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Total factor productivity analysis of a single vertically integrated electricity utility in Malaysia using a Törnqvist index method

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ABSTRACT

The objective of this paper is to measure the total factor productivity (TFP) growth of Tenaga Nasional Berhad (TNB) from 1975 to 2005. Prior to 1995, TNB was essentially the sole electricity provider in Malaysia. However, since 1995 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 TNB's productivity; however this proposition is yet to be tested. In this study we calculate TFP growth using a Törnqvist index method, finding that there is no direct evidence of productivity improvements attributable to the industry restructuring. 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.

1. Introduction

Before the deregulation era, electricity utilities in many countries were vertically integrated, owned and run by the government. It is generally believed that electricity utilities are natural monopolies because they required large fixed and sunk costs.[1] Under natural monopoly, a single electricity utility produces electricity at a lower economic cost in comparison to multiple electricity utilities. However, publicly owned utilities often operate inefficiently with high production costs due to a lack of incentives for cost saving (Nagayama, 2009; Sioshansi and 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 At least in part for these reasons, we have seen that in some countries vertically integrated utilities have been replaced by alternative market structures since the early 1990s.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 (e.g., liberalisation, privatisation) are continuing to take place in the Asia-Pacific region, especially in countries like Australia, South Korea, Thailand and Malaysia. The objectives for electricity market reform in developed countries are quite different from those in developing countries. Developed countries focus on reducing production costs and electricity prices, while developing countries aim to improve service quality, mobilise financing and expand electrification (Woolf and Halpern, 2001). Under these reforms, vertically integrated public electricity utilities are being disaggregated and replaced by other structures. In certain countries, market reforms lead to an opening-up of certain areas such as generation and retail to competition, whilst the other parts (transmission and distribution) remained vertical integrated monopoly entities. This scenario happened in the Malaysian electricity industry, whereby competition was introduced only in the generation sector, whereas transmission and distribution activities are still monopolised by a publicly-owned electricity utility i.e. Tenaga Nasional Berhad (TNB).

The electricity industry in Malaysia has been a monopoly and vertically integrated industry since 1949. The National Electricity Board (NEB) was corporatised and then privatised into TNB in 1990 and 1992, respectively (however, for convenience of analysis, this entity is referred to herein as TNB). Due to the large-scale power failure 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.

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[1] Sunk costs are a type of investment cost which produce a long chain of benefits over a large scope that can't ever be recovered (Tirole, 1988).

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In this study we measure productivity growth of TNB from 1975 to 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 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. The remainder of the paper is organised as follows. The Malaysian electricity industry background and several past TFP studies are discussed in Section 2 and Section 3, respectively. The TFP index method that was chosen (given data availability) for our analysis is presented in Section 4, while Section 5 provides an extended discussion on the input and output variables. Section 6 presents the research findings for the analysis of TFP growth of TNB. Finally, some concluding remarks and policy discussion are presented in Section 7.

2. Malaysian electricity market reform

Many developing countries like the Philippines, Thailand and Malaysia have experienced increasing difficulties in financing the expansion of capital intensive industries. Private sector participation is another option to secure capital investments that required in the electricity industry (Jamasb, 2002). In Malaysia, private entry has been encouraged to aid funding for new power plants. Currently, almost 50 percent of electricity generation is produced by IPPs (Energy Commission, 2009).

The structure of the electricity industry in Peninsular Malaysia consists of three main electricity business functions which are generation, transmission and distribution. Electricity generation is currently operating in a "limited" competitive environment where private power producers can build, own and generate electricity, which is then supplied to TNB under a 21-year power purchase agreement. This is often the case because private investors are seeking for long term contractual commitments and consistent market regulation before they decide to invest in the electricity industry (Joskow, 2008). The ownership of transmission and distribution networks, however, remains unchanged, hence TNB still monopolises these activities in the Peninsular Malaysia.

Table 1 compares the energy unit costs of the TNB generation and electricity purchased from IPPs. By referring to Table 1, the price set in the PPAs is higher compared to the TNB generation unit cost.[2] In general, there are three different versions of PPAs in Malaysia. Under all these PPAs, TNB makes two payments based on capacity and energy rates. The first purchase agreement is based on the compulsory purchase concept where TNB pays the IPP a monthly fixed rate for 21 years regardless of whether TNB buys 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 types of PPAs is generally lower compared to the price in the first type of PPA. However, the capacity charge still applied in the second and third types of PPAs. Furthermore, all costs associated with increases in fuel prices and loss of electricity during the transmission and distribution process are absorbed and paid by TNB (Jaafar et al., 2003). 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.

[2] In fact, inflation would imply that these prices are falling even faster in real terms.

Table 1
TNB generation and electricity purchased costs.

	Energy unit cost (thermal power plant only)[a]	
	IPPs (Malaysian Ringgit per kilowatt hour)	TNB (Malaysian Ringgit per kilowatt hour)
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

[a] Prices stated in nominal terms.

3. Literature reviews

From the literature survey, the majority of the studies were conducted in developed countries, such as Australia, Japan, the United States and the United Kingdom. Many empirical studies provide a good discussion of the relative influence of explanatory variables. Their role has been much debated when it comes to the efficiency and productivity in the electricity industry. Most of the empirical literature, such as Dong et al. (1996), Diewert and Nakamura (1999), Hiebert (2002), Olatubi and Dismukes (2000), Khanna et al. (1999), Sarica and Or (2007) and See and Coelli (2012) focuses on the impact that ownership may have on plant inefficiency. Furthermore, the authors also find significant differences among power plants due to other explanatory variables, such as plant age, fuel type, capacity utilisation and regulatory mechanism.

On the other hand, the literature also offers useful insights into important policy questions, especially on the impact of reforms in the electricity industry. In general, a small number of studies have found that privatisation has been linked with improvements in efficiency and productivity. For example, Atkinson and Halabi (2005) concluded that market reform plays an important role in increasing plant efficiency in Chile. Furthermore, Scully (1998) and Weyman-Jones (1991) also confirmed a significant improvement in the performance after the electricity supply industry reform in New Zealand, England and Wales, respectively. However, a few studies found that privatisation has no effect on productivity, such as Barros (2008), Kleit and Terrell (2001) and Meibodi (1998) for electricity generation; Hjalmarsson and Veiderpass (1992) and Estache and Rossi (2005) for electricity distribution.

Data envelopment analysis (DEA) and stochastic frontier analysis (SFA) are the most popular TFP measurement tools that have been employed to construct TFP index. Several model specification issues have been discussed in the empirical studies, such as orientation, returns to scale and functional form. Each measurement tool has its own merits that should be considered during the selection and comparison of TFP. Perhaps the decision between the efficiency measurement tools should also take into account the sample size, the level of measurement errors and bias.

The data collection exercise represents the most sensitive and time-consuming part of many productivity studies. In practice, we are yet to find any study that uses "ideal" data measures because they are essentially impossible to obtain. Most studies simply state the measures they obtain without any critical discussion. The availability of data should not always be a good reason to specify particular input and output measures. Without a proper discussion of choice of variables, readers will find the quality of the productivity analysis difficult to judge.

Only a few of the empirical studies use data from developing countries, such as Malaysia, Indonesia and Thailand. From the literature survey, we find that Yunos and Hawdon (1997) and See