Regulatory regime and finance:

Electricity distribution in Thailand

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ABSTRACT

This paper aims to explore the choice of regulatory regime and form for electricity distribution characterised by natural monopoloy in Thailand. Taking the specificities of developing countries, the level of development concerning regulation and characteristics of the industry into consideration, revenue cap regulation is recommended. This paper further demonstrates that to determine revenue cap, the adoption of regulatory finance from developed countries requires some modifications to fit with Thailand. As one of developing countries, Thailand is characterised by poor accounting and auditing systems and weakly functioning capital and equity markets. The problem of a lack of data and asymmetric information faced by the regulator in Thailand is more severe. The resulting revenue cap suggests that to improve efficiency in the next regulatory period, the regulator will have to reduce the allowable capital base or operating costs.

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I. Introduction

After the 1997 financial crisis, the Master Plan for State Enterprise Sector Reform (Master Plan) was drawn up and approved. The Master Plan covers main utilities industries: energy, telecommunication, transportation and water. Among these utilities, the electricity supply industry (ESI) restructuring is at the centre of debate and public concern.

The ESI has special characteristics. It consists of two kinds of activities: natural monopoly (transmission and distribution\(^1\)) and competitive activities (generation and retailing supply). These activities can be operated in either vertically integrated or disintegrated enterprises under either public or private ownership and subject to regulation.

In Thailand the ESI is a vertically integrated monopoly under public ownership. Three state owned enterprises (SOEs): the Electricity Generating Authority of Thailand (EGAT), the Metropolitan Electricity Authority (MEA) and the Provincial Electricity Authority (PEA) are responsible for these activities.

EGAT is the dominant generator and sole transmission operator, while MEA and PEA are monopoly distributors and retailers in their jurisdiction areas. With these characteristics, it is necessary to consider restructuring and reform as a package which may involve regulation and restructuring of the industry and changes from public to private ownership.

Evaluation of ESI restructuring and SOE reform in the ESI is a complicated issue.

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\(^{1}\) Electricity transmission is the high-voltage transport of electricity whereas electricity distribution is the low-voltage transport from the transmission system to the end-user or between electricity generators and end-users (International Energy Agency, 1999, pp.13-14).

Characteristic of electricity transmission is natural monopoly because it is costly to build up another transmission system to transmit electricity in the same area. Moreover to maintain and improve the security of supply the integrated electricity transmission system is the most efficient design (Gans and King, 2000).

Electricity distribution often demonstrates strong economies of density in particular areas (International Energy Agency, 1999, p. 14). Building a duplicate distribution network to serve the same local market is not cost efficient, therefore it is also characterised by natural monopoly over given geographic areas as evidently demonstrated by Salvanes and Tjøtta (1998) and Ramos-Real (2005).
To complete such an evaluation it is necessary to examine issues including the optimal regulation of monopoly infrastructure, the potential for improvements in technical and allocative efficiency and the costs and benefits of privatisation. A comprehensive and integrated assessment of these issues is beyond the scope of this study.

This study focuses only on the regulation of natural monopoly activities because with or without ESI restructuring and under either public or private ownership regulation is needed for natural monopoly activities.

Although natural monopoly activities in the ESI consist of electricity transmission and distribution, this paper aims to narrow the scope down to focus on electricity distribution only, because in Thailand electricity distribution companies are separate entities: MEA and PEA.

At the time of writing there is no formal and independent regulatory body for the ESI in Thailand. National energy policy, management and development and key regulatory functions such as price regulation, are conducted by the National Energy Policy Council (NEPC). NEPC employs a cost of service form of control to regulate retail electricity tariff\(^2\) together with regulation using CPI-\(X\) on the base electricity tariff\(^3\), where CPI is Consumer Price Index and \(X\) is the efficiency improvement factor.

Although there has been an attempt to impose an incentive for efficiency improvement on the revenue requirement of SOEs, there is no evidence that under the current regulatory model, the efficiency of electricity distribution enterprises has improved. Given that there has been an improvement in operating efficiency in natural monopoly activities, the question arises to whether

\(^2\) Retail electricity tariff comprises of base tariff and additional costs from automatic adjustment mechanism (F.). The detail of the electricity tariff structure are provided by National Energy Policy Office (2001).

\(^3\) The main criteria in determining the base tariff structure are the load pattern, the marginal costs, the revenue requirement of three SOEs in ESI, financial criteria, and social criteria. Regulation with CPI-\(X\) is imposed on the component of revenue requirement to provide incentive for efficiency improvement.
this efficiency improvement has been passed on to consumers, which is the ultimate objective of regulation.\(^4\)

The main objectives of this study are to explore which modern regulatory regime and form pioneered and employed by regulators in developed countries Thailand should adopt, and what will be the problems in the implementation of the regulation that need to be addressed. Moreover issues of regulatory finance required for the proposed regulatory form in the light of specific characteristics of the industry and the country as one of developing countries together with level of capital market development will be examined. Regulatory financial variables will then be estimated.

Although the regulatory channel and the mechanism to transfer regulatory benefits, in the form of efficiency improvement and cost reduction, are other key factors to optimise the implementation of modern regulatory regime, this issue is beyond the scope of this study.

This study is divided into 6 sections. Section 2 discusses the economic regulation of natural monopoly in practice, including the regulatory regime in developed countries, and specificity of developing countries influencing the choice of regulatory regime.

\(^4\) An analysis of any transfer of benefits to consumers resulting from an improvement in the operating efficiency can be undertaken by evaluating the retail electricity tariff. Improvements in operating efficiency can bring benefits to consumers by a decrease in the retail electricity tariff.

In Thailand, the retail electricity tariff consists of a base tariff and an additional tariff from the automatic adjustment mechanism (F\(_t\)). Since the new tariff structure was approved by the Cabinet in 2000, the base tariff structure has not changed, therefore consumers do not directly gain any benefit from efficiency improvements through the base tariff. Retail electricity tariff changes are only due to changes in F\(_t\) value. The most frequently mentioned reasons for changes in F\(_t\) are changes in fuel prices, power purchase prices from the non-EGAT generators, foreign exchange rates and the inflation rate. Operating cost reductions resulting from improvements in efficiency never appear as a component of F\(_t\) in any period.

One explanation as to why the benefits in efficiency improvement cannot successfully be transferred is that there is no well established regulatory channel to transfer the benefits of efficiency improvement to consumers in the form of a tariff reduction. With limited regulatory capacity along with incomplete and asymmetric information, the regulator cannot deliver on its mandate and SOEs appropriated the gains.
In Section 3, the choice of regulatory regime and form of electricity distribution in Thailand is explored, taking into account of the level of development concerning regulation and characteristics of natural monopoly electricity distribution.

In Section 4 and 5, this study will estimate the regulatory financial variables in order to demonstrate that the adoption of regulatory finance from developed countries with well developed capital and equity markets needs some modifications to fit with practice in Thailand. Thailand is characterised by poor accounting and auditing systems and weakly functioning capital and equity markets. The lack of data and asymmetric information is faced by the regulator in Thailand. The final section concludes the paper and provides some policy implications.

2. Economic regulation of natural monopoly

There are various types of economic regulation of a natural monopoly. The major question arises as to which type is appropriate to impose on regulated firms. The answer relies on the objectives that the regulator wants to achieve, the level of development of the country and the characteristics of the industry to be regulated.

This section will briefly explain the objectives of economic regulation of a natural monopoly, the regulatory regime and form of a natural monopoly in developed countries, and specificities of developing countries that affect the choice of regulatory regime.

2.1 Objectives of economic regulation of natural monopoly

The main (explicit or implicit) objectives in economic regulation of natural monopolies are as follows:

- Rent extraction goal: To charge consumers reasonable prices for services provided by the regulated monopoly;

- Capital attraction goal: To reduce the participation constraint by providing adequate incentives to attract additional capital to the regulated monopoly and to invest in
maintaining the existing capital stock in order to balance supply and demand over time and to ensure the continuity of services\(^5\);

- Supply-side efficiency goal: To induce the monopoly to perform its services efficiently in terms of cost and production technology; and

- Demand-side efficiency goal: To provide consumers with the incentives to utilize services efficiently through the level and structure of prices (Joskow, 1998, p.36).

Although the objectives of regulation target both the demand and supply side, in practice the regulatory mechanisms are commonly imposed on the supply side or regulated firms. The demand-side objectives will be achieved indirectly via the supply-side regulations. Essentially the regulator’s job is to maximize incentives for firms to operate efficiently while concerned with the participation constraint to secure continued service and to balance supply and demand over time.

2.2 Economic regulation of natural monopoly in developed countries

Regulation of the electricity distribution sector in practice in developed countries has been designed to achieve various objectives.

On the one extreme, if the regulator has only a capital attraction objective to secure the continuity of services and to balance supply and demand over time, which are very important to services like electricity, it has to give incentives or full insurance to the regulated firms against the possibility of making a loss so that the firms will not go bankrupt and the return to investors is guaranteed.

With full insurance, the regulated firm is not permitted to earn more than its costs and prices are allowed to rise to maintain earnings during periods of low demand. The firm would receive compensation for its actual costs by an exact amount.

\(^5\) The capital attraction goal inherently conflicts with the rent extraction goal since higher prices attract capital but yield more rent to regulated firms.
This is a ‘rate-of-return’ (ROR) regulation, sometimes called ‘cost-plus’ or ‘cost-of-service’ regulation. Under this type of regulation, the rate of return is regulated to ensure that it exactly matches the cost of capital in each period. In this regulatory regime there is no incentive for the regulated firms to pursue supply-side efficiency at all.

At the other extreme, the regulator defines a set of minimum service standards including, for example, the prices that the regulated firm can charge or the revenues that the regulated firm can earn. There is absolutely no constraint on the earnings of the firm. If the firm is able to reduce costs while complying with the regulated standards, it can retain the resulting profit. If demand is low, the firm will suffer loss. There is no earning guarantee in this regulatory regime, but it offers the strongest possible supply-side efficiency incentives to the regulated firm to minimize costs. This is called ‘incentive regulation’. The incentive regulation has many variations in practice such as price cap regulation, revenue cap regulation, sliding scale regulation, yardstick competition and the hybrid mechanism.\(^6\)

Adopting incentive regulation can create problems. Firstly, incentive regulation is aimed at the cost efficiency of the firm. The quality of service can deteriorate due to cost cutting by the firm (Church and Ware, 2000, p.857).

The second point is that under price and revenue cap regulation, the adjustment of price and revenue cap for exogenous changes in costs, inflation and productivity change are unlikely to match changes in costs. It leads to the problem of an errant index and results in substantial windfall gains for either consumers or firms, depending on whether prices are less than or greater than costs. When the prices do not match costs, price and revenue caps will lead to allocative inefficiency.

It should be noted however that in the real world, both pure regulation regimes are unfeasible. All known regimes lie somewhere between the two extremes. In addition, there has been a significant convergence in practice between ROR and incentive regulation, specifically in

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\(^6\)Rothwell and Gomez (2003), Crew and Kleindorfer (1996a; 1996b) and Vogelsang (2002) provide a good review on various types of incentive regulation. This study will not repeat them here.
terms of information required for regulatory variables. For example, setting up and revising caps requires the same type of financial and technical skills as the ROR system (Kessides, 2004, p.122).

2.3 Regulation in developing countries

The main question is whether regulations pioneered, developed and adopted by developed countries can function efficiently and effectively in developing countries. There are so many differences in their state of development including the performance of the infrastructure sector, market and enforcement mechanisms and institutions that should be taken into account in designing the regulatory regimes (Joskow, 1998, p.4).

Applying economic regulation models from the developed world to developing countries is a question of degree rather than of kind, and detail rather than fundamentals (Parker and Kirkpatrick, 2002, p.9). The problems of information asymmetries and regulatory and political capture in developing countries are more severe than in developed countries.

Laffont (1996), Laffont (1998) and Beato and Laffont (2002) have studied the specificities of developing countries which must be taken into account in choosing regulatory regimes in developing countries. These specificities can be summarised as follows.

2.3.1 High cost of public funds

The cost of public funds in developing countries is higher than in developed countries. The cost of public funds refers to the marginal cost of public funds, which is the social cost of raising one unit of funds. Due to inefficient tax systems, this cost includes a deadweight loss because governments raise revenues by means of distortionary taxes. The common estimate of the deadweight loss is around 0.3 in developed countries, which means that to raise one unit of account it costs the citizens 1.3 units. According to World Bank data, the deadweight loss in developing countries is greater than 1, examples being 1.2 in Malaysia, 2.48 in the Philippines and between 1.19 and 1.54 in Thailand (Laffont, 1996, p.165).
2.3.2 Lack of well-developed accounting and auditing systems

The ability to audit the costs of regulated firms is an important instrument for the regulator in designing the regulatory variables. Developing countries lack the elaborate accounting and auditing systems, including proper auditing staff and administrations (Beaton and Laffont, 2002, p.1). This results in costs reported by state-owned incumbents and monopolists that are unlikely to be efficient, meaning that they do not reflect the market values of inputs (Kessides, 2004, p.124)

2.3.3 Corruption

The internal cost of side transfers in developing countries is lower than in developed countries, which occurs when two parties design side transfers to arrange a private deal. Two parties take into account the costs of being identified and the necessity of using indirect compensations that are less efficient than money. These costs are the internal cost of side transfers.

In developing countries, it is more difficult to identify the side transfers and the social norms that may value some types of side transfers.

Moreover, the regulators and bureaucrats in developing countries receive low salaries (Fischer and Serra, 2000, p.188), which can allow them to be easily captured by interest groups. The low internal cost of side transfers thus leads to widespread corruption in developing countries.

2.3.4 Political constraint

Developing countries do not have efficient constitutional control of the government and the ability to commit to and write long-term contracts. The checks and balances provided by well-functioning democracies, court systems, government auditing bodies and other counter powers leads government to be more resistant to be captured by interest groups and less able to favour them excessively. Lack of political democracy and well-functioning political institutions increases the uncertainty of future regulations and it is difficult for a government and regulator to
make credible commitments to long-run policies. In addition, the regulators are often prone to pressures from populist politicians and industry lobbyists (Fischer and Serra, 2000, p.188).

2.3.5 Technical and financial constraints

Technical constraints include managerial deficiencies and a lack of administrative and regulatory capacity. The shortage of qualified regulatory staff is major obstacle to establishing effective regulatory institutions (Stern, 2000, p.137). The other defining characteristics of developing countries are the financial constraints which result from the inefficient credit and capital markets and the difficulty of attracting the necessary foreign capital.

3. Regulatory regime and form for electricity distribution in Thailand

The regulatory regime ideal for Thailand depends on the specific characteristics as discussed in Section 2.3.

Laffont (1996), Laffont (1998), Stern (2000) and Beato and Laffont (2002) argued that the characteristics of the developing countries, consisting of the high cost of funds, low transaction cost of collusion, high cost of communications and imperfect decision making, supports the adoption of ROR regulation or low-powered incentive regulation.

It is not however only the characteristics of the Thai economy that the regulator should consider but also the stages of development concerning regulation. Laffont (1996) proposes that regulatory regimes adhere to the stages of development concerning regulation as follows.

In the first stage of development, the availability of experts and auditing mechanisms are so poor that powerful incentive regulation should be adopted. By using this type of regulation, short-run efficiency can be promoted. This however encourages some types of corruption in regulatory and political institutions and they are costly for the rest of the economy due to the money drain toward the regulated monopolies they create. In this stage a good auditing system and regulatory capacity should be developed and improved.
Once a well-functioning auditing system is established in the second stage, regulation should move toward a less powerful incentive regulatory regime that facilitates large scale investment.

As development continues and the infrastructure system is established, it will be optimal to slowly move toward more powerful incentive schemes in the third stage.

The quality of regulation in each of these stages depends critically on the ability of the governments to commit with credibility to the implementation of the schemes (Laffont, 1996, pp.176–177).

Therefore when considering the stage of development concerning regulation, Thailand is in the first stage.

In this stage the critical problem in effectively adopting low-powered incentive regulation is poor accounting and auditing systems, along with unstable macroeconomic conditions in the wake of the 1997 financial crisis. The new regulatory body is also inexperienced at this early stage.

To achieve the objective of improvement in supply-side efficiency, high-powered incentive regulation is therefore recommended for Thailand.

Price cap and revenue cap are the most popular variations of high-powered incentive regulation that have been employed in most developed countries. Choices of the type of incentive regulation that should be adopted in Thailand will be discussed.

Regulatory regimes must be considered based on the characteristics of the regulated industry as well. Regulation employed reflects the approach to regulate capital investment in distribution activities.

The cost of distribution companies varies with demand because a big proportion of the total costs of distribution companies is noncapital or operating costs, which are more volume-related than capital costs. The capital costs of distribution companies are also likely to be variable with respect to volume because investments are on a small scale.
Assessment of projects is based on the need to invest in reinforcing existing systems and to meet new volumes and new customers. There is also great uncertainty over the change in demand at the distribution level, therefore the capital costs of distribution activity can be considered to be affected by changes in demand or volumes supplied over the price control period.

Price cap regulation provides strong incentives to firms to increase sales volumes in order to increase profit. This concept conflicts with the demand side management program which aims at reducing the consumption of electricity and preserving the environment in Thailand. Firms’ gains or losses are also subject to differences between forecast volumes at the time of price control being set and the actual volumes. In either case, firms can make excess profits or losses which will call for the reopening of the price control.

As shown in Table 1 and 2, in Thailand peak demand and energy demand forecasts for each year were conducted and adjusted several times by various methods and under different assumptions.

The most recent forecast tends to predict peak demand and energy demand more accurately. For example, peak demand and energy demand forecast error (actual minus forecast values) of 2003 from a forecast conducted in June 1993 were -3,319 MW and -24,422 GWh respectively, which accounted for -18.31 and -20.92 per cent of actual values respectively. The forecast error for 2003 from a forecast conducted in August 2002 was 278 MW and 1,824 GWh, which accounted for 3 and 1.56 per cent of actual values respectively.

Future demand in Thailand is highly uncertain due to, for example, the financial crisis 1997. In Table 1 and 2, evidence shows that forecasts of peak demand and energy demand in 1997–2003, conducted in October 1996 before the financial crisis, were far higher than actual values because it was beyond the authorities’ capability to foresee the incident and its effects on demand.

Even though reforecasting of peak demand and energy demand are needed to capture current economic factors, various forecasts mislead firms to draw investment plans based on
expansion of electricity distribution requirement because investment in capital intensive
distribution activities requires long term planning.

Revenue cap regulation can reduce the severity of these concerns. Because revenue
remains unchanged, firms will be indifferent to variations between forecast and actual volumes,
however consumers may bear volume risk and face fluctuating prices.

Price cap regulation has the disadvantage of leading to inefficient consumption of
electricity. As for fluctuating demand, the regulator can provide incentives to regulated firms by
continually reviewing the revenue cap during the regulatory period.

4. Issues in regulatory finance in electricity distribution in Thailand

Under fixed or pure revenue cap regulation, the regulated firm’s allowed revenues are set
during a regulatory period. The allowed revenue has to be determined in a way that ensures the
regulated firms earn a fair return, operate efficiently and cannot exercise the monopoly power.

According to the standard building block approach, the major components of the allowed
revenue, also called the revenue requirement, are the allowed return on capital, the allowed return
of capital and the allowed return of noncapital costs.

The allowed return on capital is the allowed return to the regulated firms to achieve a fair
and reasonable rate of return, whereas the allowed return of capital is associated with recouping
the capital that the regulated firm has invested in its business assets over the useful lives of those
assets. The key elements of return on and return of capital are the regulated capital base, the rate
of return and depreciation.

The allowed return of noncapital costs or operating costs allows the firm to recover
operating and maintenance costs as well as administration and general costs.

The standard formula is

\[
Revenue\ requirement = (WACC \times \text{Capital base}) + (\text{Depreciation rate} \times \text{Capital base}) + \text{Efficient OPEX},
\]

where \(WACC\) is the weighted average cost of capital and \(OPEX\) is the noncapital cost.
The allowed return on capital, estimated by $WACC \times \text{Capital base}$, is the allowed return to the regulated firm to achieve a fair and reasonable rate of return.

The allowed return of capital or depreciation, estimated by $\text{Depreciation rate} \times \text{Capital base}$, is associated with recouping the capital that the regulated firm invested in its business assets over the useful lives of those assets.

The efficient noncapital cost ($\text{Efficient OPEX}$) is estimated from operating expense adjusted through price index-$X$ mechanism. It provides the regulated firm incentive for efficiency improvement.

This section aims to discuss issues in the revenue requirement determination for electricity distribution in Thailand.

Financial issues relating to capital base, rate of return, depreciation, noncapital cost and price index-$X$ adjustment mechanism will be discussed respectively. With each financial variable, estimation methods widely used by regulators in developed countries will be addressed and attempted together with discussion on the possibility, obstacles and options of adopting these methods in the Thai case. The discussion will focus on electricity distribution activities only because in Thailand electricity distribution companies are separate entities.

4.1 Capital base

Capital base is the main variable to estimate allowed returns on and of capital. The choice of capital base valuation depends on the overall philosophy of the regulatory regime. If the objective of the regulatory regime is to compensate investors for the capital they have invested into a business, assets should be valued based on historic cost.

SOEs in the ESI in Thailand employ a historic cost approach to value assets, depreciated by the straight line method. Capital base of MEA and PEA, reported in their annual reports in 2003, are 76.58 and 158.14 billion baht respectively. Even though historic cost valuation is relatively inexpensive to measure, simple to administer and can avoid the subjectivity associated with determining current asset values, historic cost values have no relationship with market values or replacement costs and rely on asset age. This means that historic cost valuations could lead to
shocks in cost change when the assets are replaced. In addition, employing historic cost values as a capital base in revenue requirements does not encourage efficiency improvement because firms ensure that their costs are recovered.

To promote efficiency, which is the main objective of regulation in Thailand, MEA and PEA should adopt the depreciated optimised replacement cost (DORC) approach as the valuation approach of the assets. The central idea of DORC is to optimise the asset value in a way that the most efficient facilities necessary to produce a specified level of services is identified. Values are thus set based on the most efficient configuration of assets that could be used to deliver service by eliminating any redundant assets. To estimate DORC value, a study of the entire network is required, with assets valued at depreciated replacement cost and redundant assets are eliminated.

For general asset valuation, DORC is widely employed by regulators in developed countries. In Australia these include The Essential Services Commission of South Australia (ESCOSA); Office of the Tasmania Energy Regulator (OTTER); Queensland Competition Authority (QCA); and Essential Services Commission (ESC) (Prior to 2002 called Office of Regulator-General (ORG)). It should be noted that this method requires costly examination and assessment procedures, and subjective judgement is required in determining optimal network configuration and the degree of excess capacity considered to be efficient. The asymmetry of information between the regulator and the network owner aggravates this valuation process.

4.2 Rate of return

The allowed rate of return is the rate which ensures the continuing financial viability of the firms and encourages them to invest in new and replacement assets. It is not so high as to lead to monopoly rent extraction.

In competitive capital markets, the rate of return is determined by demand and supply for capital. Therefore, the rate of return would provide a return to investors that corresponds to the returns available from other assets of similar risk.
Due to the special nature of natural monopoly businesses owned by either government or private firms, it is not easy to make direct comparisons to other similar businesses listed on the stock market to observe what might constitute the reasonable rate of return.

For a regulated firm, the rate of return is established by the regulator, and should be set at a level that is equal to the cost of attracting capital to fund a particular asset given its level of risk. If the allowed rate of return is too high, the price charged to end consumers will be above the level that reflects costs. If it is too low, investment by firms will be limited and the quality of service offered to customers may be reduced.

The next issue is how to determine the rate of return. As the rate of return provides a return that corresponds to the prevailing cost of funds available in the market and to the risk involved in delivering distribution services, the rate of return should be set on the basis of a weighted average cost of each source of funds, namely equity and debt.

The most widely used model to determine the weighted average cost is the weighted average cost of capital (WACC). The allowed rate of return for a group of assets can be derived by calculating the appropriate WACC.

The firms can use two sources of capital: equity and debt. Each source of capital involves different risks and costs. A firm’s WACC is calculated by the sum of the cost of its debt, weighted by the proportion of debt to total assets and the cost of equity funds weighted by the proportion of equity funds to total assets. The nominal WACC is

\[
WACC = \frac{\text{Debt}}{(\text{Debt} + \text{Equity})} R_{\text{debt}} + \frac{\text{Equity}}{(\text{Debt} + \text{Equity})} R_{\text{equity}},
\]

where

- \( R_{\text{debt}} \) is the return on debt (the cost of debt);
- \( R_{\text{equity}} \) is the return on equity (the cost of equity);
- \( \text{Debt} \) is the market value of debt; and
- \( \text{Equity} \) is the market value of equity.

The major components of WACC are the cost of debt, the cost of equity and the appropriate capital structure. The cost of equity is the most difficult and controversial element in
WACC. There are several asset pricing models to estimate the cost of equity: capital asset pricing model (CAPM), nonlinear models, conditional models, and multifactor models such as Arbitrage Pricing Theory and consumption and intertemporal CAPMs. CAPM is a linear model whereas the remainder are nonlinear models.

Even though there is considerable evidence of empirical shortcomings in CAPM, its clear theoretical foundations and simplicity lead to its continuing popularity (Wright et al., 2003, p.76).

There are several reasons why the alternative of nonlinear models cannot achieve the popularity of CAPM.

The first reason is the problem of data overfitting. This means that the nonlinear models fit the sample too well, and both systematic and entirely random factors are explained by the model. Moreover, in many cases nonlinear models can be approximated by a linear model. The conditional CAPM, in which the parameters of the model vary over time, usually performs better than a nonlinear model.

The most popular competitor to CAPM has been in the form of linear multifactor models. These models assume that there is more than one factor driving asset returns, however it is difficult to identify the factors. These models are also criticised for overfitting and data mining. These models have their own shortcomings, meaning that in practice there is no good successor to CAPM for estimating the cost of equity. The CAPM is widely used by regulators because it is still considered to be both more objective than and at least as robust as alternatives.

It is recommended that Thailand should follow the international practice, employing CAPM, to estimate the cost of equity.

The determination of rate of return is related to financial issues, particularly the capital market. Thailand is classified by the World Bank as a developing country and its capital market is

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7 Wright et al. (2003) discussed the various asset pricing models starting from CAPM and the other successive models aiming to overcome the shortcoming of CAPM. This section will not repeat that discussion.
also classified by the International Finance Corporation, a subsidiary of the World Bank, as an emerging market.\(^8\)

Füss (2002) conducted a discriminant analysis and confirmed that the capital market of Thailand is the emerging market, hence the technical issues in this section will be discussed by taking the characteristics of an emerging market into account.\(^9\)

To estimate the cost of equity, the traditional local or domestic CAPM have been widely employed, particularly in developed markets. The local CAPM\(^10\) is expressed as

\[
R_i = R_f + \beta_{id} \left[ R_{md} - R_f \right],
\]

where

- \(R_i\) is the expected return on asset \(i\);
- \(R_f\) is the risk free rate;
- \(R_{md}\) is the expected return on the domestic market portfolio;
- \(\beta_{id} = \frac{COV(R_i, R_{md})}{\sigma_{md}^2}\) is the risk of asset \(i\) against the domestic market portfolio returns;
- \(\left[ R_{md} - R_f \right]\) is the risk premium on the domestic market portfolio.

Equation 3 can be rewritten as a weighted average of the risk free rate with weight \((1-\beta_{id})\) and the expected return on the market portfolio with weight \(\beta_{id}\)

\[
R_i = (1 - \beta_{id}) R_f + \beta_{id} R_{md}.
\]
The equity beta estimated by historical data can be conducted through the application of
the CAPM as following
\[ R_i = R_f + \beta_{id} (R_{md} - R_f) \]
\[ R_i = R_f (1 - \beta_{id}) + \beta_{id} R_{md} \]
\[ R_i = \alpha_i + \beta_{id} R_{md} \quad (5) \]
where
\[ \alpha_i = R_f (1 - \beta_{id}) \]; and
\[ \beta_{id} \] is domestic beta.
Stulz (1999) argued that using a domestic market index is only appropriate for an asset
traded in a closed, national financial market. Stulz (1995) also proposed that the above CAPM
can be adapted to an international context for assets in the global market portfolio given that the
purchasing power parity condition holds.
The Equation 3 can be adjusted to a global CAPM\(^{11}\) as following
\[ R_i = R_f + \beta_{ig} \left[ R_{mg} - R_f \right] \quad (6) \]
where
\[ R_i \] is the expected return on asset \( i \) in a specific pricing currency;
\[ R_f \] is the risk free rate denominated in the pricing currency;
\[ R_{mg} \] is the expected return in the pricing currency on the unhedged global market
portfolio;
\[ \beta_{ig} = \frac{COV(R_i, R_{mg})}{\sigma_{mg}^2} \] is risk of asset \( i \) against the unhedged global market portfolio
returns with returns computed in the pricing currency; and
\[ \left[ R_{mg} - R_f \right] \] is the risk premium on the unhedged global market portfolio.

\(^{11}\) The global CAPM is based on the assumption of perfect capital markets, which means the markets are perfectly
integrated to the world capital markets. In the integrated capital market, the global CAPM is defined as the expected
return that is determined by the beta with respect to the world market portfolio multiplied by the world risk premium
(Bekaert and Harvey, 2002, p.431). It means that the assets within a particular country are rewarded in terms of their
contribution to a well-diversified world portfolio.
From the Equation 5, the global equity beta estimated by historical data can be conducted through the application of the CAPM as following

\[ R_i = \alpha_i + \beta_{ig} R_{mg}, \]

(7)

where

\[ \alpha_i = R_f (1 - \beta_{ig}) \]; and

\[ \beta_{ig} \] is global beta.

For Thailand, as an emerging market, it is difficult to determine which CAPM, domestic or global, is the best estimator of cost of equity. The domestic CAPM with the assumption of a completely segmented market is not totally appropriate due to the capital market and financial liberalisation.

The structure of the capital market in emerging markets is moving toward the integration end rather than the segmentation end. Realistically the domestic CAPM requires data in the local market which is not available, particularly in the sector of electricity distribution in Thailand. The cost of equity measurement in emerging markets is a bet on market integration (Bruner et al., 2002, p.317). Gerard et al. (2003) found little or no evidence of market segmentation in Southeast Asia over the period of 1985–1998, however they found that emerging markets in Southeast Asia are not yet fully integrated either.

Bekaert and Harvey (2002; 2003) provided evidence that gradually the emerging markets being integrated into the world market through market liberalisation. In their review, there are a number of measurement methods of the degree of market integration, ranging from investigating the event, noting the regulatory reform date, employing finance data such as equity return and economic data such as capital flow, and adopting an integrated approach which encompasses all the variables (events, financial, and economic data).

Bekaert and Harvey (1995) employed equity return data and found that the emerging markets exhibit time-varying integration. For Thailand, the model estimates show a dramatic

\[ \text{It should be noted that market liberalisations are not necessarily defining events for market integration (Bekaert and Harvey, 2002, p.431).} \]
increase in the ex ante probability of integration, beginning in 1986 which coincides with the year of trading commencing on the Alien board. Bekaert and Harvey (2000) recorded the date of important events, such as the opening and liberalisation of equity markets in emerging countries.

For Thailand, the official liberalisation date was September 1987; the first country fund\textsuperscript{13} introduction date is July 1985; the first American Depositary Receipt\textsuperscript{14} introduction was on January 1991; and the break point in the jump in net US capital flows was in July 1988.

Bekaert et al. (2002) uses the idea that market integration is an all-encompassing event that should change the return-generating process. They search for a ‘break date’ of market segmentation and integration and compare this with the official date of capital market reform. The results show that the break dates are mostly within two years of alternative measures of liberalisation events, and highlights the fact that market liberalisation does not necessarily lead to immediate market integration.

Compared to the dates in Bekaert and Harvey (2000), the result of the univariate analysis examining breaks in the ratio of US holdings to market capitalisation shows that the break point for Thailand is on July 1988, whereas the multivariate results show that most break points were in 1993.

In summary, the recent literature agrees that the capital market in Thailand has been liberalised and integrated into the world market for more than a decade. Therefore the world CAPM should be the approach to adopt. The assumption of a perfect capital market is not perfectly valid either however, therefore an estimation of both domestic and global CAPM for the regulation of electricity distribution will be attempted.

\textsuperscript{13} A country fund is an investment company that invests in a portfolio of assets in a foreign country which is an emerging market and issues a fixed number of shares domestically, such as in the US.

\textsuperscript{14} American Depositary Receipts are rights to foreign shares that trade in dollars on the US exchange or over-the-counter.
4.2.1 Betas

The estimation of both domestic and global CAPMs starts with the estimation of beta. The empirical counterpart of CAPM is known as the market model, which represents a statistical relationship of CAPM (Brailsford et al., 1997, p.4). The standard specification of the market model of domestic CAPM is expressed as

\[ R_{it} = \alpha_i + \beta_{id} R_{mkt} + \varepsilon_{it} \quad (8) \]

where

- \( R_{it} \) is the realised return on asset \( i \) for period \( t \);
- \( R_{mkt} \) is the realised return on the domestic market portfolio for period \( t \);
- \( t \) is the measurement interval and \( t = 1, 2, \ldots, T \);
- \( T \) is the number of measurement intervals;
- \( \alpha_i \) is the intercept term for asset \( i \);
- \( \beta_{id} \) is the sensitivity measure of return on asset \( i \) to domestic market returns assumed to be constant through time; and
- \( \varepsilon_{it} \) is the residual term for asset \( i \) in period \( t \).

The standard specification of the market model of global CAPM is expressed as

\[ R_{it} = \alpha_i + \beta_{ig} R_{mgt} + \nu_{it} \quad (9) \]

where

- \( R_{mgt} \) is the realised return on the global market portfolio for period \( t \);
- \( \beta_{ig} \) is the sensitivity measure of return on asset \( i \) to global market returns assumed to be constant through time; and
- \( \nu_{it} \) is the residual term for asset \( i \) in period \( t \).

For beta estimation, the data employed is the main issue. In Thailand, there is no electricity distribution company listed in the stock exchange market. The firms listed are the electricity generation companies which are either independent power producers or small power producers. The estimations of both domestic and global betas of the Thai electricity generation sector, as firms in the same industry, are conducted instead. Again
as there are no listed Thai electricity distribution companies, comparable overseas electricity companies from developed countries should be considered. The US electricity sector is chosen because of manageable and comparable data.

To obtain beta estimates, returns are required and have to be constructed. For simplicity and due to data limitation, discrete returns are calculated as follows

\[ R_{it} = \frac{P_{it} - P_{it-1}}{P_{it-1}}, \]  

(10)

where

- \( R_{it} \) is realised return on asset \( i \) for period \( t \); and
- \( P_{it} \) is price of asset \( i \) at time \( t \).

The return on domestic market portfolio, \( R_{mdt} \), and the return on global market portfolio, \( R_{mgt} \), are calculated by Equation 10.

Instead of measuring returns of assets or of companies, due to data unavailability the estimate of returns in the electricity industry and the market is conducted. \( P_{it} \) is proxied by the total market return index of industry and the market. Both Thai and US data of the total return index of the electricity industry and of the market are obtained from DataStream in US dollars. The global total market return index in US dollar is also obtained from the same source. The detail of the raw data is shown in Table 3.

The returns of the Thai and the US electricity sector, the returns of domestic market and the returns of global market are calculated by through Equation 10 by employing quarterly, monthly and daily raw data. Data for Thailand starts in 1995, which is the year that the first electricity company was listed on the stock exchange market in Thailand. Data for the US and the world starts in 1989. The summary statistics of returns are shown in Table 3. It is obvious that average of returns from the Thai data are lower than those from the US and world data, whereas variation of returns are higher. That can result from a smaller number of observations.

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15 Returns include both dividends and retained earnings.

16 Brailsford et al. (1997) provided a good discussion on the measure of returns in practice.
Equation 8 and 9 on the Thai and the US electricity sector will be estimated by ordinary least squares. In this section, the computer software, Eviews 4.1, is employed to conduct all of the regressions. The estimations of domestic and global betas from Thai data will be conducted and discussed and then those estimations of the US data will be attempted.


For the Thai electricity sector, the data on listed electricity companies started in 1995, therefore the period of data is reduced to 10 years. To capture the effect of the financial crisis in 1997, the estimation of pre crisis (1995–1997) and post crisis (1997 onwards) time intervals are conducted.

In regressing a time series variable on another time series variable, the problem of spurious regression may arise. Hence a test of stationarity or unit root test, is needed before running regressions.

The unit root test adopted in this section is the augmented Dickey-Fuller test to control for higher-order correlation. The augmented Dickey-Fuller specification is

\[ \Delta y_t = \mu + \gamma y_{t-1} + \delta \sum_{i=1}^{p} \Delta y_{t-i} + \eta_t, \]  

where \( y_t \) is returns and \( \Delta y_{t-i} \) is lagged difference terms of \( y_t \).

This augmented Dickey-Fuller specification is then employed to test the null hypothesis of \( \gamma = 0 \), that is a unit root exists in \( y_t \). If null hypothesis is rejected, \( y_t \) is stationary or integrated of order 0, I(0). If not, \( d \)-differenced series is tested until it is stationary, then the original series, \( y_t \), is integrated of order \( d \).

The results of stationarity tests of each data series of both Thai and the US in various period of time are reported in Table 5 and 6.

As shown in Table 5, quarterly returns of electricity sector in Thailand are not stationary in any periods of study. Most of them are integrated of order 1, I(1), except quarter returns in pre crisis period, that is integrated of order 2, I(2). Monthly and daily returns of electricity sector in Thailand are stationary. All of the returns of the Thai stock market are stationary except quarterly
and monthly returns during the pre crisis period. The reason that the returns of the Thai electricity sector and the returns of Thai stock market are not stationary is that the number of observations in the pre crisis period is small, and it is likely that before the financial crisis stock returns in the stock market of Thailand were not well behaved. Daily returns are all integrated of order 0.

Table 6 shows that all of the daily, monthly and quarterly data of the US returns in the electricity sector and stock market in various time periods are stationary except quarterly returns during 1999–2004 which is integrated of order 1. It is obvious that the US data is better behaved than that of Thailand.

Regression of nonstationary data can result in spurious regression. The results from this regression are dubious. If both series are integrated of the same order, called cointegrated, regression is meaningful or not spurious.

The results of both the domestic and global beta of Thailand are shown in Table 7.

The domestic CAPM of the Thai electricity generation sector is estimated using the data from various periods. The domestic betas obtained are all statistically significant and range from 0.5 to 1, depending on the estimation period. The global beta is also attempted.

The results show that the betas from quarterly data are not statistically significant at all, unlike the betas from the daily and monthly data. The values of betas range from 0.2 to 0.8.

Local CAPM regressions on the quarterly data are all spurious because returns of electricity market and returns of stock market in Thailand are not cointegrated at all. Results from regressions for global beta show that the quarterly returns of Thai electricity sector and global market during period of pre crisis and of 1995–2004 are not cointegrated.

Evidence from Durbin Watson statistics show that few of the estimated betas suffer autocorrelation problem, particularly those estimated during the pre crisis period and suffering spurious regression.

To alleviate the autocorrelation problem, the autoregressive model, in which the lagged value of the dependent variable is added as one of the explanatory variables, is commonly recommended.
Hence Equation 8 and 9 are remodelled as following

\[ R_{it} = \alpha_i + \beta_i \mu_{it} + \beta_{\mu} R_{it-1} + \epsilon_{it} \quad \text{and} \]
\[ R_{it} = \alpha_i + \beta_{\mu} R_{mgt} + \beta_{\nu} R_{it-1} + \nu_{it} \]

where

- \( R_{it} \) is the realised return on asset \( i \) for period \( t \); and
- \( \beta_{\mu} \) is the sensitivity measure of return on asset \( i \) at time \( t \) to the return on asset at time \( t-1 \) which is assumed to be constant through time.

Compared to the results in Table 7, results the from autoregressive model in Table 8 improve immensely as shown by the increase in \( R^2 \) in domestic CAPM models. There is, however, no significant improvement in global CAPM models.

A test for serial correlation is thus needed. With the inclusion of the lagged dependent variable as the explanatory variable, Durbin-Watson statistics are not appropriate as a test for serial correlation.

The Breusch-Godfrey Lagrange Multiplier test statistic is adopted to test autocorrelation in an autoregressive model. The null hypothesis of the Breusch-Godfrey Lagrange Multiplier test is that there is no serial correlation up to lag order \( p \), where \( p \) is a pre-specified integer.

The Lagrange Multiplier statistic has asymptotic chi-square distribution, with degrees of freedom equal to the number of lag, \( p \), \( \chi^2(p) \). One practical problem of the Lagrange Multiplier test statistic is to specify the right value of \( p \) a priori. The value of \( p \) is roughly specified based on observations of autocorrelation and partial autocorrelations of residuals from correlograms.

Null hypothesis is rejected when the Breusch-Godfrey Lagrange Multiplier statistic is greater than the critical value, \( \chi^2_{0.05(p)} \), meaning that residuals are serially correlated and that estimated betas are not efficient.

Results of tests for autocorrelation of all regressions from Table 8 are shown in Table 9. Evidence shows that in most of the domestic and global CAPM autoregressive models, null hypothesis, that there is no autocorrelation, is not rejected.
This problem may result from poor data from the Thai stock market and the misspecification of models. Returns in the electricity sector in Thailand are not explained well by the simple CAPM because Thai market returns are not normally distributed (Bekaert and Harvey, 2002, p.37). Efficient estimates therefore cannot be obtained from simple ordinary least square estimation. Moreover, Thai returns in the electricity sector can be affected by other variables which are not included in the CAPM.

To obtain better estimates, new model specification and estimation techniques are required, however the search for the best model is not the aim of this section.

As data from the Thai stock market is poorly constructed, estimation of betas employing data from developed countries should be conducted. Among electricity sectors in equity markets in developed countries, the US electricity sector has the largest size and the longest history. Its data is long, publicly available, well recorded and well behaved.

In Table 10 results from regression of both domestic and global CAPM in the US shows that all of the domestic and global betas are statistically significant and range from 0.3 to 0.6. None of the regressions suffer from autocorrelation, and none of them are spurious.

With a well developed equity market, regressions from the US data provide more reliable results, so in this study the global beta of the US will be employed.

The choices of sampling interval for the data and the length of the estimation period lead to the different values of global beta. The short interval data, such as daily intervals, are systematically biased in such a way that highly traded securities are overstated whereas those of infrequently traded securities are understated. The long intervals however, such as annual data, lower the number of observations for the estimation and reduce the accuracy of beta values. Brailsford et al. (1997) empirically showed that the beta estimates using monthly data for four to five years provide a reasonable trade off between the number of observations and the stability of beta estimates. The global beta of the US, estimated from monthly data for five years, is 0.39, which is called the raw beta.
Raw beta can be adjusted based on the assumption that the beta factor changes over time, especially in industries where there is considerable structural reform taking place. Over time, there is a tendency for the true beta to move toward the market average of one, because firms that survive in the market tend to increase in size over time, become more diversified and have more assets to produce cash flow. Following the Bloomberg adjustment approach which is generally employed in practice, the result is

\[
\text{Adjusted beta} = (\text{Raw Beta} \times 0.67) + 0.33.
\]  \hspace{1cm} (14)

It should be noted that Bloomberg approach, employing the constant weights to adjust betas, implies that the speed with which betas converge to one is the same across companies. The fact is that each firm has a different speed, depending on their diversification strategy. Firms that then diversify more broadly would have a faster speed than firms which stay in the same single business.

According to the Bloomberg adjustment approach, the adjusted equity beta is 0.6.\(^\text{17}\)

The next step is to ungear the adjusted equity beta to produce an asset beta using the relationship between the asset, debt and equity betas,\(^\text{18}\) as following

\[ R_{\text{asset}} = R_{\text{debt}} \left( \frac{\text{Debt}}{\text{Debt} + \text{Equity}} \right) + R_{\text{equity}} \left( \frac{\text{Equity}}{\text{Debt} + \text{Equity}} \right). \]  \hspace{1cm} (F1)

Substitute CAPM for each of the returns: \(R_{\text{asset}}, R_{\text{equity}}\) and \(R_{\text{debt}}\) into Equation F1

\[ R_{j} + \beta_{d} \left( R_{m} - R_{f} \right) = \left[ R_{j} + \beta_{d} \left( R_{m} - R_{f} \right) \right] \left( \frac{\text{Debt}}{\text{Debt} + \text{Equity}} \right) + \left[ R_{j} + \beta_{e} \left( R_{m} - R_{f} \right) \right] \left( \frac{\text{Equity}}{\text{Debt} + \text{Equity}} \right). \]  \hspace{1cm} (F2)

Hence, the relationship between the asset, debt and equity betas is

\[ \beta_{a} = \beta_{d} \left( \frac{\text{Debt}}{\text{Debt} + \text{Equity}} \right) + \beta_{e} \left( \frac{\text{Equity}}{\text{Debt} + \text{Equity}} \right). \]  \hspace{1cm} (F3)

\(^\text{17}\) Evidently the implied domestic and global betas estimated from five-year monthly data of Thailand are 0.51 and 0.52 respectively. These numbers are very close to this adjusted equity beta. A possible reason is that the implied beta represents long-run estimate of beta.

\(^\text{18}\) Relationship between the asset, debt and equity betas is derived from the WACC relationship as follows
\[
\beta_a = \beta_d \left[ \frac{\text{Debt}}{\text{Debt + Equity}} \right] + \beta_e \left[ \frac{\text{Equity}}{\text{Debt + Equity}} \right],
\]

where

- \( \beta_a \) is the asset beta;
- \( \beta_d \) is the debt beta; and
- \( \beta_e \) is the equity beta.

Asset betas are not directly observable and hence must be derived from the adjusted equity betas and debt beta. The difference between an asset beta and an equity beta reflects the extent to which debt is used to finance the firm’s assets.

Given the value of adjusted equity beta and debt beta, the asset beta can be calculated from Equation 15. The asset beta is the beta applicable to the assets of the firm.

The debt beta, reflecting the financial risk borne from the firm’s use of debt financing, can be estimated from CAPM as follows

\[
R_d = R_f + \beta_d \left( R_m - R_f \right)
\]

\[
\beta_d = \frac{R_d - R_f}{R_m - R_f},
\]

where

- \( R_f \) is the risk free rate;
- \( R_m \) is the expected return on the market portfolio;
- \( R_d \) is the expected return on debt or cost of debt;
- \( \beta_d = \frac{COV(R_d, R_m)}{\sigma_m^2} \) is the debt beta; and
- \( R_m - R_f \) is the market risk premium.

The estimation of debt beta is sensitive to the size of the market risk premium.

The choice of market risk premium employed in this study is 6 per cent. The risk free rate of the US is represented by the ten-year US Treasury bond rate in April 2004 of 4.5 per cent.
The cost of debt for the US electricity utilities is 5.5 per cent estimated from adding a one-per-cent basis spread of electric utilities in the US from Damodaran (2004) on the bond rate. The calculated debt beta is 0.17. This study will employ debt beta values of zero and 0.17 and the capital structure $\left( \frac{\text{Debt}}{\text{Equity}} \right)^{19}$ for asset beta estimation will be assumed at 30 and 60 per cent.

The levered equity beta, estimated by Equation 17 as following, is 0.6.

$$\beta_e = \beta_a + (\beta_a - \beta_d) \frac{\text{Debt}}{\text{Equity}}$$

(17)

Another secondary source of the levered betas of comparable electricity companies are from a study by Damodaran from New York University. Damodaran publishes an industry summary of betas for the electricity sector in the US, Europe, Japan, and emerging markets. The figures from January 2004 are reported in Table 12.

Note that employing the beta from overseas electricity companies has to be undertaken with care, as significant differences between these companies and those operating in Thailand exist. There are differences in stock markets, macroeconomic conditions, regulatory regimes, industry structure and levels of competition and non-distribution activities within the companies.

The estimated value of the levered equity beta of the US electricity sector is 0.6. This levered beta incorporates business risk and financial (or capital structure) risk, however in the developing countries such as Thailand the regulated firms are also subject to higher regulatory

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19 Because the actual capital structures of the firms will change over time and will be different across the firms, employing these will result in different inputs to the WACC model for different firms. This leads to inconsistent regulation. Therefore for regulatory purposes the industry benchmark of capital structure is preferred.
risk due to the specific characteristics of developing countries.

Also, regulation in the US is generally accomplished with the rate of return model and is different from regulation in Thailand. Therefore, the risk in the electricity distribution business in Thailand should be higher than in the US. This study assumes a 0.2 difference related to the regulatory risk, hence the levered equity beta of 0.8 is adopted.

4.2.2 Market risk premium

Research on market risk premium is vast and varies by estimation approach. There are several practical methods to estimate market risk premium, such as the use of historical data, surveys, the supply-side approach and extrapolation from foreign markets. There is no consensus on what the best methods are and what the appropriate value of market risk premium should be. The historic based measure is the most widely used estimate of market risk premium.

The studies on the US market risk premium are well developed, and are discussed based on the estimation approach selected.

1. Historic based approach

There are a number of recent studies on historical based market risk premium in the US, however for Thailand there are very few studies on market risk premium. The summary of recent studies is shown in Table 13.

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20 Regulatory risk occurs from regulatory discretion and sunk investment (Church and Ware, 2000, p.768). The regulator can itself introduce risk through unpredictable or unjustifiable regulatory intervention so raising the firms’ cost of capital and leading to inefficient investment.

Ex ante, the regulator sets the regulatory regimes and instruments, which allows the regulated firms to compensate for their investment. This means revenues obtained are estimated to be sufficient to allow for a return on and a return of investment. However, ex post, it can happen that a regulator has failed to carry out a commitment and changed the regulatory instruments which after all do not allow the firms to cover the capital costs. The regulator expropriates the firm’s capital investment.

The firms with sunk investment which does not have alternative uses can protect themselves by underinvestment, which means that firms will have higher costs and binding capacity constraints, which results in the loss of efficiency. Alternatively, the firms can be compensated for regulatory risk through a higher rate of return.
2. Supply side approaches

The supply side approach of estimating a forward-looking market risk premium is to calculate the implied risk premium using the discounted cash flow model. The basic idea is to estimate the expected future cost of capital in the market and then to subtract the prevailing yield on treasury securities. The expected cost of capital can be estimated by the dividend growth model or residual income model. Most of the research available on supply side approaches has been undertaken in the US as shown in Table 14.

The market risk premiums obtained from supply side approaches are generally lower than the historical based market risk premium. Many researchers have been concerned about employing the market risk premium from the historic based approach because they are too high and might overstate the true market risk premium.21

3. Surveys

The final approach directly measures risk premium obtained from surveys with financial academics, experts and chief financial officers in the US. As shown in Table 15 these surveys are conducted at a specific point in time, and the results vary by the sample group and time of survey.

From the reviews of various estimation methods of market risk premium, there is no consensus on what the best method is. The value of market risk premium of the US ranges from 3 to 7 per cent, and there is also no consensus on what the appropriate value of market risk premium should be.

Estimation of market risk premium by employing Thai data is likely to be inaccurate. This is due to the unavailability of a long series of a risk free rate, which is usually proxied by long term government bond rate. In Thailand, direct financing through government bonds is small and the Thai bond market is not yet developed.

To select the appropriate market risk premium for regulatory purpose for Thailand, the values of market risk premium employed by the various Australian and the UK regulators are

21 Gebhardt et al. (2001), Claus and Thomas (2001) and Jagannathan et al. (2000) provide a discussion on reasons of high market risk premium obtained from historic based approach.
explored. As shown in Table 16, apart from Office of Gas and Electricity Markets (OFGEM) all of the regulators employ a 6 per cent of market risk premium which is estimated from the most conservative historical based approach. OFGEM considered that a forward-looking market risk premium is more appropriate than a historical market risk premium. OFGEM argued that 5 to 6 per cent of market risk premium is too high, particularly when a reduction in expected market risk premium is due to such factors as a more stable business environment and better opportunities for investors to diversify. Hence market risk premiums adopted by OFGEM are lower than the other regulators.

It should be noted that 6 per cent of market risk premium is consistent with values obtained from empirical studies conducted in the US, as discussed above.

As for Thai economic conditions, the arguments set out by OFGEM are not applicable, therefore in this study a market risk premium set at 6 per cent will be employed.

4.2.3 Country risk premium

To value equity for Thailand, which is an emerging market, an additional risk premium for country risk included in the CAPM should be considered.

Country risk represents the uncertainty that investors face over future prospects in a given economy. Country risk is composed of two primary components: a country’s ability to pay its obligations relating to financial and economic risk, and a country’s willingness to pay its obligation relating to political risk.

Whether this additional country risk premium is included in CAPM depends on whether the market is viewed as open or segmented. If the markets are segmented, in which marginal investors cannot or will not invest outside their domestic market, risk premiums can be different in each market.

Marginal investors cannot diversify their portfolio outside their domestic market, and the likelihood that country risk is diversified declines substantially. Hence the additional country risk premium should be included in CAPM.
Even if the marginal investor is globally diversified, the condition that all or much of country risk should be country specific has to be met so that the additional country risk premium is not needed.

That country risk is country specific can be proven by low correlation across markets. If the correlation of returns across countries is significantly positive, country risk has a market risk component which is not diversifiable and has to be included in risk premium.

Bekaert and Harvey (2002) estimated the correlation of the International Finance Corporation composite with the Morgan Stanley Capital International world return in two periods: before and after 1990 for 20 emerging markets, including Thailand, and found that the correlation across countries has increased. The results also show that correlation among emerging markets has increased as well. When the correlations increase, the country risk is less diversifiable, thus the country risk premium should be included in CAPM.

The next step is to measure country risk premium and include it into CAPM.22

The simplest and most widely used method is a country bond default spread which is the difference between the yields on bonds issued by the country and the default free bond yield in the same currency (Damodaran, 2003, p.65). This default spread is typically added into both the cost of equity and debt.

Given that country risk premiums have been estimated, Damodaran (1999) summarised three alternative views to include country risk premium into the expected cost of equity as shown in Table 17.

Estache et al. (2003) proposed the model of cost of equity in developing countries by adding $CR$ into the standard CAPM in the same way as the first view proposed by Damodaran

22 The literature on estimation of country risk premiums is vast. Erb et al. (1997), Harvey (2001) and Damodaran (2003) have reviewed other methods to measure country risk, such as use of beta from global CAPM as country risk, the country spread model, the Ibbotson model and the Erb-Harvey-Viskanta model using country credit rating. This study aims to employ the method that is simple and transparent for the regulated firms, and thus complicated methods will not be suitable.
They also suggested that country risk premium ($CR$) should also be included in the cost of debt: $R_{debt} = R_f + CR$.

Assuming that large public utilities have good credit rating, the cost of debt can be proxied by the return on public bonds in the country.

For the regulatory purpose, Green and Pardinia (1999) proposed the modified CAPM in which the country risk premium is added into the cost of debt and equity, resulting in

$$R_{debt} = R_f + CR$$

and

$$R_i = R_f + \beta_i \left( R_m - R_f \right) + CR,$$

respectively, for the developing countries.

If the regulated company is not quoted on a stock market, CAPM cannot be used and the regulator should determine the rate of return for similar companies.

Useful information for the calculation of the cost of debt and equity can be obtained from other companies in the same part of the industry, in the home country, in other countries with similar economies and from regulated companies in other industries. For example, the gas regulator (ENARGAS) of Argentina calculated the cost of debt by employing the US risk free rate and adding the country risk premium. The use of the US Treasury bond risk free rate is justifiable as long as the country is interested in attracting foreign capital into the sector. To estimate the cost of equity, ENARGAS employed the beta and market risk premium of the US gas distribution companies. The country risk was estimated from the difference between the yield of a domestic bond in US dollar and the risk free rate with the same average life. The cost of capital based on data from the developed market will set the benchmark for efficient firms.

For the purpose of regulating electricity distribution in Thailand, the local CAPM of the US as the comparable electricity sector with Thailand is calculated and adjusted by the country risk premium following the first view that all companies in a country are equally exposed to country risk.

$$R_{IT} = R_{RUS} + \beta_{US}^{electricity} \left( R_{mUS} - R_{RUS} \right) + \left( R_f - R_{RUS} \right)$$

(18)
where
\[ \beta^\text{electricity}_{US} \] is the levered equity beta of the US electricity sector obtained from the global CAPM, \[ R^\text{electricity}_{US} = \alpha_i + \beta^\text{electricity}_{US} \mu_{mg} \], and
\[ (R_f - R_{g,US}) \] is country risk premium; where \( R_f \) is the risk free rate of Thailand and \( R_{g,US} \) is the risk free rate of the US.

\( R_f \) is proxied by Thai baht denominated ten year Thai government bond yield in June 2004, at 5.13 per cent whereas \( R_{g,US} \) is represented by the ten year US Treasury bond rate in April 2004, at 4.5 per cent.

The country risk premium is thus 0.63 per cent.

The Thai bond rate is surprisingly low. Most Thai government bonds are issued in the Thai domestic market in Thai baht, and it should be noted again that the domestic bond market in Thailand is immature and not well developed. Most capital mobilisation has been done through bank intermediation, and direct financing through both government and corporate bonds is relatively small. Thailand’s strong fiscal balances between 1988 and 1996 provided no incentive for the government to issue regular and large amounts of government bonds (Chabchitrchaidol and Permpoon, 2002, p.190).

Since the 1997 financial crisis, Thailand’s domestic bond market has grown because of an increase in the supply of government bonds in order to borrow to meet the cost of financial restructuring and to finance public debt. Since then a regular supply of government bonds has been created.

The other estimation method of country risk premium is to use country default bond spreads that come with country risk rating, adjusted by the volatility of the equity market in a country relative to the volatility of the bond market used to estimate the spread. The country risk premium can be estimated as following.

\[ \text{Country risk premium} = \text{Country default spread} \star \left[ \frac{\sigma_{\text{Equity}}}{\sigma_{\text{Country bond}}} \right], \quad (19) \]
where \( \sigma_{\text{Equity}} \) is the annualised standard deviation in the country equity index and \( \sigma_{\text{Country Bond}} \) is the annualised standard deviation in the country bond. This country risk premium will increase if the country rating drops or if the relative volatility of the equity market increases.

Damodaran, from New York University, estimated the country risk premium of many developed and developing countries including of Thailand, using the country rating from Moody’s and estimating the country default spread for that rating. The emerging market average of 1.5 was then used as the relative equity market volatility for that market (standard deviation in country equity market/standard deviation in country bond) which means that equity markets are about 1.5 times more volatile than bond markets.

In January 2004, Moody’s rating of Thailand is Baa1 which leads to a 150 basis points of country default spread.

Therefore the country risk premium of Thailand is 2.25 per cent. Damodaran (2003) argued that this method provides a more accurate measure of country risk premium than the country bond default spread method for the immediate future.

4.2.4 Cost of equity, cost of debt and weighted average cost of capital

The market risk premium of the US market is 6 per cent. With 0.63 per cent of country risk premium, the costs of equity of the Thai electricity sector, \( R_{j}^{*} \), are 8.73 and 9.93 per cent based on the levered equity beta of 0.6 and 0.8 respectively, whereas with 2.25 per cent of country risk premium, the costs of equity, estimated by Equation 18 are 10.35 and 11.55, respectively. Obviously the low country risk premium leads to the low equity beta.

Since the country risk premium calculated from the country bond default spread is too low as a result of the low Thai denominated government bond rate, this study will use the country risk premium, 2.25 per cent, from the country default spreads derived from the country risk rating.

The cost of debt, 7.38 per cent, is calculated from \( R_{\text{debt}} = R_{f} + CR \), where \( R_{f} \) is the nominal risk free rate of Thailand, 5.13 per cent, and \( CR \) is the country risk premium, 2.25 per
cent. The nominal risk free rate of Thailand is proxied by a ten-year government bond yield on June 2004 obtained from Bank of Thailand.

The nominal WACC is estimated by Equation 2. With the levered equity betas of 0.6 and 0.8, the costs of capital obtained are 9.46 and 10.3 per cent respectively. The summary of parameters and WACC estimates by various regulators in Australia and the UK, and by developing countries, Pakistan and Argentina, is shown in Table 19. Compared to WACC regulated by the Australian and UK regulators in the electricity distribution business, WACC of Thailand is higher, mainly owing to the inclusion of country risk premium in both cost of debt and cost of equity. When compared with the same industry in the developing country, Pakistan, the resulted WACC of Thailand is lower, due to the lower cost of debt and lower capital structure. Pakistani regulators relied on more debt financing than equity which is in contrast to the capital structure for Thailand.

4.3 Depreciation

Following international practice, the choice of depreciation method for Thailand should be the straight line depreciation method. With the high investment levels forecast by MEA and PEA, the straight line depreciation method leads to very low capital costs at the end of an asset’s life. It helps to smooth prices throughout the regulatory period.

4.4 Noncapital cost

The noncapital or operating costs mainly include of operating, maintenance and administrative costs of business. Noncapital costs are associated with providing services and running the business.

The regulator has to be careful that the costs are not excessive nor represent inefficient operating practices arising from the natural monopoly status of the firms. To determine the efficient noncapital costs, the regulator has to adjust the costs with the inflation and efficiency factor to provide an incentive for the firms to improve their operating efficiencies. The regulator is also mindful that there is a tradeoff between operating efficiency and service quality. The
efficient noncapital cost has to be set at a level which is not too high to operate inefficiently and not too low for the firms to provide adequate maintenance and service quality. The impact of demand growth on noncapital cost has to be taken into account as well. The price index-$X$ adjustment mechanism on non-capital costs is more central to the discussion in the case of Thailand.

4.5 Price index-$X$ adjustment mechanism

The key aspect of incentive regulation which differs from ROR regulation is the aim to provide regulated firms with an incentive to improve their performance. To achieve the objective of incentive regulation, the regulator has to provide an incentive to the firm to outperform a benchmark set by the regulator and allowing them to retain part or all of the benefit from doing so. The price index-$X$ mechanism involves inflation adjusted price (revenue) typically being reduced by $X$ factor, called the adjustment factor. To apply the price index-$X$ adjustment mechanism to determine the caps, the main issues are the choice of price index and the measurement of $X$ factor.

In Thailand regulated firms are expected to be able to raise most or all of their funding from Thai baht denominated sources, and most of their expenditures are also likely to be Thai baht denominated. Therefore it is not necessary to include indexation of exchange rates into the price index.

The general measure of changes in costs in Thailand, the Consumer Price Index, is appropriately employed. Even though it does not reflect true input costs, it is more convenient and less costly than constructing an industry specific index which is not readily available in Thailand. Moreover, the use of an industry specific index also has the drawback that it may encourage less effort in negotiating prices with union and input suppliers if the firm knows it can pass those prices on to consumers.

For the $X$ factor, it can be directly constructed by econometric methods or mathematical programming, based on the data available from two distributors in Thailand: MEA and PEA.
An inherent difficulty in measuring the $X$ factor is that regulated firms have private information about their operation which enables them to extract information rents.

In addition, issues of efficiency and productivity of firms under public ownership are politically sensitive in Thailand. It is likely that Thai distributors prefer to supply data in such a way that estimated $X$ factors are favourable to them.

Yardstick competition can be a regulatory option which can weaken the firms’ information monopolies. By comparing enterprises with comparable firms providing similar services, it is possible to determine the lowest cost potential of every firm. Potential drawbacks are regulatory gaming between the regulator and regulated firms, and the unavailability of comparable firms. Because electricity distributors operate in geographically separate areas, the latter problem can be controlled by using exogenous variables for performance measurement.

Another problem is that in Thailand only data from two distributors can be used for efficiency comparisons. To obtain a more robust $X$ factor, a larger database is required, hence international benchmarking is recommended.

Data on comparable firms from other countries can increase the amount of data, however the problems of comparability and data collection still exist. To solve problems of firm comparability, again exogenous variables, including country’s variables, such as the level of economic development, must be considered (Estache et al., 2004).

For Thailand, international benchmarking against comparable firms from such countries as Malaysia, the Philippines and Singapore can be a good option. International coordination of electricity regulation in Southeast Asia can also be promoted.

The other option for Thailand is to directly employ the $X$ factor from the other regulators in developed countries and set it as a goal for Thai distribution companies to achieve.

5. Revenue cap regulation

As discussed in Section 3, revenue cap regulation is recommended for electricity distribution in Thailand.
This section aims to estimate revenue requirement of two electricity distribution companies in Thailand: MEA and PEA. The data for estimating Equation 1 are taken from discussion and estimation in previous section and from annual reports of MEA and PEA in 2003.

The values of WACC estimated in Section 4.2 are 10.35 and 11.55 per cent.

Although Capital base should be estimated by DORC approach, as discussed in Section 4.1, due to data unavailability, capital base of MEA and PEA, proxied by values of electric assets reported in their annual reports in 2003, which are 76.58 and 158.14 billion baht, are employed. As the service area of PEA is larger than that of MEA, values of electric assets of PEA are greater than those of MEA.

Again due to data unavailability, depreciation rate is assumed to be 3 per cent for both companies.

Due to data unavailability, Efficient OPEX, is proxied by operating expenditures of MEA and PEA, excluding the expenses on purchase of electricity energy, reported in their annual report in 2003. The reason is that in unbundled firms, distribution and retailing businesses are operated by separate firms. Electricity distribution companies operate only on electricity distribution business. The consumers purchase and pay for the electricity through the retailers. Although electricity distribution and retailing businesses in MEA and PEA are not unbundled, to regulate distribution companies in Thailand, exclusion of expenditures on purchase of electricity supply is needed because purchasing electricity supply is not main operation of distribution companies. Incentive for efficiency improvement through efficient operating expenses should be imposed on only electricity distributing operations.

The resulting operating expenditures for estimation of revenue requirement of MEA and PEA are 7.36 and 14.23 billion baht respectively.

Results from estimation of Equation 1 are shown in Table 20. With 9.46 per cent of WACC, revenue caps of MEA and PEA are 16.9 and 33.93 billion baht respectively whereas with 10.3 per cent of WACC, they are 17.55 and 35.26 billion baht respectively.
With both WACCs, revenue caps, obtained from estimation, of MEA and PEA exceed actual revenue in 2003, as shown in Table 20. Note that actual revenues obtained from annual reports of MEA and PEA in 2003 exclude expenditures from purchase of electricity supply so that the operating revenue represents income from operating distribution business.

The results show that revenue caps based on existing operating costs and book values of capital are slightly greater than the existing revenue. The differences between revenue caps and actual revenue can be explained by a margin of error associated with estimates of WACC and other financial parameters obtained from a number of assumptions.

For regulatory purposes in the next regulatory period if prices are not to increase, regulators will either have to reduce the allowable capital base or require reductions in operating costs in order to provide MEA and PEA with more incentive for efficiency improvement.

6. Concluding remark

With the characteristics of the Thai economy and level of development concerning regulation, the high powered incentive regulatory regime should be adopted in electricity distribution activities, characterised by natural monopoly, to achieve the objective of economic efficiency improvement. The particular regulatory form for this activity should be revenue cap regulation. Price cap regulation is not appropriate because it provides incentives for firms to increase sale volumes which conflicts with the demand side management program in Thailand and also provides more risk to firms and less incentive to invest owing to high demand forecast error in Thailand. Revenue cap regulation can reduce the severity of these problems.

This study estimated the revenue caps for MEA and PEA electricity distribution companies in Thailand. The aim of this exercise was to demonstrate that the adoption of regulatory finance from developed countries with well developed capital and equity markets needs some modifications to fit with developing countries, which are characterised by poor accounting and auditing systems and weakly functioning capital and equity markets. The problem of lack of data and asymmetric information faced by the regulator in Thailand is more severe than in developed countries.
With these considerations the revenue caps for MEA and PEA based on building block approach are estimated. Evidence shows that under revenue cap regulation MEA and PEA’ actual revenues are slightly less than their revenue caps, therefore both enterprises are not receiving any significant monopoly profits from their operation.

For regulatory purposes, in the next regulatory period regulators will either have to reduce the allowable capital base or require reductions in operating costs in order to provide MEA and PEA with more incentive for efficiency improvement.

It should be noted that the major limitation of this study is lack of availability of data. Note that this limitation has been mentioned throughout this study, particularly where estimations are conducted.

Without the true value of DORC, the proxy of the asset values of the distribution business obtained from annual reports may overvalue the efficient costs, which results in a high revenue cap. Also, the estimated rate of return of Thailand is obtained from many comparable data from comparable distribution companies. It can over/undervalue of rate of return, which ultimately affects the level of revenue requirement.

This regulatory analysis demonstrates that although regulatory reform is needed, adoption of regulatory regime, form and finance from developed countries has to be undertaken with care and modified in light of Thai characteristics and economy.

Although the regulatory regime and form are set out correctly, then regulatory capacity, instruments and transfer mechanisms have to be enhanced in order that benefits from regulation are finally transferred to the consumers. The regulatory tools should be revised through time to fit with the changing structure of ESI and electricity distribution business.

Moreover the regulatory regime, form and tool in this study is recommended for regulating the existing distribution firms under the current structure of ESI in order for them to operate efficiently. It does not cover the other regulatory issues such as public service obligation, entrance of new distribution companies and investment in distribution systems.
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