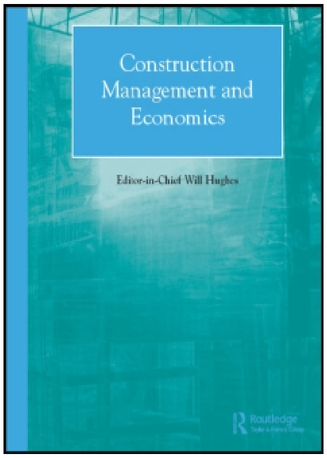

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Tariff adjustment frameworks for privately financed infrastructure projects

Sudong Ye [a]; Robert L. K. Tiong [a]
[a] Centre for Advanced Construction Studies, School of Civil and Environmental Engineering, Nanyang Technological University, Singapore.

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Tariff adjustment frameworks for privately financed infrastructure projects

SUDONG YE and ROBERT L. K. TIONG*

Centre for Advanced Construction Studies, School of Civil and Environmental Engineering, Nanyang Technological University, Singapore

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Since privately financed infrastructure (PFI) projects are usually natural monopolies, their tariffs should be regulated to ensure socially desirable outcomes. In reality, the regulation is usually realized through tariff adjustment mechanisms. There are four basic tariff adjustment frameworks for PFI projects – adjustment based on sale price, revenue, operating income and profit after tax. They have different risk exposures and incentives. The adjustment based on the sale price provides the project company with the highest potential to increase profit but exposes it to the highest risk, while the adjustment based on the guaranteed ROR exposes the project company to the lowest risk but provides the least potential for increasing profit. Adjustments based on the revenue or the operating income are somewhere in between. In practice, a hybrid of two or more adjustment frameworks may be adopted to adapt to specific project environments. A well-designed tariff adjustment framework can create a 'win–win' solution for both the public and private sectors.

Keywords: Regulation, tariff adjustment framework, privately financed infrastructure, BOT, risk management

Introduction

Most infrastructure projects are monopolies or near-monopolies in nature. The 'standard' competition is very unlikely to be the first-best solution to privately financed infrastructure (PFI) projects since it would imply a multiplication of the infrastructure in the same neighbourhood (Crampes and Estache, 1997). As a result, the developer may use its market power to obtain a higher price. To prevent monopolistic behaviours, concessions for the development of PFI projects may be awarded through *ex ante* competition. To promote *ex ante* efficiency, it would be necessary to carry out periodic re-bidding, but this is not practical due to high transaction costs. Therefore, it is necessary to introduce regulation into PFI projects to prevent project companies from pursuing monopoly prices using their market power.

In the absence of contractual guarantees, after the facilities have been constructed, the government might arbitrarily regulate tariffs and the developers might attempt to increase tariffs in their favour. Thus, tariff adjustment is often used as a substitute for regulation. The question is then how to design responsive tariff adjustment mechanisms for PFI projects. In this case, a regulatory framework provides a sound basis for designing tariff adjustment mechanisms.

Traditionally, firms with monopolies are regulated by the rate-of-return (ROR) framework. The Averch-Johnson model shows that regulated firms may use inputs inefficiently under this regulation (Train, 1991). Moreover, it is also criticized for being costly to regulators (Liston, 1993). As an alternative, sale-price regulation was developed to induce regulated firms to perform more efficiently, but this cannot overcome all the shortcomings of ROR regulation. According to Brennan (1989), if the price caps are not tied to quality in some way, and if quality can be varied by the regulated firm, the quality may be lowered to minimize costs. Nevertheless, both ROR and sale-price regulations can be used as a sound basis on which tariff adjustment mechanisms can be designed. Since most PFI projects are exposed to various risks, more tariff adjustment frameworks should be developed to meet the need of risk management.

*Author for correspondence. E-mail: clktiong@ntu.edu.sg

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This paper systematically explores tariff adjustment frameworks for PFI projects. It then qualitatively analyses their risk exposure and incentives and quantitatively assesses the effect of adjustment frameworks on the tariff charged to customers and the ROR earned by the project company through simulation analysis. Finally, considerations in choosing adjustment frameworks are suggested to make them more responsive to risk control considerations.

Tariff adjustment mechanism

The mission of tariff regulation is to replicate the results that the competitive market system would achieve in the way of reasonable prices and profits (Morin, 1994). It contains two key concepts – reasonable prices and profits – because consumers are concerned with prices, whereas project developers are concerned with profits after tax. As a substitute for regulation, tariff design (consisting of the initial tariff and adjustment mechanism) for PFI projects has the same mission. Thus, it should safeguard consumers' interests without undermining the project viability, while maintaining a certain incentive for the project company to develop and operate projects efficiently. In other words, the general principle of tariff design is to ensure that such services are provided at the lowest possible costs (i.e. economic efficiency), while providing sufficient monetary incentives (fair return and risk control) for project companies to devote their resources to the development of infrastructure.

Bases of tariff adjustment

According to the above principle, the operating revenue of the project company should at least meet the cost of production, which includes operation and maintenance (O&M) costs, debt service, allowance for depreciation, taxes and a fair return. The operating revenue is the product of tariff and demand, and the fair return is cash flow remaining after deducting O&M costs, debt service, depreciation and taxes from the operating revenues. These deductions from the revenue form 'cash waterfalls'. Any change in tariff will lead to changes in downstream components of the cash waterfalls such as revenue, operating income, profit before and after tax. Theoretically, any component of the cash waterfalls can be chosen as a basis on which the tariff is adjusted to maintain the base at a given level. In reality, adjustment based on the profit before tax has more or less the same effect as that of adjustment based on the profit after tax because tax is relatively stable over a long period time. Thus, there are four possible tariff adjustment bases: (1) sale price; (2) operating revenue; (3) operating income; and (4) profit after tax.

Once the adjustment base is identified, the next step is to determine an allowable level of adjustment base, namely, an allowed price (price cap), an allowed revenue, an allowed operating income and an allowed ROR after tax. Then, a mechanism should be developed to adjust the tariff in order to maintain this targeted level. When changes in the adjustment base are observed due to changes in specified control factors, the tariff will be adjusted accordingly in order to maintain the adjustment base at a specified level (i.e. a guaranteed value), or within a given range (i.e. a band of values), or under a given level (i.e. a cap), as shown in Figure 1.

Determination of base levels

Adjustment base levels can be determined directly or indirectly. The direct approach is to determine the base

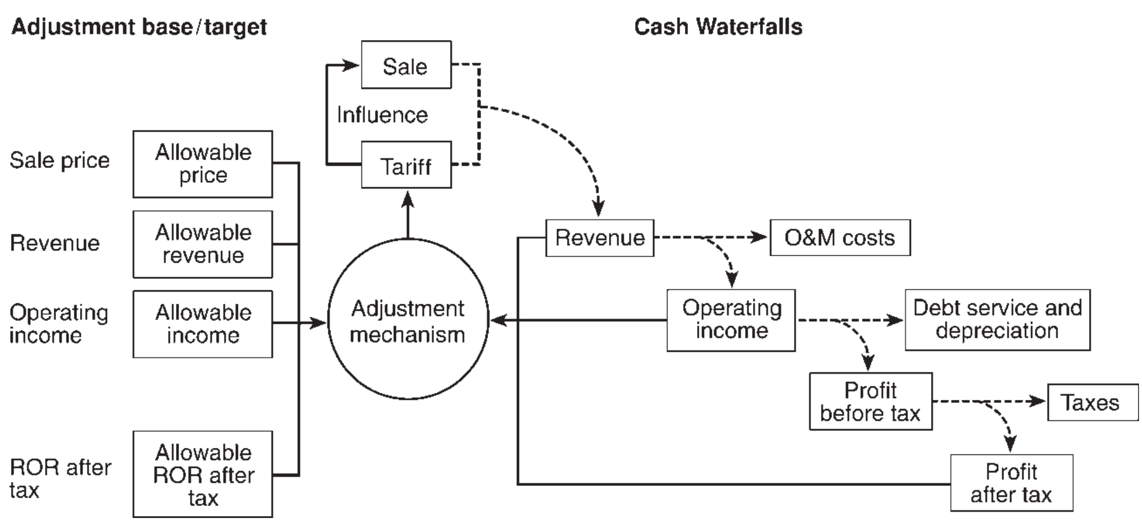

Figure 1 Cash waterfalls and tariff adjustment bases

levels based on the concept of a fair return, whereas the indirect approach determines the base levels by comparing the performance of similar projects, or by estimating those of a model efficient project, or by competitive bidding.

A fair return is the production of the rate base and the ROR. For a PFI project, the rate base can be measured by estimating the construction costs of the project. The actual yearly rate base varies year to year and depends on the depreciation method of the investment. This results in unnecessary changes in tariff. To simplify the problem, the equivalent uniform annual worth (EUAW) may be used as a yearly rate base. In this case, although the tariff determined in this way may not exactly reflect actual yearly revenue requirements, the project company can have more flexibility to choose debt – equity ratios and depreciation methods. As a result, the varieties of capital structures and depreciation methods will be reflected in the profit after tax rather than in the tariff.

Theoretically, the ROR can be measured as the cost of capital. For PFI projects, which are usually financed by debt and equity, the cost of capital is the weighted average cost of capital. The debt interest rate is the inter-bank offer rate for a specified financial market, and the required ROR on equity can be derived from various financial models such as the capital asset pricing model (CAPM) and the Arbitrage Pricing Theory (APT). Actual RORs are negotiated by the contracting parties.

Once the ROR is determined, adjustment base levels can be determined by using the ROR as the discount rate. According to the concept of EUAW, the investment is recovered through a series of uniform amounts calculated by multiplying the capital investment by the capital recovery factor. Thus, the annual revenue requirement consists of EUAW of the total investment, yearly O&M costs and tax. This revenue requirement can be used as the operating revenue cap, that is, the revenue requirement for the first year can be used as the initial operating revenue cap. The initial 'fair' price cap can be obtained by dividing the operating revenue cap by a 'fair' expected demand. And the operating income cap is obtained by deducting estimated O&M costs from the operating revenue cap. The ROR after tax is assumed to be the ROR.

If the allowed base level is determined based on the concept of a fair return, all the regulatory frameworks require similar information to determine the ROR. According to Liston (1993), information requirements for price-cap regulation are comparable with those for ROR regulation if regulators want to determine a proper price cap. In contrast, if the allowable level of regulatory base is determined based on benchmarking, different regulatory frameworks have different information requirements. For example, price-cap can be determined by comparing similar projects without knowing the actual production cost of the project, or alternatively the concession is auctioned off to the promoter that offers to charge the lowest per-unit price.

Adjustment mechanisms and risk management

In the development of PFI projects, the project company is exposed to various risks such as exchange rate movements, demand uncertainty, changes in fuel prices and interest rate fluctuation. To secure the profit after tax, a project company is concerned not only with the determination of allowed levels of adjustment bases that will yield the expected profit, but also with the design of adjustment mechanisms that will protect the profit against adverse business conditions. Since tariff adjustment mechanisms do not increase or reduce, but only redistribute, the total and real risks among the contracting parties, tariff adjustment is concerned with whether or to what extent the project company is entitled to protection of its real income against adverse changes in business conditions.

Adjustment based on the sale-price and inflation and exchange rate risk control

Under the sale-price adjustment framework, constraints are directly set on prices charged to consumers. The common constraints are to set minimum and maximum prices as boundaries and allow discretion between these boundaries (i.e. banded sale-price regulation), or to put a cap on price (i.e. price-cap regulation).

Over the long concession period, inflation may cause operating costs to rise and the real ROR to shrink. According to the above concept, the price cap (or the lower and upper bounds) should be adjusted through either a pre-specified upward adjustment formula or an inflation-rate indexed enhancement, that is $P_t = P_{t-1}(1 + I_t)$, where P_t and I_t are the price and inflation rate at period t, respectively. Since technological advancement may increase operating efficiency and reduce operating costs, leading to efficiency gains, the X-factor (productivity efficiency/offset) should be introduced, that is $P_t = P_{t-1}(1 + I_t - X_t)$.

To allow the company the flexibility to recover additional capital, Crew and Kleindorfer (1992) introduce the Z-factor (capital recovery/depreciation factor) into the price-cap formula, that is $P_t = P_{t-1}(1 + I_t - X_t + \delta_t)$, where δ_t is the company-selected capital recovery factor for period t. According to the underlying concept of sale-price regulation, the company may propose a higher capital recovery factor, but is required to accept a higher X-factor so that the ratepayer is better off over the life of the concession period.

The price formulae above address only inflation risks. When there are mismatches between the revenue currency and currencies for operating costs, debt repayment and dividend payments, the developer may suffer losses resulting from changes in exchange rates. Thus, the sale-price regulation may be extended to address exchange rate risk – the price cap may be adjusted also for exchange rates. Two forms of adjustment are considered: (1) total adjustment where currency for revenues mismatches currencies for all production costs; and (2) partial adjustments where currency for revenues mismatches currencies for partial production costs. Usually only partial production costs require foreign exchanges. Thus, tariff adjustment is limited to the currency-mismatched portion if an all-in tariff structure is employed; or to currency-mismatched components if a compound tariff structure is adopted. In this case, $P_t = P_{t-1}(1+I_t-X_t+\delta_t)(1-\alpha_t+\alpha_t\gamma_t)$, where α_t is the percentage of mismatched component for period t, and γ_t is exchange rate index for period t.

The underlying concept of adjustment based on sale prices is that the ROR earned by the developer should be of no interest to the concession authority or customers as long as the developer can keep the rate of increase of prices less than the inflation rate. As a result, once the initial price is determined, prices charged to customers are decoupled from profits earned. Thus, the project company can achieve high profit through (1) increasing the quantity of sales, (2) enhancing operation efficiency to reducing O&M costs, (3) using low cost of capital, and (4) seeking preferential tax treatment from the government. The project company, however, may suffer losses if any of the above items goes wrong, since the adjustment-based sale-prices can control inflation and exchange rate risks only. For example, decline in market demand, soar in O&M costs, rise in debt interest rates and adverse changes in tax law can all lead to losses of profits. Therefore, this adjustment framework provides the most incentive for the project company to develop and operate projects efficiently on the one hand, but exposes the project company to a high level of risk on the other hand. Moreover, this adjustment requires less information except that the initial base-level determination requires more information, and provides predictable tariffs.

Adjustment based on revenue and demand risk control

Adjustment based on revenue aims to control the revenues of the project company at a given level, for example, to put a cap on the revenue (revenue-cap adjustment) or to set a midpoint revenue and then allow revenue to vary in either direction by some pre-specified amount (banded revenue adjustment).

Since the revenue is the product of sale price and demand, keeping the revenue at a given level means adjusting sale price with demand: if the revenue is reduced due to the decline in market demand, it will be offset by an increase in sale price, and vice versa. Under revenue-cap adjustment, tariff is directly adjusted with the quantity of demand: $P_t = R_t/Q_t$, where P_t and Q_t are the price and the quantity of demand at period t, respectively; R_t is the expected operating revenue at period t.

Similar to the adjustment mechanism-based sale prices, adjustment for inflation can be made through the operating revenue using either a pre-specified upward adjustment formula or an inflation-rate indexed enhancement which takes account of inflation and efficiency gains – the expected operating revenue at period t is derived from $R_t = R_{t-1}(1 + I_t - X_t)$. Exchange rate risk can also be taken into account through introducing an exchange rate index factor to adjust the relevant portion of the revenue cap. The basic idea is the ROR earned by the developer should be of no interest to the government or customers as long as it can keep the rate of increase of revenues less than the rate of inflation.

Therefore, the adjustment based on revenues can control demand risk as well as inflation and exchange rate risks. But risks of O&M costs and debt interest, and adverse changes in taxation remain in the project company's hand. The removal of demand risk may remove the incentives to maximize sales to consumers because the project company may intentionally produce less output and charge a higher price. On the other hand, the uncovered risks may provide the project company with incentives to increase its profit after tax through efficient operation and optimal financing. In addition, the revenue cap includes O&M costs, which are set at a certain level of output. When market demands are less than the expected levels, the actual O&M costs are less than the O&M cost component of the revenue cap, which will benefit the project company and result in higher tariffs.

Adjustment based on operating income and fuel price risk control

Adjustment based on operating income aims to control the operating income of the project company at a given level. As the operating income is the difference between revenue and O&M costs, any change in demand and O&M costs results in changes in operating income. Therefore, in addition to adjustment for demand, the tariff should be adjusted for O&M costs.

As O&M costs include fuel costs –largely dependent on fuel prices, which are out of the control of the project company – the tariff should be adjusted for the fluctuation of fuel prices. In this case, the tariff should be broken down to separate the component (T_f) related to fuel costs. To stimulate the project company to operate efficiently, only the fuel-related component is indexed to fuel prices or adjusted by using a cost pass-through formula. The most common approach is to reduce the impact of fuel price fluctuations on profit using the cost pass-through formula: $T_{f,t} = T_{f,t-1}(P_{f,t}/P_{f,t-1})$, where $T_{f,t}$ and $P_{f,t}$ are the fuel tariff and the fuel price at period t, respectively.

Similarly, adjustment for inflation can be made through escalating the operating income by using either a pre-specified upward adjustment formula or by indexing to the inflation rate. Moreover, the X-factor (productivity offset factor) may be introduced to enhance operation efficiency. Exchange rate risk can also be taken into account through introducing an exchange rate index factor to adjust the relevant portion of the operating income cap.

Under this adjustment framework, the risk of O&M cost over-run is mitigated. This may eliminate the incentives to operate efficiently. Thus, fuel cost pass-through is used instead of 'pure' income-cap regulation. Since both demand and O&M cost risks are mitigated, this framework is less risky. On the other hand, it has less potential for the project company to earn more.

Adjustment based on rate of return and risk management

Adjustment based on profit after tax allows the project company to earn a fair return. The typical adjustment framework based on profit after tax is a guaranteed ROR on investment, by which the price is adjusted to allow project companies to earn a specified ROR with respect to an agreed rate base. Since profit after tax is the final component of cash waterfalls, changes in any of the other components will result in changes in ROR. Therefore, the tariff should be adjusted with inflation, exchange rate, demand, fuel price, debt interest rate and taxation, so as to control the ROR at a targeted level.

When the cost of production consists of several components that are affected by different factors, a compound tariff structure may be adopted to accommodate different adjustment mechanisms. In this case, it seems to form a hybrid of two or more adjustment frameworks.

Under this adjustment mechanism, any unforeseen cost or loss will be compensated by increasing the tariff on the one hand and any increase in return will be controlled by cutting the tariff on the other hand. The project company may abuse this adjustment mechanism. For example, the project company has no incentive to minimize production cost because it may achieve the allowed ROR by increasing prices rather than removing inefficiencies in production. In order to stimulate the project company to develop and operate the project efficiently, the guaranteed ROR regulation is modified, extended and refined to involve incentives. The principal variants include (1) revised ROR adjustment framework, which sets an allowed range of ROR, or sets a ceiling ROR but does not guarantee any minimum ROR; and (2) incentive ROR adjustment framework, which incorporates incentive schemes into the framework such as performance-linked allowed ROR (performance bonus and penalty) and profit-sharing mechanisms. In addition, it is worth noting that double risk compensation will occur when the adjustment mechanism contains vigorous risk mitigation measures and, at the same time, the developer is allowed to earn a higher risk premium.

The comparison of tariff adjustment frameworks

The four adjustment frameworks are different to each other. The key difference lies in the range of cash flow components to be adjusted. This difference leads to different risk exposures. The sale-price regulatory framework may only cover inflation and exchange rate movements, while the ROR regulatory framework may cover almost all risk factors, such as demand and operating costs, as well as inflation and exchange rate movements. The others are somewhere in between. Table 1 shows the

Table 1 Risk factors addressed under different adjustment frameworks

Adjustment bases	Risk factors to be addressed				
	Inflation risk	Exchange rate	Market demand	Fuel cost	Taxation
Sale-price cap	√	√			
Revenue cap	√	√	√		
Operating income	√	√	√	√	
ROR after tax	√	√	√	√	√

coverage of risk factors under different adjustment frameworks.

The difference also leads to different incentives. The adjustment based on sale price provides the project companies with a strong incentive to improve internal efficiency on the one hand. The guaranteed ROR after tax provides a weak incentive to improve internal efficiency at the other end. Adjustments based on revenue and operating income are somewhere in between. As far as their incentive properties and risk exposures are concerned, the adjustment frameworks can be placed on a two-dimensional diagram (Figure 2). It is worth noting that Figure 2 presents just the relative relationships among the adjustment frameworks. If the costs of operation and maintenance are relatively small, there is not much difference between the adjustment based on revenue and the adjustment based on operating income because there is little difference between the revenue and the operating income.

Moreover, the difference also leads to different information requirements for the implementation of adjustment mechanisms and, hence, the costs of enforcing the adjustment will increase accordingly. The adjustment based on sale price controls tariff directly and thus requires less information. In contrast, the guaranteed ROR after tax requires more information about the project's financial performance. Adjustments based on revenue and operating income are somewhere in between.

To sum up, each adjustment framework has its own advantages and disadvantages. The more cash flow components a tariff adjustment framework is designed to adjust, the more protection it provides. This results in a complicated adjustment process, which carries some high costs, including potential losses in flexibility.

Quantitative assessment of adjustment frameworks

To quantitatively assess the performance of the four tariff adjustment frameworks, a simulation model is developed by integrating the conventional discounted cash flow model and the Monte Carlo sampling technique. As the public is concerned with the tariff and the investors are concerned with profit, the average tariff and the internal rate of return (IRR) are chosen as performance indicators. Thus, the model outputs are average tariff and IRR distributions. Input data are from a hypothetical PFI project, which can be any kind of infrastructure project, for example, a coal-fired power plant. The input data include five stochastic variables, namely demand, fuel price, exchange rate, debt interest rate and inflation rate. They are assumed to be independent and normally distributed. In addition, the capital investment is assumed to depreciate in a straight-line method, and the principal of the debt is repaid in equal instalments (note that different depreciation methods and debt repayment schedules will result in a different IRR). Basic data of the hypothetical project are presented in Table 2, and assumptions for simulation are presented in Table 3.

Determining allowed levels of adjustment bases

Assume that 15% of ROR after tax on the book value of investment will produce a fair return. According to the concept of EUAW, the annual revenue requirement consists of EUAW of the total investment, yearly O&M costs, and tax. The revenue requirement for the first year can be used as the initial operating revenue cap. The initial 'fair' price cap can be obtained by dividing the

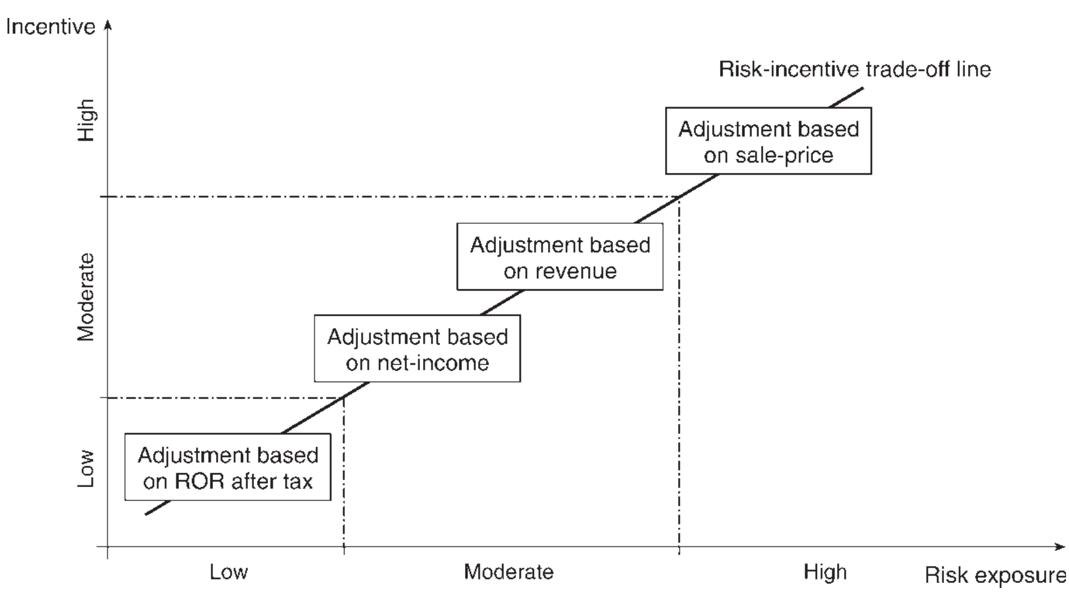

Figure 2 Risk-incentive characteristics of regulatory frameworks

Table 2 Basic data of the hypothetical project for simulation

Items	Base case (budget/forecast)	Remarks
Design capacity	5670 million units per year	For power projects, the unit is 'kWh'.
Capital investment	$US600 million	Excluding interest during construction
Concession period	18 years (including three-year construction)	
Debt-equity ratio	75:25	A typical ratio of PFI projects
Loan maturity period	12 years (four-year grace period)	

Table 3 Assumptions for simulation

Variables	Assumed/expected value	CoV(σ/μ)	Distributions
Market demand	4252.5 M units (= 75% of design capacity)	0.3	$N(4252.5, 1275^2)$
Fuel required	1 760 000 tonnes (for the expected demand)	–	
Fuel price	$L320/tonne (a stochastic variable)	0.3	$N(320, 96^2)$
Other O&M costs	45% of fuel cost at expected demand	–	
Exchange rate	$L8 = $US1 (a stochastic variable)	0.3	$N(8, 2.4^2)$
Debt interest rate	10% per year (a stochastic variable)	0.3	$N(0.1, 0.03^2)$
Inflation rate	4% per year (a stochastic variable)	0.3	$N(0.04, 0.012^2)$
X-Factor	2% per year (constant)	–	

Note: $L = local currency dollar; CoV = coefficient of variation.

operating revenue cap by an expected demand. And the operating income cap is obtained by deducting an estimate O&M costs from the operating revenue cap. The allowed base levels are listed in Table 4.

Analyses of simulation results

Table 5 summarizes the results of simulation, and Figures 3 and 4 show the cumulative distributions of average tariffs and IRR under the four adjustment frameworks.

From Figures 3 and 4 it can be seen that the tariff under the price-cap adjustment framework is spread in the narrowest range between $L0.497 and $L0.657 per unit ($L = local currency dollar), while its IRRs vary in the broadest range (between 11.06% and 22.88%). This means that the tariff is well controlled, while the project company has great potential to earn high IRR or suffer heavy loss. This supports Beesley and Littlechild's (1989) claim that price-cap regulation provides straightforward commercial incentives to greater efficiency and at the same time ensures that expected gains would be passed on to the consumers. This is because uncertainties in demand, fuel price and interest rates are reflected in the realized ROR rather than in the tariff.

Figure 3 shows that the revenue-cap adjustment framework has the broadest range of tariff distribution (between $L0.448 and $L2.294 per unit). The broad-spreading tariff distribution results from the overpaid O&M costs when market demands are less than expected. Figure 4 shows that it has a relatively

Table 4 Levels of tariff adjustment bases

Adjustment bases	Initial value	Remarks
Sale-price cap	$L0.50/unit	= Revenue requirement ÷ Expected demand
Operating revenue cap	$L2020 million	= Revenue requirements = EUAW + O&M costs + Tax
Operating income cap	$L1436 million	= Revenue cap – Estimated O&M costs
ROR after tax	15%	Assumed (negotiated by contracting parties)

Table 5 Tariffs and IRRs under different adjustment frameworks

Adjustment frameworks	Average tariff ($L/unit)				IRR			
	Mean	Standard deviation	Min.	Max.	Mean (%)	Standard deviation	Min. (%)	Max. (%)
Sale-price cap	0.577	0.0269	0.497	0.657	16.49	0.0181	11.06	22.88
Operating revenue cap	0.660	0.1412	0.448	2.294	16.54	0.0128	12.09	20.22
Operating income cap	0.645	0.1046	0.467	1.819	16.54	0.0040	15.13	17.81
ROR after tax	0.644	0.1040	0.463	1.807	16.48	0.0029	15.74	17.32

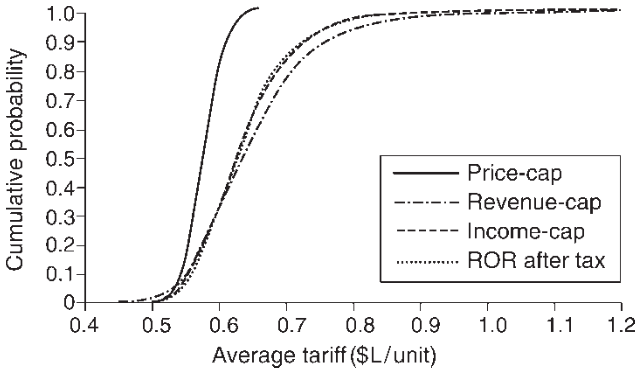

Figure 3 Tariff under different regulatory frameworks

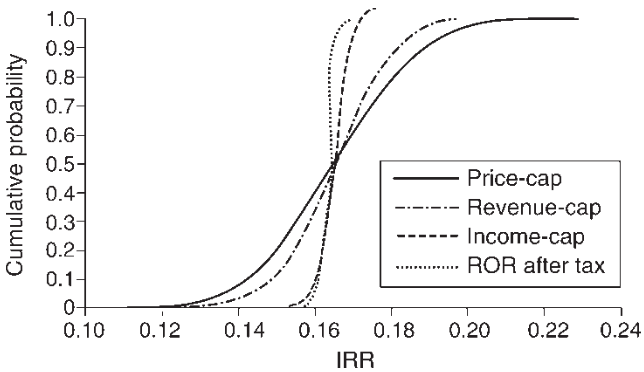

Figure 4 IRR under different regulatory frameworks

broad-spreading IRR distribution ranging from 12.09% to 20.22%. This is because uncertainties in fuel price and interest rates are reflected in the realized ROR rather than in the tariff, but the uncertainty in demand is reflected in the tariff rather than in the ROR.

The tariff of the operating-income cap adjustment framework is distributed in the range of $L0.467 to $L1.819 per unit, while its IRR is distributed in the range of 15.13% to 17.81%. This is because uncertainties in demand and fuel prices are reflected in the tariff rather than in the ROR, but the uncertainty in interest rates is reflected in the realized ROR rather than in the tariff.

The tariff under the 'ROR after tax' adjustment framework varies from $L0.463 to $L1.807 per unit. This broader distribution means that it is more difficult to predict tariffs. On the other hand, the IRR is relatively stable, varying between 15.74% and 17.32%. The narrow-spreading IRR distribution shows that the project company is exposed to less risk and has less potential to increase its return because uncertainties in demand and fuel price are reflected in the tariff rather than in the ROR.

There are two points worth further discussion. Among the four adjustment frameworks, the revenue-cap adjustment framework has the broadest range of tariff distribution. Theoretically, the tariff should vary in a range which is broader than the range under the price-cap adjustment framework but narrower than the range under the operating-income-cap adjustment framework. This is because revenue requirements will be reduced because of the reduction in fuel costs under the operating-income-cap adjustment when demands are less than expected, while the fuel costs are kept at the expected level under the revenue-cap adjustment framework, regardless of actual demands. This difference will be diminished when the weight of fuel costs in the total production cost reduces. The second point is that the tariff distributions of the operating-income-cap adjustment framework and the ROR adjustment framework are very close to each other. This is because the adoption of the EUAW method ignores the varieties of capital structures and depreciation methods. As a result, there is little difference in revenue requirements.

Applications of tariff regulations in PFI projects

Although the 'pure' form of the above-mentioned adjustment frameworks can be applied to PFI projects, a hybrid of two or more adjustment frameworks is usually used in order to adapt to specific project environments. In this kind of adjustment design, compound tariff structures are usually adopted in that different tariff components are adjusted with different factors using different adjustment mechanisms. The adjustment mechanism is designed to reflect changes in costs resulting from factors that are outside the project company's reasonable control. Most independent power projects have hybrid tariff adjustment mechanisms, for example the Laibin B power project in China, the Paiton power project in Indonesia and the Hub power project in Pakistan.

(1) *Laibin B*. The tariff of Laibin B consists of the operating tariff (floating) for minimum net electricity output (MNEO), the operating tariff (fixed) for MNEO, the operating tariff for additional net electricity output (ANEO) and the fuel tariff. Among them, the floating portion of the operating tariff is adjusted in accordance with variations in the value of the RMB (Renminbi, the Chinese monetary unit) against the US dollar. When the value of the RMB against the dollar is below 95% of the base exchange rate, the exchange rate factor is increased accordingly, and when the value of the RMB against the dollar is above 105% of the base exchange rate, the exchange rate factor is reduced accordingly. In other situations, the exchange rate factor is kept unchanged. The demand

risk is controlled by guaranteed minimum purchase of electricity output. The fuel tariff is adjusted with fuel prices over three load ranges: above the base load of 80%, from load 80% to 60%, and from load 60% to 40%. Inflation is implicitly taken into consideration through (i) escalating the coefficient of operating tariff (floating) for MNEO, which gradually increases from RMB0.2416/kWh (equivalent to $US0.0291/kWh at the then exchange rate) in the first operation year to RMB0.3174/kWh (= $US0.0382/kWh) in the last year of concession; (ii) increasing the operating tariff (fixed) for MNEO from RMB0.0358/kWh (= $US0.0043/kWh) in the first operation year to RMB0.1839/kWh (= $US0.0222/kWh) in the last year of concession gradually; and (iii) increasing the operating tariff for ANEO from RMB0.1400/kWh (= $US0.0169/kWh) in the first operation year to RMB0.3722/kWh (= $US0.0448/ kWh) in the last year of concession year by year.

(2) *Paiton*. The power purchase agreement (PPA) of the Paiton power project in Indonesia provides for a four-part tariff structure consisting of capital component, fixed O&M component, fuel component and variable O&M component. The capital component provides for debt service, taxes and return on equity. The fixed O&M component is designed to pay fixed O&M costs, which is adjusted annually for changes in the consumer price index. The fuel component is calculated based on the costs of fuel charge (pass-through formula). The variable O&M component is intended to recover all of the variable O&M costs. The tariff is denominated and made in the local currency but adjusted to account for exchange rate fluctuations. The capital component and fixed O&M component are based on net dependable capacity available to the offtaker, irrespective of market demands, while the fuel component and variable O&M component are based upon the actual amount of net electrical output. Moreover, the fixed and variable O&M components are adjusted annually for changes in the consumer price index.

(3) *Hub*. The tariff of the Hub power project is made up of four elements: (i) capacity purchase price; (ii) energy purchase price; (iii) supplemental charges; and (iv) supplemental tariff. The capacity purchase price is designed to cover (a) debt service, which is indexed for changes in interest and exchange rates; (b) insurance costs; (c) company fixed operating costs, which are indexed for inflation and exchange rate movements; (d) a ROR; and (e) other financial costs. The energy purchase price is design to cover (a) the fuel cost, which is indexed for changes in fuel price, (b) variable operating costs, which are indexed for inflation and exchange rates, and (c) import tax (Iqra), which is adjusted for change in tax rate and indexed for inflation and exchange rate movements. The supplemental charges consists of a unit start-up charge, a hot standby charge and a part load adjustment charge, which are each indexed for changes in fuel prices. The supplemental tariff is designed to meet the cost of any debt service due to the Pakistan government. This results in a complicated adjustment mechanism.

Moreover, incentive schemes may be introduced. An example is given by the concession for the Western Harbour Crossing in Hong Kong, whose toll is regulated by guaranteed ROR with profit-sharing schemes. If the project produces IRR between 15% and 18%, the project company can increase the toll every four years regularly. If its IRR is below 15%, the project company can increase the toll immediately in the coming year or get compensation from the 'Toll Stability Fund' (TSF) established by the government. If its IRR is between 18% and 19%, the exceeded revenue above 18% will be shared equally with the government (saved to TSF) and the increase of toll is deferred to next year. If its IRR is above 19%, the exceeded revenue between 18% and 19% will be shared equally with the government, and the exceeded revenue above 19% should be totally saved to TSF and the increase of toll is deferred to next year.

Adjustment frameworks may be designed with the aim of encouraging the use of facilities. The toll structure of Highway 407 in Canada consists of a flat monthly account fee plus a charge based on the distance travelled. The Province of Ontario has provided in the Tolling Agreement with 407 International Inc. for a maximum toll for the initial operation year. The toll is allowed to increase at an annual rate of 2% of the initial toll threshold plus inflation to a total increase (before inflation) of not more than 30%. A base traffic flow (traffic threshold) is established, by which the toll is adjusted. If traffic flows are greater than the traffic threshold, tolls may be raised without limit to discourage the use of the road; however, if traffic levels are below the traffic threshold, toll rates should be regulated to encourage the use of the road.

Sometimes, the concession contract just specifies the general principles and procedures regarding tariff adjustment and leaves many particulars to future resolution. For example, in Tate's Cairn Tunnel, the initial toll rates were $HK4 for private automobiles, $HK7 for lightweight commercial vehicles and $HK8 for medium to heavy-duty trucks. Annual increases in the toll rate structure must be submitted to the Governor in

Council for approval. The approval of annual increases is a dynamic procedure depending on actual situations, which might not be predicted when signing the contract. The design of a less precise tariff adjustment mechanism would provide flexibility. Its advantage is that decisions are made in an environment where the parties are more completely informed about the relevant economic variables. On the other hand, its weakness is that it leaves considerable scope for opportunistic behaviour by parties attempting to effect tariff adjustment in their own favour.

Considerations in choosing adjustment frameworks

The choice of an appropriate tariff adjustment framework for a given PFI project depends partly on the characteristics of the project, such as the complexity of production costs and the nature/source of revenues, and partly on the objectives sought in the development of the project.

The characteristics of the adjustment framework should match the characteristics of the project. When the production costs consist of several components, each of which is affected by one or more external factors, different regulatory frameworks will have different effects on the risk–return profile of the developers. In contrast, when the production costs have a simple component, there is little difference among the different adjustment frameworks. Moreover, when a project has market-led revenues, the tariff will be subject to the law of demand–supply equilibrium to some extent. For example, the Second Link between Singapore and Malaysia is experiencing huge losses because users are reluctant to pay more. In this case, adjustment based on sale price is suitable because it provides the strongest incentive to maximize sales to consumers. Most toll roads/bridges adopt this adjustment framework. When a project has contract-led revenues, the tariff may be distorted from the law of demand–supply equilibrium and adjustments may be made using one of the four bases, depending on the other decision-making criteria of the participants.

The characteristics of adjustment framework should meet the objectives sought in the development of the project. The use of PFI strategy should meet the interest of project companies on the one hand, and the interest of the consuming public on the other. Therefore, the major desirable objectives of tariff design are (1) to provide sufficient monetary incentives to attract private capital investment into the development of infrastructure; and (2) to operate the project efficiently to ensure that such services are provided at the lowest possible cost. Other minor objectives are (1) consumer rationing and (2) tariff stability and predictability. Among the four adjustment frameworks, each may achieve these objectives to different extents.

Moreover, other factors should also be taken into consideration, for example, the affordability of products/services and the availability of information required for adjustment. To achieve the guaranteed return, revenue, or operating income, the tariff may have to be increased to a level that is beyond what the customers can afford. For example, due to the Asian financial crisis in the 1990s, the tariffs of BOO power projects in Indonesia had to be renegotiated because the tariffs would have become unacceptable if they were increased according to prevailing foreign exchange rates. The availability of information required for adjustment also influences the choice of adjustment frameworks. If the detailed information of production costs is unavailable or costly to be obtained, the sale-price regulation, the price cap of which is determined by benchmarking or competitive bidding, may be more suitable.

In general, the design of adjustment frameworks should adapt to project characteristics to streamline the adjustment process and reduce information requirements, and to maximize consumers' surplus and promoters' profits, based on a risk–incentive trade-off. The optimum choice must be that of a wise trade-off between risk and return.

Conclusion

Tariff adjustment mechanisms largely depend upon tariff adjustment frameworks. For a given PFI project, there is the need for an appropriate tariff adjustment framework that provides a mechanism to adjust tariffs and contains incentives to stimulate the project company to operate as efficiently as possible.

Different adjustment frameworks expose the project company to different levels of risk exposure and have a different impact on financial viability. The direct price adjustment provides the project company with the highest potential to increase its profit, while the adjustment based on the ROR provides less potential to increase profit, depending on the incentive schemes. In designing a tariff adjustment framework for a given project, the characteristics of the project, such as O&M costs and market complexity, play an important role. Compared with projects with high O&M costs, projects with low O&M costs have a wider choice of adjustment frameworks. Projects with contract-led revenues have a wider range of choice of incentive schemes than projects with market-led revenues. After all, the choice of the appropriate adjustment framework is largely based on a risk–return trade-off of participants. An appropriate adjustment framework can create a 'win–win' solution for both project promoter and the host government.

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