Centre for Efficiency and Productivity Analysis

Working Paper Series
No. WP06/2009

Title

The Effects of Competition Policy on TFP Growth:
Some Evidence from the Malaysian Electricity Supply Industry

Authors

Kok Fong SEE
Tim COELLI

Date:
August 2009

School of Economics
University of Queensland
St. Lucia, Qld. 4072
Australia

ISSN No. 1932 - 4398

The Effects of Competition Policy on TFP Growth: Some Evidence from the Malaysian Electricity Supply Industry

Kok Fong SEE
Centre for Efficiency and Productivity Analysis
The University of Queensland
Email: k.see@uq.edu.au

Tim COELLI
Centre for Efficiency and Productivity Analysis
The University of Queensland
Email: t.coelli@uq.edu.au

Abstract

The main objectives of this paper are to measure total factor productivity (TFP) growth in the electricity supply industry in Peninsular Malaysia from 1975 to 2005 and to assess the impact of private entry reforms upon TFP in this industry. Prior to 1995, a government-linked, vertically-integrated electricity utility, Tenaga Nasional Berhad (TNB), was essentially the sole operator. However, since 1995 privately-owned Independent Power Producers (IPPs) have also begun generating electricity, all of which is purchased by TNB under fixed Power Purchase Agreements (PPAs). The introduction of IPPs has reduced the need for TNB to find finance for new power plants. It has been argued that the participation of IPPs in the electricity generation industry should also facilitate improvements in industry productivity; however this proposition is yet to be tested. In this study we calculate TFP growth using Törnqvist index methods, finding that there is no direct evidence of productivity improvements attributable to the privatization. Furthermore, it is not clear that consumers have benefited from this, since the PPAs have generally been quite generous to the IPPs in terms of risk sharing and prices paid.

Keywords: Total Factor Productivity Growth, Privatization, Electric Utilities
JEL Classification: D24, L33, L94

1. Introduction

Before the deregulation era, electricity utilities in many countries were vertically integrated, owned and run by the government. It was generally believed that electricity utilities were natural monopolies because they required large fixed and sunk costs. However publicly owned utilities often operate inefficiently with high production costs due to a lack of incentives for cost saving (Nagayama, 2009; Sioshansi & Pfaffenberger, 2006). Moreover, in a number of cases government control and political intervention caused mediocre performance and wasteful resources (Shleifer, 1998). At least in part for these reasons, we have seen that in some countries vertically integrated utilities have been replaced by alternative market structures since the early 1990s.

Electricity market reforms are expanding in the Asia Pacific region, in countries such as Australia, New Zealand, South Korea, Thailand and Malaysia. We can observe that some public ownership is being replaced by a privatized system in which previously vertically integrated functions have been disaggregated and some degree of competition has been introduced. The drawback of these reforms is that the government no longer has the authority to implement restructuring especially in privatised monopolies (Newberry, 1999). In order to monitor the industries and avoid exploitation of consumers in competitive markets, regulatory bodies are established. For example, the Office of Gas and Electricity Markets (Ofgem) in the United Kingdom (UK) is responsible for setting regulated prices in the non-competitive sections of energy businesses in the UK. They use econometric performance measurement methods to help them identify efficient price levels.

In certain countries, this market reform leads to an opening-up of sections of the business to competition (e.g., generation), whilst the other parts still remain with the traditional monopoly utility (e.g., transmission and distribution). This scenario happened in the Malaysian Electricity Supply Industry (MESI), whereby competition was introduced in the generation sector whilst the other parts, namely transmission and distribution activities, are still a monopoly business run by the government linked company, Tenaga Nasional Berhad (TNB).

The electricity supply industry in Malaysia has been a monopoly and vertically integrated industry since 1949. The National Electricity Board (NEB) was corporatized and then privatized into TNB in 1990 and 1992, respectively. Due to the large-scale power failure[1] in Peninsular Malaysia in 1992, several immediate actions were taken to improve the quality of electricity supply, such as allowing the private sector to enter the power generation sector by selling electricity to TNB based on a Power Purchase Agreement (PPA). It has been argued that the participation of these Independent Power Producers (IPPs) in the Malaysian electricity industry should facilitate TNB in raising its total factor productivity (TFP); however, this proposition is yet to be tested.

In this study we measure total factor productivity growth in the Malaysian electricity supply industry from 1975-2005, with a particular interest in investigating the effect of the private entry reform described above. Our most difficult task is the identification of sufficient quality data to allow us to conduct a defensible analysis. Hence, we provide a detailed discussion of input and output variables used in our analysis. This allows readers to judge the quality of our analysis, and should also provide a useful guide to other researchers who may be considering conducting similar empirical studies in the future.

2. The Malaysian Electricity Supply Industry

Malaysia is a developing country that is located in Southeast Asia with the estimated population at 27.61 million and a per capita income of US$6,896 in 2009 (Malaysia Statistics Department, 2009). The Malaysian electricity supply industry established the Central Electricity Board in 1949 (renamed later as National Electricity Board in 1965) as a publicly owned utility to generate, transmit and distribute electricity in Peninsular of Malaysia (see Figure 1). In line with the privatization of other government agencies to ease the government's burden in raising capital, the privatization of the industry started when the National Electricity Board was corporatized in 1990 as TNB under the Electricity Act 1990 and subsequently privatized and floated on the Kuala Lumpur Stock Exchange, with the Ministry of Finance holding about 70 percent of the shares.

In the year 1992, there was a grave power crisis in Malaysia and it created concerns regarding the competence of TNB, the sole electricity provider. The government began looking for the best-suited model to safeguard the electricity industry. As a result, the government decided to relax industry regulation by allowing the entry of IPPs. The Malaysian model of deregulation of the

[1] On September 29, 1992 Malaysia suffered an electricity blackout that lasted two days and was caused by heavy storms leading to electricity network failures.

electricity supply industry was designed to meet various social and economic objectives: provide a safe, secure and adequate electricity supply, ensure affordable prices to the final consumers; and promote competition and improve industry performance. This policy resulted in the building of new power utilities, starting in 1995, by the private sector. With the involvement of the private sector, the government established the Department of Electricity and Gas Supply (JBE&G) in 1990 to monitor activities on electricity and gas and this department was replaced by the Energy Commission in 2002.

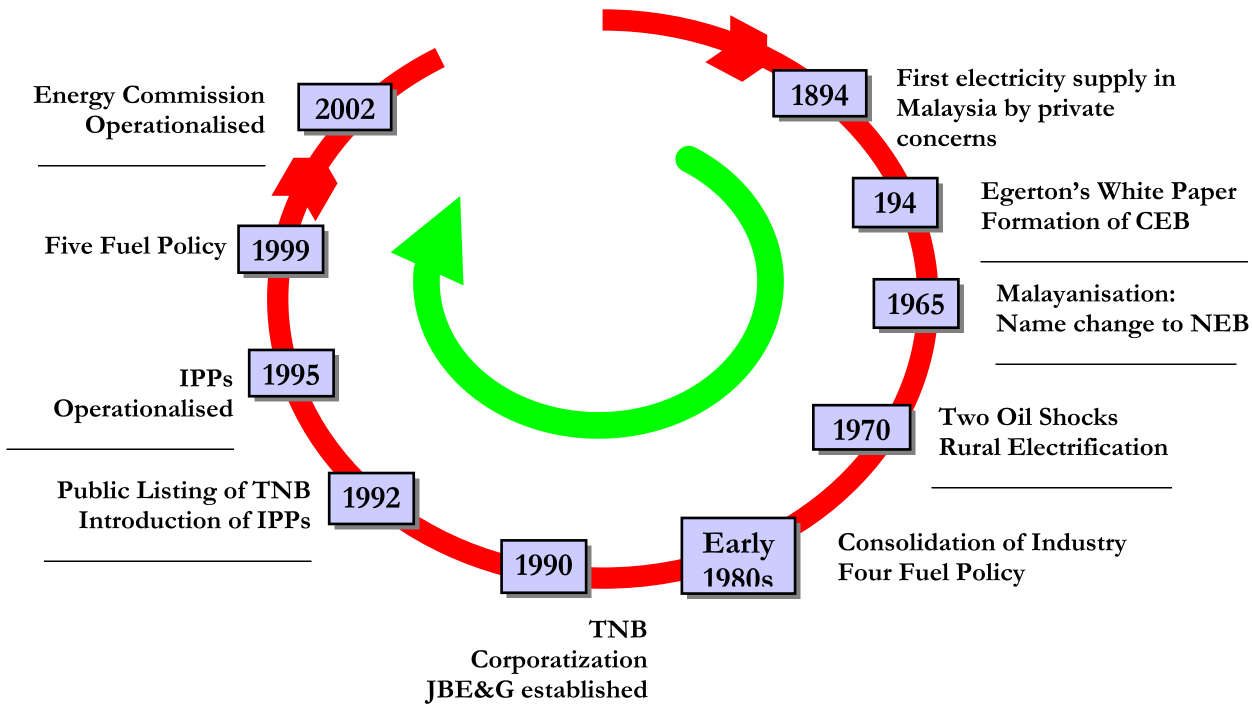

Figure 1: Evolution of Malaysia Electricity Supply Industry

Source: Ministry of Energy, Water and Communication (2005)

A single buyer model is used in the Malaysia electricity supply industry. The industry structure is separated into three components, namely generation, transmission and distribution. TNB, independent power producers and co-generators all generate electricity for consumers in the Malaysia. Nevertheless, TNB still monopolises the market of transmission and distribution in the Peninsular Malaysia. All the energy produced by the IPPs is purchased by TNB at a fixed price under a PPA, which are generally quite favourable to the IPPs (Smith, 2003). In general, the price set in the PPAs was higher compared to the TNB generation unit cost (refer to Table 1 and Table 2).

Table 1: IPP Energy Payment Based on PPAs

	IPP Energy Payment (MYR/KWh)
1st PPA (1993)	0.130-0.150
2nd PPA (1998)	0.110-0.125
3rd PPA (2002)	<0.110

Source: Energy Commission (2006, 2007)

Table 2: TNB Generation Cost and IPP Energy Cost, 1997-2003

	Energy Unit Cost (Thermal Power Plant Only)	
	IPPs (MYR/KWh)	TNB (MYR/KWh)
1997	0.190	0.099
1998	0.171	0.113
1999	0.187	0.100
2000	0.157	0.087
2001	0.148	0.090
2002	0.157	0.109
2003	0.148	0.086

Source: Tenaga Nasional Berhad Annual Report (1998-2005);
Energy Commission (2006, 2007)

Under this power purchase agreement, TNB makes two payments based on capacity and energy rates. There were three different versions of PPA in Malaysia. The first purchase agreement was signed based on the compulsory purchase concept where TNB pays the IPP a monthly fixed rate for 21 years regardless on whether TNB takes their electricity. As for the second and third types of purchase agreements, the 'take and pay' concept was introduced, where TNB would pay the IPP only if TNB buys electricity generated by the IPP. The price set in the second and third PPAs was generally lower compared to the price in the first PPA. However, the capacity charge still applied in the second and third version of PPAs (refer to Table 1). Furthermore, all the cost of increases in fuel prices and loss of electricity during the transmission and distribution process are absorbed and paid by TNB. Overall, it is fair to say that the PPAs have generally been quite generous to the IPPs in terms of risk sharing and prices paid.

In 2004, TNB generated 49.2 percent of the energy while the investor-owned independent power producers contributed nearly 50 percent, with the remaining small amount being produced by co-generation and self generation. In the year 2004, the total electricity generated was 96,060 giga-watt hours (Gwh) with a generation mix of gas (66.5 percent), coal (23.5 percent), hydro (5.8 percent) and the rest diesel and biomass (Energy Commission, 2006). The generation mix in Malaysia is different to other countries, such as Australia, Canada and United Kingdom, which mainly use coal, hydro and nuclear, respectively, in electricity generation. The number of electricity customers in Malaysia at the end of 2004 was 6.7 million, of which 83.4 percent were domestic customers followed by commercial (15.5 percent), industrial (0.4 percent) and the rest public lighting and mining (0.7 percent) (Energy Commission, 2006).

3. Literature Review

A large number of empirical studies had investigated the linkages between market reforms (i.e., liberalization, privatization etc) and TFP growth in the electricity industry (e.g., Atkinson & Halabi, 2005; Domah & Pollitt, 2001; Estache & Rossi, 2005; Hjalmarsson & Veiderpass, 1992; Weyman-Jones, 1991). However, the overall results tend to be mixed. There are a considerable amount of studies that support the proposition that privatization and liberalization could lead to improvements in the TFP growth. For example, Kleit & Terell (2001) employed Bayesian SFA to study cost efficiency of 78 US power plants operating in 1996. Exogenous variables are specified as annual output (MWh), peak output (MWh), fuel price, capital price, wages while total costs is the endogenous variable. The study found efficiency gains immediately after the deregulation and restructuring of the electricity industry in the US.

Atkinson & Halabi (2005) show that in the case of Chile, privatization has been associated with improvements in technical efficiency and TFP growth. They gathered an unbalanced panel of monthly data from 16 hydroelectric plants in Chile from 1986 to 1997. The inputs for the model were the number of fulltime employees, capital stock (i.e., depreciated replacement value deflated by Chilean CPI), water consumption (thousand cubic meters per MWh) and the relative hydrologic conditions with gross electricity generated (MWh) as the output measure. The results of a SFA distance model obtained weighted annual TFP change of 4.61 percent over the sample period. The productivity growth is mainly driven by technical change of plus 3.08 percent per year, primarily because over utilization of labour (relative to capital and water) have been reduced effectively over the study period.

In contrast, Meibodi (1998) also did not find evidence of efficiency gains after the privatization of the electricity industry. Their study used panel data for the period from 1987 to 1988 to compare the performance of Iran's electricity generation industry with 26 other countries. The study suggested that the electricity industry in developing countries needed to reduce their cost of production to reach the production frontier. Moreover, market reforms, such as privatization, were not a good choice to resolve their industry's problem.

This particular point is recognised by Yunos & Hawdon (1997) in the case of Malaysia. This study is the only empirical study (that we know of) that has measured the technical efficiency of the Malaysian electricity industry. They compared the performance of the electricity industry between National Electricity Board (NEB) in Malaysia (now is known as Tenaga Nasional Berhad, TNB) and 26 other selected developing countries in 1987 and 1988. Nameplate generating capacity, labour, total system losses, capacity factor and gross electricity generated at the aggregate level were the variables used in their study. From the results of their DEA analysis, Malaysia is ranked 18th out of 27 countries with a technical efficiency score of 0.7042. Moreover, they also concluded that changes in ownership would not bring development to this industry without the existence of competition.. The similar conclusions also supported by Hjalmarsson & Veiderpass (1992) and Estache & Rossi (2005) for their electricity distribution studies.

Although a number of studies have examined productivity and efficiency among power utilities before and after deregulation, there has been little or no agreement on the relationship between privatization and total factor productivity growth. Moreover, this review of the literature revealed a dearth of electricity studies in Malaysia and thus arise the purpose to study while filling the research gap and guide for future research works.

4. Research Methodology

A large number of the TFP measurement tools have been adopted in past empirical studies, as described in Section 3. The popular methods used to measure performance can be divided into two groups, price based index number methods and frontier methods (refer to Figure 2). In general, price-based index number methods make use of market prices, while frontier methods require a specifying a production technology and the application of implicit (shadow) prices is then reflected in the shape of the production frontier (Coelli et al., 2003). The index number methods have the advantage that they can be used when limited data are available, such as industry-level data, while frontier methods require more data, for instance, firm-level panel data.

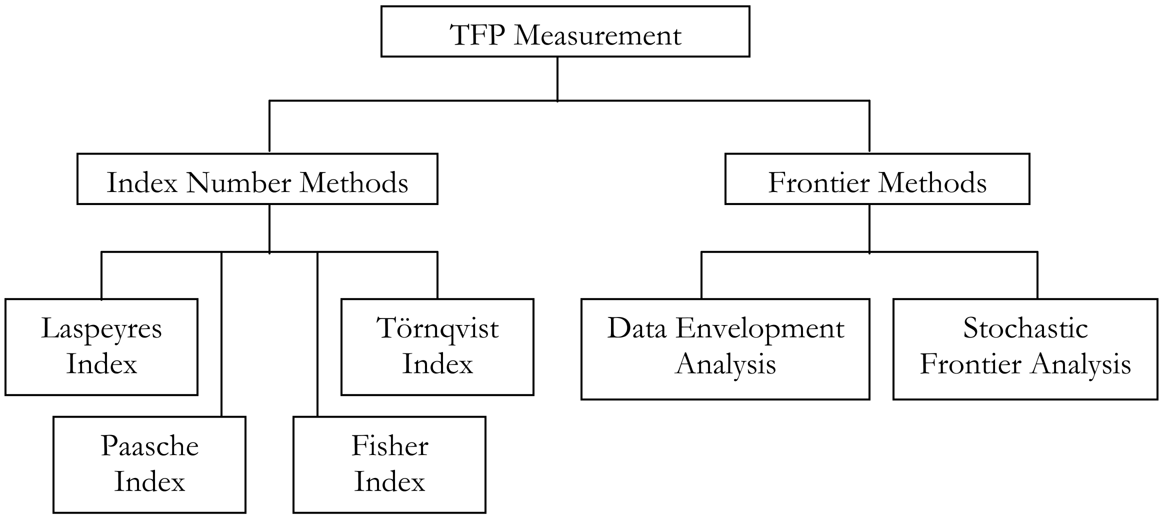

Figure 2: Total Factor Productivity Measurement Tools

a) *Index Number Methods*

Price-based Index numbers use traditional index based techniques to aggregate input and output variables of the utilities. For example, using a Tornqvist or Fisher index number formula. In general, price information is used in constructing the aggregate indices. Price-based index numbers are a sensible choice when limited data are available. Index methods are generally applied when you only have access to data on one firm or a few firms. However, index methods require market price information and cannot be used to decompose TFP into components, such as technical change and technical efficiency (Coelli et al., 2003).

b) *Frontier Methods*

Frontier methods require data on the input and output quantities used by a sample of firms. The estimated frontier is constructed to fit over the top of the data points. The technical efficiency score can be calculated by the distance from each observed data point to the efficient frontier. Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) are the two most frequently adopted approaches to develop efficient production frontiers. Data Envelopment Analysis uses linear programming methods to construct the frontier, while SFA uses econometric methods. With access to data on a number of firms over a number of time periods (panel data), one can estimate a sequence of frontiers over the different time periods and use the distance measures to construct Malmquist indices of TFP growth. See Coelli et al. (2003; 2005) for further details on the SFA, DEA and Malmquist TFP indices.

Törnqvist Price-Index Number

In this study we investigate the performance of a single integrated power utility. Since no panel data are available, a price based-index number is appropriate for use in this study. Three index number formula are generally used in constructing quantity indices, namely the Laspeyres, Törnqvist and Fisher. The Törnqvist and Fisher indices provide second-order approximations to the underlying production technology, and hence are favoured relative to 1st order indices, such as the Laspeyres (Coelli et al., 2005). The choice between the Fisher and the Törnqvist indices is generally not crucial, since they tend to approximate each other quite closely when used to calculate changes over short periods, such as adjacent years. In practice, the Törnqvist index seems to be preferred and used in many empirical studies in the last decade, such as IPART (1999) and Coelli (2002). Therefore, we adopt the Törnqvist index to measure TFP change in Tenaga Nasional Berhad from 1975 to 2005.

The Törnqvist input quantity index is generally expressed in additive (log-change) form as:

$$\ln Q_{st}^{I} = \sum_{i=1}^{N} \left(\frac{\omega_{is} + \omega_{it}}{2} \right) (\ln x_{it} - \ln x_{is}) \tag{1}$$

where Q_{st}^{I} is the Törnqvist input quantity index from period s (the base period) to period t, ω_{it} is the value share of the *i*-th input in the *t*-th period, x_{it} is the quantity of the *i*-th input in the *t*-th period. Alternatively, the Törnqvist input index may also be expressed in multiplicative form as:

$$Q_{st}^{I} = \prod_{i=1}^{N} \left[\frac{x_{it}}{x_{is}} \right]^{\frac{\omega_{is}+\omega_{it}}{2}} \tag{2}$$

Here we observe that the input quantity index is a weighted geometric mean of the index numbers for each component input, where the weights are the average cost shares in the two periods. In our study, we applied this formula to the cost share and revenue share with the input and output quantity data described in the next section to obtain Törnqvist input and output indices.

The TFP index is calculated as:

$$\text{Törnqvist TFP Index} = \frac{\text{Törnqvist Output Index}}{\text{Törnqvist Input Index}} = \frac{\prod_{j=1}^{M}\left[\frac{y_{jt}}{y_{js}}\right]^{\frac{\gamma_{js}+\gamma_{jt}}{2}}}{\prod_{i=1}^{N}\left[\frac{x_{it}}{x_{is}}\right]^{\frac{\omega_{is}+\omega_{it}}{2}}} \qquad (3)$$

where ω is the input cost share in the relevant period for the relevant input, γ is the output revenue share in the relevant period for the relevant output, x is the input quantity, and y is the output quantity.

5. Variable Choice

In electricity supply studies, capital, labour, fuel, purchased power and maintenance services are generally chosen as input measures, while electricity delivered is often chosen as the output variable in the measurement of TFP. The price and quantity data are used to construct the respective input and output growth indices. We will begin with a discussion of each variable that assumes that we have no data constraints, and then follow with a discussion of the more usual situation where we have factor in the data restrictions

Inputs

a) Labour

The quantity of labour is generally measured using the number of full time equivalent employees (FTE). This measure will be appropriate if there have been no substantial changes in skill composition in the work force over time. However, if the average skill level has risen (for example) then the FTE measure will provide a downward biased measure of the change in labour quantity over time. If this is a concern, an ideal labour measure would involve the collection of data on FTE in various skill categories, such as cleaners, engineers, etc. and then the construction of an aggregate index (e.g., Törnqvist) given access to wages data in each of these categories also.

Unfortunately we do not have access to this type of data. One alternative could be to take the data on total labour costs (which we have) and then deflate this by an appropriate labour price index to obtain an implicit quantity index. This will be a good measure if the relative wage rates for the various categories reflect their relative marginal products. Unfortunately, we do not have access to a suitable labour price index for this period, so this is not an option either. Thus the quantity of labour used in this study is the number of full time equivalent employees and the implicit price of labour is calculated by dividing labour costs by the quantity of labour. Thus we are implicitly assuming that the composition of labour has not changed significantly during this period.

b) Fuel

Power plants use various fuel types, such as natural gas, coal, diesel, and crude oil. In this study we aggregate fuel types by converting each one into a Petajoules (Pj) equivalent measure and then summing these. This aggregate measure of fuel quantity assumes that each Pj is equally "useful". However, it could be argued that for some bulky fuels, such as coal, there are extra costs associated with handling the bulk and removing the ash. One alternative is to take a measure of the total cost of fuels and then deflate this by a fuel price index to obtain an implicit quantity measure. However, this approach would implicitly assume that the relative prices of the fuels reflected their productive contribution, when often price differences are driven more by external supply and demand conditions or government policies. Furthermore, a fuel price index in Malaysia did not exist prior to 1990, so this was not a feasible option in our case.

Perhaps an ideal fuel quantity measure would have involve the construction of a Törnqvist index measure using data on quantity and price for each fuel type, but unfortunately such detailed data was not available. Thus we used the aggregate Pj quantity measure. Fuel price was then obtained implicitly by dividing the total fuel cost by this quantity measure.

c) Capital

While comparing this input to others, capital is probably the most complicated input to measure. The capital for instance, could be classified into different categories according to electricity activities, such as installed generation capacity for electricity generation, network length and total number of transformers for electricity transmission and distribution. It is widely believed that some capital assets (e.g., nameplate generating capacity) can deteriorate physically and hence provide less service over time. For this reason, the estimation cost for this particular type of input should reflect an annual average potential service flow that derives from the capital assets during its lifetime (Coelli et al., 2003). A variety of alternative ways to estimate capital have been adopted in past electricity industry studies.

Depreciated replacement value is a popular proxy for the quantity of capital. It has the advantage that the effects of inflation have been removed. For example, Goto and Tsutsui (2008), Filippini and Luchsinger (2007), Industry Commission (1992) adopted perpetual inventory method in estimating depreciated replacement values are follows:

$$K_t = K_{t-1} + I_t - \delta_t - R_t \tag{4}$$

where

K_t, K_{t-1} is the real depreciated capital stock in period t and period t-1,

I_t is the real investment in period t,

δ_t is a real value of economic depreciation of capital stock in period t, and

R_t is real retirements in asset in period t.

Unfortunately, the depreciation value reported in company accounts does not always reflect the true diminution of the asset's usefulness (or productive capacity) but is more an accounting device. Although depreciation expenses are easy information to obtain from annual financial reports, different utilities may assume different asset lives or use different depreciation methods. In addition, this measure can become biased when lumpy capital investment occurs. This is because the company can appear to have a lot of capital immediately after the building of a new large asset (e.g. a power plant) and then ten years later appear to have much less capital (because of depreciation) even though the actual productive capacity of the assets is near identical.

For these reasons, the quantity of physical capital measured by the nameplate capacity is often used in empirical studies of electricity generation. Nameplate installed capacity is the full load capacity rating of a plant to continuously produce electricity. Its use as a proxy for capital is consistent with prior studies such as Kopp and Smith (1980), Fare et al. (1986), Golany et al. (1994), Coelli (2002) and Lam and Shiu (2004). The nameplate capacity for capital stock gets closer to the economic concept underlying production functions and avoids the problem of differing valuation techniques. However, nameplate capacity may not appropriate in analysis of vertically integrated utilities because they involve both generation and distribution activities.

In our assessment, the *undepreciated* replacement value of capital stock is the preferred choice in order to estimate the capital stock in a productivity study. In this study we have access to data on the nominal undepreciated capital stock, which helps avoid the depreciation problems but will suffer from inflation biases. As a consequence, we have attempted to convert this nominal capital stock data into real (replacement) values by using a weighted average price index, as outlined in the following formulas:

$$RC_t = C_t * WPI_t \tag{5}$$

where

RC_t is real undepreciated capital stock in time period t,

C_t is nominal undepreciated capital stock at beginning of time period t,

$WPI_t = \sum_{t=1}^{n} W_t PI_{t-30}$ is weighted capital price index in period t,

PI_t is consumer price index, and

$W_t = \frac{(30-t)}{\sum_{S=1}^{n} S}$ is weighted for WPI.

In an ideal situation, a good quality capital price index would be used in the above calculations. But since a capital price index was not available prior to 1990, the consumer price index is used to proxy the capital price index in this study.

The price of a unit of capital "consumed" in a particular period is calculated using the rental price of capital (RPC):

$$\mathrm{RPC}_t = \left[D_t + g_t - \left(\frac{dPk_t}{Pk_t} \right) \right] WPI_t \tag{6}$$

where

D_t is depreciation rate in period t,

g_t is three months Treasury bill rate in period t,

dPk_t/Pk_t is the rate of capital gains in period t, and

WPI_t is weighted capital price index in period t.

The rental price of capital index is widely used in TFP studies, such as Industry Commission (1992). In order to compute RPC in this study, we assumed 30 year asset lives for all TNB assets and hence the linear depreciation rate is equal to approximately 3.3 percent per annum. In addition, we also used the three months Treasury bill rate as the estimated opportunity cost of capital. This information can be obtained from IMF Statistic Database. Due to the data restriction described above, the rate of capital gains was computed on the basis of the consumer price index.

d) Other Inputs

The "other inputs" category includes other expenses related to operating and maintaining power plants, transmission and distribution networks incurred over the period. Maintenance is always one necessary operation to keep the unit working economically and reliably. The expenditure of this category can be computed as the difference between total operating cost and the sum of fuel, labour, depreciation and interest expenses. This factor is a heterogeneous mixture of goods and services (e.g., office supplies, outsourced business services). The implicit quantity measure for "other inputs" is obtained by deflating the cost of other inputs by an appropriate price index. In an ideal world we would have a price index constructed to reflect the diverse basket of goods and services included in this category, but unfortunately we did not have access to such information. Hence, once again the CPI is used as a proxy.

In this study, our main analysis involves measuring the TFP of TNB. However, in some extra calculations, we also measure the TFP of the full industry (TNB plus the IPPs). This is done by adjusting the output measures (see below) and including power purchased from the IPPs into the "other inputs" category. In this latter case, we do not use the CPI to deflate the other inputs cost, we instead use a Törnqvist price index that has been formed using the CPI and the average price level for the purchased power.

Outputs

The output of a vertically integrated electricity company is usually represented using the volume of electricity delivered. However, electricity is not a homogenous commodity. For example, it can be delivered in small quantities to residential customers or in large quantities to industrial customers (the latter generally being less costly per unit), and can be delivered into densely populated or sparsely populated areas (the latter generally being more costly per unit). In this study we do not have access to data on density, but we do have information on customer type and hence make use of it in our output measures.

a) Electricity Delivered

Electricity delivered to residential and non residential customers in giga-watt hours (Gwh) are used as output quantity variables in this study. Price data in Malaysia Ringgit (MYR) per Gwh is obtained implicitly by deflating revenues by these quantities.

b) Electricity Generated

When a vertically integrated company generates all the power that it delivers, there is no need to include a power generation output variable as well. However, in the case of TNB, we observe that after the introduction of the independent power producers in Malaysia in 1995, not all electricity delivered is generated by TNB's power plants. Thus, total electricity generated from TNB will be included as an output variable to capture these changes. The price of each unit of electricity generated was obtained by dividing the total value of electricity generation by total electricity generated, yielding a price expressed in Malaysia Ringgit (MYR) per giga-watt hours.

However, when we do our additional calculations to measure TFP growth for the whole industry (TNB plus IPPs) we drop this extra output variable because it will be equal to the sum of the energy delivered measures (less any losses).

6. Empirical Analysis

This section discusses the empirical analysis of total factor productivity growth of Tenaga Nasional Berhad from 1975 to 2005. The availability of data and data sources for each of the variables proposed in this study are summarised in Table 3.

Table 3: Data Variables

Variable	Quantity (Q)	Price (P)	Value (V)
Capital	Undepreciated Real Capital Stock	Rental Price of Capital	Quantity × Value
Fuel	Petajoules	Value / Quantity	MYR
Labour	Full Time Equivalent Employees	Value / Quantity	MYR
Other Inputs	Value / Price	Consumer Price Index	MYR
Residential Energy Delivered	Gwh	Value / Quantity	MYR
Non Residential Energy Delivered	Gwh	Value / Quantity	MYR
Electricity Generated	Gwh	Value / Quantity	MYR

Note: The data is sourced from NEB/TNB Annual Reports, with the exception of CPI and interest rate data being sourced from the IMF.

In order to shed some light on what factors have the largest influence on the TFP index, input cost shares and indices of the individual variable changes are plotted in Figures 3 to 6.

6.1 TNB Input Cost Shares

The electric utility industry is characterized by high capital expenditure and high fuel cost operational costs. For most utilities, fuel represents a large portion of operational costs, usually in the region of 30-40 percent of total operating costs. Figure 3 displays the input cost shares as a percentage of total cost. In the early part of the sample period, fuel expenses was a large contributor, being between

50-75 percent of total costs, followed by capital costs (15-35 percent), other input costs (10-20 percent) and labour (5-10 percent). One item of note is that, in the sample period from 1981 to 1983, we can see that the capital cost share is less than 10 percent of total costs. This unusually low value is essentially due to the capital price index increasing at a higher than average rate during this period while interest rates are held artificially low. As a result the real discount rate (g-dPk/Pk) is near zero or negative and hence the rental price of capital index and capital cost shares become smaller (refer to Figure 4).

After TNB corporatization and the introduction of IPPs, TNB input cost shares have dramatically changed, especially in fuel costs. Prior to 1995, fuel costs represent around 40 percent of total costs. From Figure 3, we can see that the fuel costs share have reduced to 25-30 precent of total costs after market reforms. However, capital, labour and other input costs account for between 25-40 percent, 5-10 percent and 15-20 percent, respectively, over this latter period.

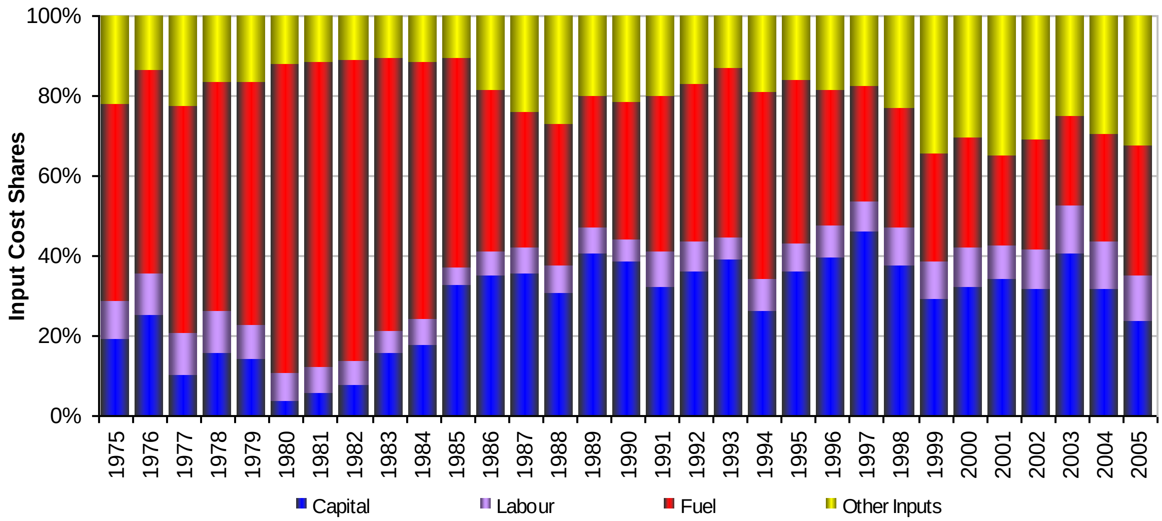

Figure 3: TNB Input Cost Shares, 1975-2005

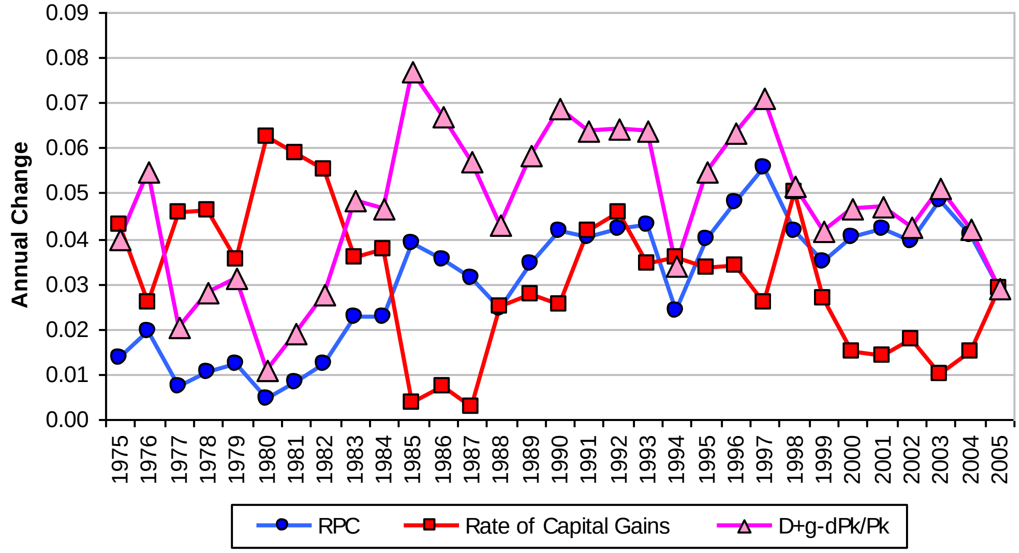

Figure 4: Rental Price of Capital, Rate of Capital Gains, D+g-dPk/Pk

Note: D is depreciation
g is opportunity cost of holding capital
dPk/Pk is rate of capital gains

6.2 Indices of Input and Output Variable Changes

Indices of input change and output change were calculated for each quantity variable and are plotted in Figure 5 and Figure 6. In Figure 5, we observe that the indices for capital stock and other input costs have a similar trend which increases slowly in the first half of the sample period and then accelerates in the latter half of the period. Overall, the average annual rates of growth are 9.8 percent and 9.6 percent, respectively over the sample period. During the same period, labour has increased by only 2.7 percent per annum, where the index increases slowly over the full sample period. Finally, we observe that fuel consumption grew by 8.1 percent per year. However, the index of fuel changes was lower during the post privatization period relative to the previous period, due to the entry of the IPPs.

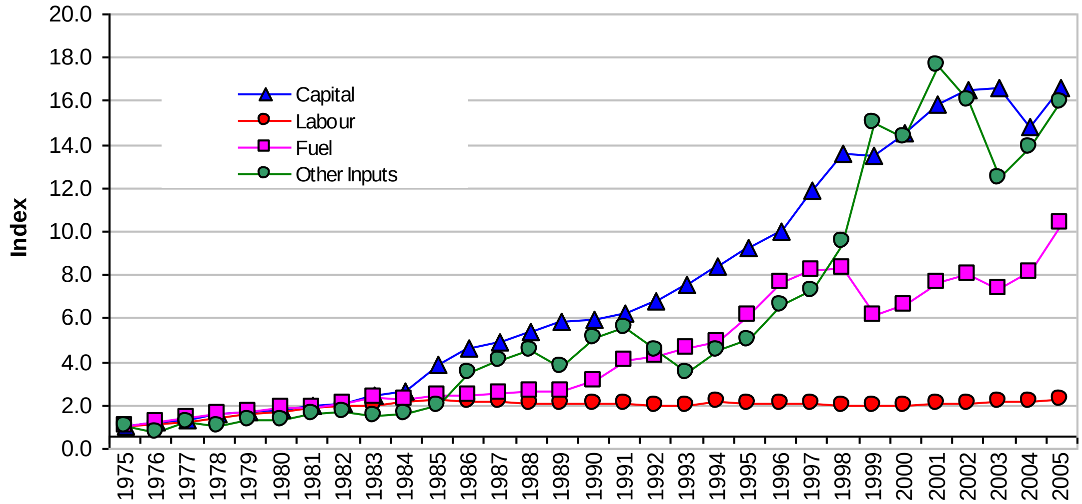

Figure 5: Input Indices, 1975-2005

Output indices are presented in Figure 6, where we see that the average annual increase in residential energy supplied was 13.9 percent prior to TNB corporatization, while the average increase in the period after the market reforms was 9.7 percent. The pattern for non residential energy supplied was similar to residential energy supplied with average changes of 9.7 percent and 10.1 percent, respectively. However, these rates are not significantly different at the five percent level. For electricity generated, TNB had an average total growth of 9.9 percent before 1990. After that, there was a lower annual increase of 5.6 percent per annum during the post privatization period.

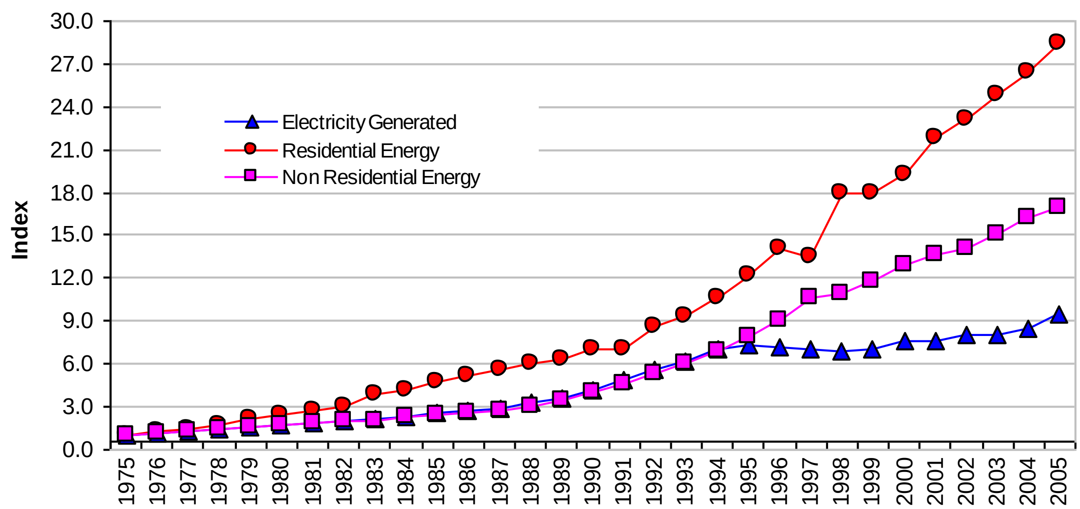

Figure 6: Output Indices, 1975-2005

6.3 TFP Results

As mentioned earlier, we wish to compare the total factor productivity growth of TNB in the periods before and after privatization and after the introduction of independent power producers. We have decided that four inputs and three outputs will be used in our TFP analysis for TNB from 1975 to 2005. The inputs for the model were capital, fuel, labour, and other inputs. Residential and non residential energy supplied and TNB electricity generated were identified as the outputs of the study. It is important to highlight that IPP energy cost is not added in order to measure TFP of TNB. A number of comments can be made regarding the results in Table 4.

Table 4: Average Annual TFP Growth Rates of TNB, 1975-2005

	Average TFP Growth
Full Period (1975-2005)	0.53%
Pre TNB Corporatization (1975-1990)	0.86%
Post TNB Corporatization (1990-2005)	0.21%
Post IPP Participation (1995-2005)	-1.15%

Prior to TNB corporatization, we obtained an average annual TFP growth of 0.86 percent over the first 15-year period. After National Electricity Board was corporatized and privatized in 1990, the TFP index of the Tenaga Nasional Berhad has changed notably. To illustrate the effect of TNB corporatization, we have plotted indices of TFP in Figure 7. The TFP index for Tenaga Nasional Berhad has increased from 0.834 in 1990 to 1.054 in 1994. This improvement of total factor productivity for TNB between 1990 and 1994 could perhaps be attributed to the privatization that was implemented during the early 1990s.

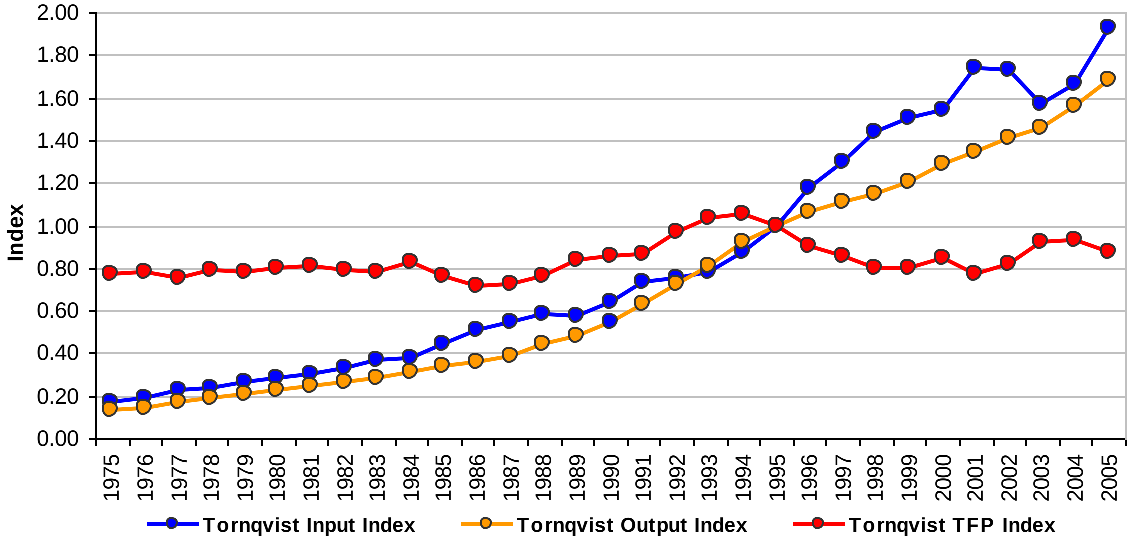

Figure 7: Törnqvist TFP Index of Tenaga Nasional Berhad, 1975-2005

From 1995 onwards, the private sector was allowed to enter the generation sector by selling electricity to TNB based on Power Purchase Agreements (PPA). When the private entry occurs, we observe that TFP for TNB reduces to 0.86, which suggested that private entry has a negative relationship with productivity growth. Table 4 indicates that TNB obtained an average TFP change of minus 1.15 percent over the last 10-year period. This finding corroborates Pollitt's (1999) claim that the positive growth in productivity need not be a direct consequence of privatization.

6.4 Sensitivity Analysis

The previous of TFP results relate to our preferred model, where undepreciated capital stock is used to proxy capital and a weighted price index is adopted to deflate undepreciated capital stock. The following discussion will allow us to compare the Törnqvist TFP results when we use a different capital measure and an alternative model specification.

a) Alternative Capital Measure – Perpetual Inventory Method

As we discussed in our discussion of capital, the perpetual inventory method is a popular approach in estimating depreciated replacement value. To obtain a better idea of the effect of different capital measures upon our TFP results, information on input cost shares, indices of capital stock and TFP indices are presented in Appendix B. The two indices of capital stock changes based on the different capital measures are plotted on the one graph in Figure A2. In this figure we observe that the two indices have a quite similar trend in first half of the sample period. However, after TNB was corporatized and privatized, a gap between these two indices develops, with the PIM index being slightly lower. This is perhaps due to the fact that capital investment (in generation plant) slowed after IPP entry and hence the PIM will tend to depreciate the existing capital items so that the amount of capital available is apparently lower than the reality.

To illustrate the effect of the use of perpetual inventory method, we have plotted TFP indices in Figure A3. We see that average annual TFP change of TNB over 30 years is slightly lower at 0.38 percent per year (refer to Table 5). However, overall the two TFP indices tell quite a similar story. Thus we can conclude that, in our case, the alternative capital measures do not influence our results in a notable manner. This is most likely because capital investment has been steadily rising during the sample period, with no substantial "lumpiness". Hence our results seem to be robust to our choice of capital measure.

Table 5: Sensitivity Results: Average Annual TFP Growth Rates, 1975-2005

	TFPG Undepreciated Capital Stock[1]	TFPG Perpetual Inventory Method[2]	TFPG 2 Output Model[3] (TFP Industry)
Full Period (1975-2005)	0.53%	0.38%	0.19%
Pre TNB Corporatization (1975-1990)	0.86%	0.67%	0.55%
Post TNB Corporatization (1990-2005)	0.21%	0.01%	-0.75%
Post IPP Participation (1995-2005)	-1.15%	-1.39%	-2.49%

Notes:
1: Weighted capital price index is adopted to deflate capital stock
2: Value Annual User Charge is applied to calculate capital price
3: Two Outputs: Residential energy and non residential energy

b) Industry-level Model Specification

In this extra analysis we aim to measure TFP growth for the whole electricity supply industry in Peninsular Malaysia (i.e., both TNB and the IPPs). In terms of our TFP model, this is achieved by excluding the electricity generated output and adding in the power purchase costs into "other inputs' measure. One would expect the index of "other inputs" would change noticeably when we combine other costs with power purchased cost in this case. From Figure B1, we observe that input cost shares have dramatically changed after the introduction of IPPs in 1995. On the other hand, capital and fuel costs account for between 15-30 percent and 15-20 percent over this latter period. From Table 5, we observe an average TFP change of plus 0.55 percent prior to TNB corporatization. During the post IPP participation, we see that average annual TFP change over this industry is equal to a 2.45 percent decline per year. Thus, these results suggest that privatization and introduction of IPPs did not imply increases in productivity or decreases in production costs. More detailed results for this model are provided in Appendix B.

7. Conclusions

In this study we provide a comprehensive productivity study for the Malaysian electricity supply industry. We use a Törnqvist index to measure total factor productivity growth for TNB and the electricity supply industry in Peninsular Malaysia over the 30 year period from 1975 to 2005. TNB obtains an average annual TFP change of plus 0.53 percent and the industry obtains an average TFP change of plus 0.13 percent over the full sample period. Furthermore, the result from the Törnqvist index method shows that the existence of IPPs in the Malaysian electricity supply industry is perhaps a contributing factor in TNB's productivity level falling, with a declining TFP index beginning from 1996.

Thus we find no direct evidence to allow us to conclude that positive changes in productivity are attributable to the privatization. Therefore, we suggest that privatization by itself is not sufficient to increase total factor productivity and it has to be accompanied by either the introduction of competitive markets or a regulatory framework that encourages more efficient behaviour. The Malaysian electricity market is not fully competitive because there is only one buyer. If there is more competition, such as contracts established through tendering process, a spot market, or more buyers being able to purchase the electricity in the market, we believe that power utilities and consumers could benefit from this regulatory change.

We noted that a variety of alternative ways to estimate capital stock, such as an undepreciated real capital stock approach and the perpetual inventory method, are available for use in TFP studies such as these. From our sensitivity analysis, we observe that the selection of a capital measure does not have are large effect upon the empirical results obtained in our study. In discussing possible measures for our variables, we observed that many of the "ideal" input and output measures are difficult to be put in practice because of insufficient quality data. For example, a labour measure should ideally attempt to take account of differences in skills and expertise. Furthermore, the choice of good price deflators is crucial in productivity studies, such as this, where the use of one or more value measures is generally unavoidable. The consumer price index should generally be used as a last resort if better price information is not available. Thus, we wish to emphasise that further work on data measurement in needed to allow us to be more confident in our conclusions regarding the impact of introduction of privatization and competition on total factor productivity in this industry.

References

Atkinson, S.E. and C.E. Halabi (2005). "Economic efficiency and productivity growth in the post-privatization Chilean hydroelectric industry", *Journal of Productivity Analysis*, 23: 245-73.

Coelli, T. (2002). "A comparison of alternative productivity growth measures: With application to electricity generation", in Fox, K. (ed), *Efficiency in the Public Sector*. Boston: Kluwer Academic Publishers.

Coelli, T., A. Estache, S. Perelman, and S. Trujillo (2003). *A Primer on Efficiency Measurement for Utilities and Transport Regulators*. Washington: WBI Development Studies.

Coelli, T., D.S. Prasada Rao, C. O'Donnell, and G.E. Battese (2005). *An Introduction to Efficiency and Productivity Analysis*, 2nd Edition, Springer Publishers, Boston.

Domah, P. and M. Pollitt (2001). "The restructuring and privatization of the electricity distribution and supply businesses in England and Wales: A social cost benefit analysis", *Fiscal Studies*, 22: 107-146.

Energy Commission (2006). *Statistic of Electricity Supply Industry in Malaysia 2005*, Kuala Lumpur.

Energy Commission (2007). EC Annual Report, Kuala Lumpur.

Estache, A. and M. Rossi (2005). "Do regulation and ownership drive the efficiency of electricity distribution? Evidence from Latin America", *Economics Letters*, 86: 253-257.

Fare, R., S. Grosskopf and C. Pasurka (1986). "Effects on relative efficiency in electric power generation due to environmental controls", *Resources Energy*, 8: 167-184.

Filippini, M. and C. Luchsinger (2007). "Economies of scale in the Swiss hydropower sector", *Applied Economics Letters*, 14: 1109-1113.

Goto, M. and M. Tsutsui (2008). "Technical efficiency and impacts of deregulation: An analysis of three functions in U.S. electric power utilities during the period from 1992 through 2000", *Energy Economics*, 30: 15-38.

Hjalmarsson, L. and A. Veiderpass (1992). "Productivity in Swedish electricity retail distribution", *Scandinavian Journal of Economics*, 94: 193-205.

Industry Commission (1992). *Measuring the Total Factor Productivity of Government Trading Enterprises*, Melbourne.

IPART (1999). *Regulation of Electricity Network Service Providers: Incentives and Principles for Regulation*, Independent Pricing and Regulatory Tribunal of New South Wales, Discussion Paper DP-32.

Kleit, A.N. and Terrell, D. (2001). "Measuring potential efficiency gains from deregulation of electricity generation: A Bayesian approach", *Review of Economics and Statistics*, 83: 523-30.

Kopp, R.J. and V.K. Smith (1980). "Frontier production function estimates for steam electric generation: A Comparative Analysis", *Southern Economic Journal,* 46: 1049-1059.

Lam, P.L. and A. Shiu (2004). "Efficiency and productivity of China's thermal powers generation", *Rev. Ind. Org.,* 24(1).

Malaysia Statistics Department (2009). *Monthly Statistical Bulletin,* Kuala Lumpur.

Megginson, W.L. and J.M. Netter (2001). "From state to market: A survey of empirical studies on privatization", *Journal of Economic Literature*, 39: 321-389.

Ministry of Energy, Water and Communication (2005). *Energy Policies of Malaysia,* Kuala Lumpur.

Nagayama, H. (2009). "Electric power sector reform liberalization models and electric power prices in developing countries: An empirical analysis using international panel data", *Energy Economics*, 31: 463-472.

Newbery, D.M. (1999). *Privatization, Restructuring and Regulation of Network Utilities*, MIT Press.

Pollitt, M.G. (1999). "A survey of the liberalisation of public enterprises in the UK since 1979", *University of Cambridge Department of Applied Economics Working Paper* 9901.

Sioshansi, F. and Pfaffenberger, W. (2006). *Electricity Market Reform: An International Perspective*, Elsevier.

Shleifer, A. (1998). "State versus private ownership", *Journal of Economic Perspectives*, 12: 133-150.

Smith, T. (2003). "Privatizing electric power in Malaysia and Thailand: Politics and infrastructure development policy", *Public Administration and Development*, 23: 273-283.

Tenaga Nasional Berhad (1998-2005). *Annual Report,* Kuala Lumpur.

Weyman-Jones.T.G (1991), "Productive efficiency in a regulated industry: the area boards of England and Wales", *Energy Economics*, 13: 116–122.

Appendix A

Sensitivity Analysis: Alternative Capital Measure – Perpetual Inventory Method

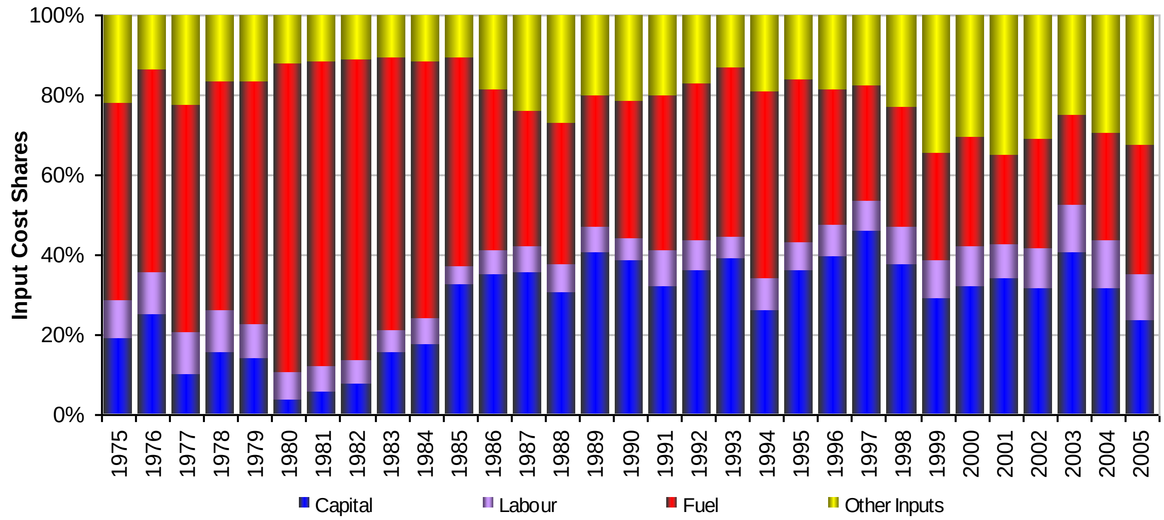

Figure A1: PIM Method: TNB Input Cost Shares, 1975-2005

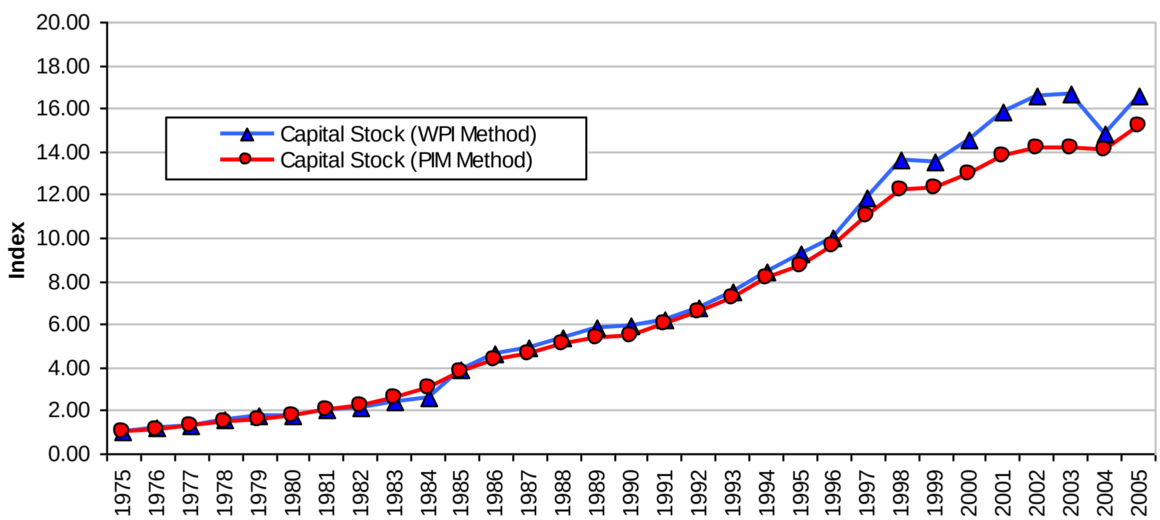

Figure A2: WPI and PIM Methods: Capital Stock Indices, 1975-2005

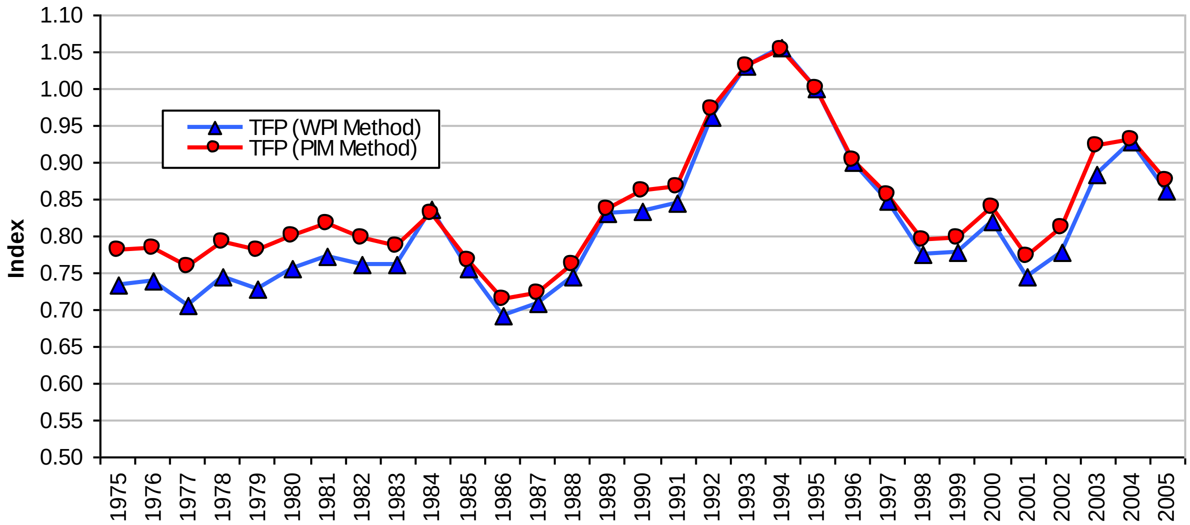

Figure A3: WPI and PIM Methods: Törnqvist TFP Index of Tenaga Nasional Berhad, 1975-2005

Appendix B

Sensitivity Analysis: Industry-level Model Specification – Two Outputs Model

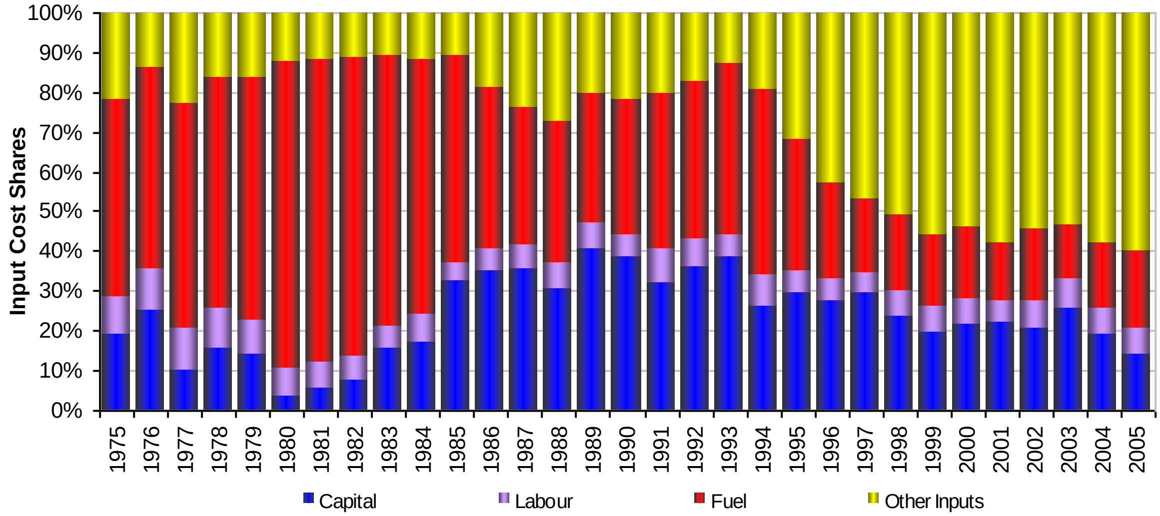

Figure B1: Industry-level Model Specification: Input Cost Shares, 1975-2005

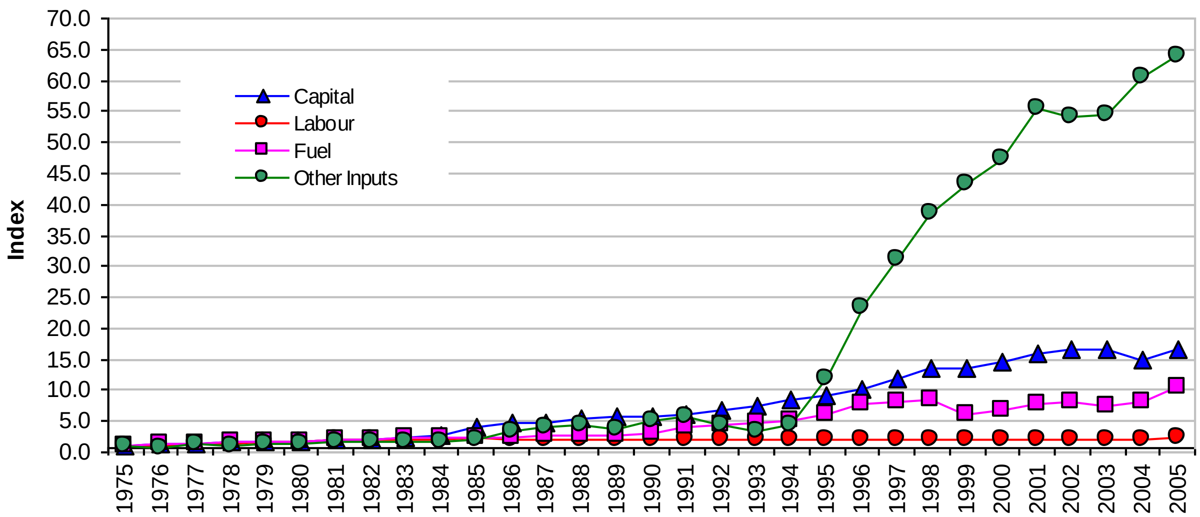

Figure B2: Industry-level Model Specification: Input Indices, 1975-2005

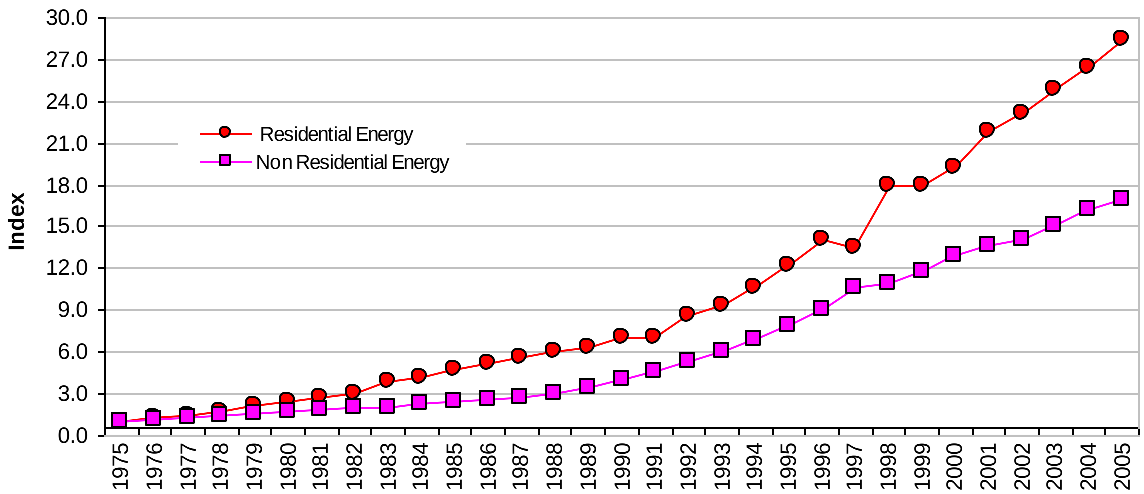

Figure B3: Industry-level Model Specification: Output Indices, 1975-2005

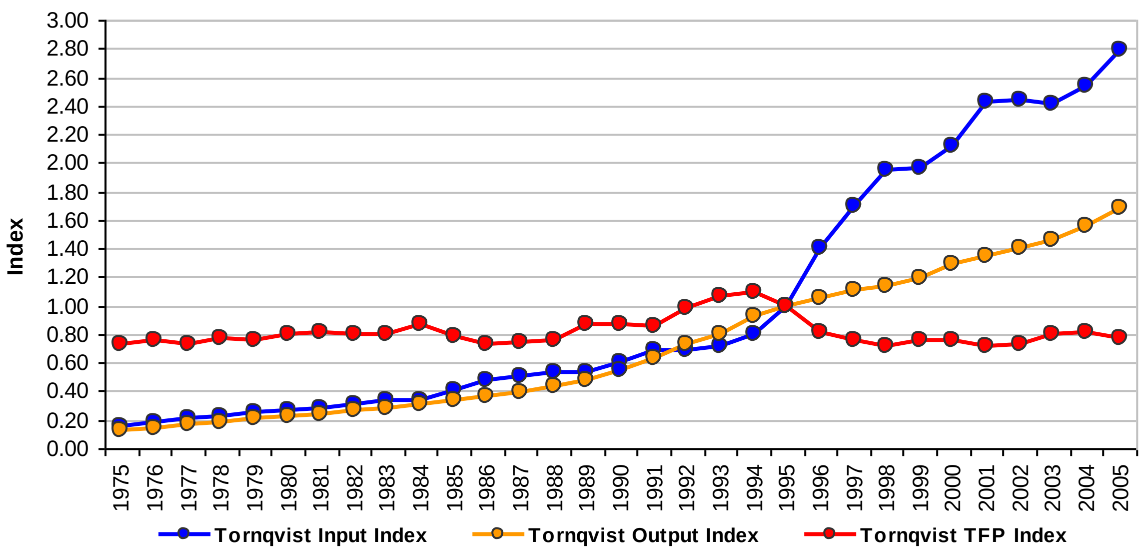

Figure B4: Törnqvist TFP Index of Electricity Supply Industry in Peninsular Malaysia, 1975-2005