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Estimating and decomposing productivity growth of the electricity generation industry in Malaysia: A stochastic frontier analysis

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HIGHLIGHTS

- This is the first empirical study that examines the TFP growth of the Malaysian electricity generation industry using the SFA method.
- An average annual TFP change of the Malaysian electricity generation industry over eight years (1998-2005) has been achieved at 2.34% per year.
- The technical progress contributing the most to the TFP growth and technical efficiency change and scale change making small contributions over the sample period.

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ABSTRACT

This study examines the total factor productivity (TFP) growth of the Malaysian electricity generation industry over the 1998 to 2005 period. The stochastic frontier analysis (SFA) approach is used to measure TFP change and decompose TFP growth into efficiency change and technical progress. We find that it achieved average annual TFP growth of 2.34%, with technical change contributing the most to the TFP growth over the eight year period. We hence hypothesise that the new power plants with their newer capital-embodied technologies commencing during the sample period are likely to be the main reason for this strong technical change. In addition, it is also noted that this estimate for the Malaysian electricity generation industry is larger than the estimate obtained for the electricity sector as a whole, where we obtain 1.34% per year for a comparable period.

1. Introduction

Electricity market reforms have occurred in many countries, including both developed and developing countries. In general, the choice of which market liberalisation structure to adopt is in part influenced by the state of their economies and their development levels. Different countries have different reasons to adopt a variety of market structures for their electricity industries. For instance, many developing countries, such as Thailand and Malaysia have experienced increasing difficulties in financing the expansion of capital intensive industries. Therefore, private sector participation is a viable option to secure capital investments that required in the electricity industry (Jamasb, 2002).

It is largely believed that electricity market reforms, such as increases in competition and unbundling vertically utilities, are expected to enhance efficiency, as it has been found in a number of empirical studies, such as Atkinson and Halabi (2005), Rodriguez-Pardina and Rossi (2000), Weyman-Jones (1991). For example, the unbundling of electricity activities can promote competition which could lead to potential cost savings. Therefore, market reforms can improve performance of the industry, provide a better service and lower price to the customers (Jamasb, 2002; Nagayama, 2009; Sioshansi, 2008).

A number of past studies have investigated whether the objectives have been achieved. The majority of these studies focused more on developed countries (e.g., the United States and the United Kingdom) while there are only a few studies that look at developing countries (e.g., Argentina, India, and Thailand). This is partly due to the fact that electricity industry data in developed countries, especially in the United States (i.e., Federal Energy Regulatory Commission (FERC) database and Energy Information Administration (EIA) form), are readily available for public access.

In the case of Malaysia, there was a grave power crisis in 1992 and it created concerns regarding the competence of Tenaga Nasional Berhad (TNB),[1] the sole electricity provider in Peninsular Malaysia (for further discussion, please refer to Section 2). As a result, private entry has been encouraged to aid funding for new power plants. In order to ensure the security of electricity supply

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[1] Tenaga Nasional Berhad is a publicly-owned utility where the government still owns 70% of its shares. The remaining shares are in the public floatation.

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in Malaysia, the construction of a new power plant is certainly not the only way to improve the reliability of electricity supply. Instead, efforts to improve the performance of the less-efficient power plants and network utilities should be considered.

Since the productivity of the electricity generation industry in Malaysia has not been measured in the period following the electricity industry restructuring, a comparative study is conducted to investigate total factor productivity (TFP) growth in Malaysia. From the literature survey, we find that See and Coelli (2012) is the only study that has studied the performance of this sector in Malaysia in recent years. It examined technical efficiency and sought to identify the determinants of technical inefficiency of power plants in Malaysia. They employed the stochastic frontier with a technical inefficiency effects model to account for the effects of explanatory variables on the technical efficiency.

To identify the sources of TFP growth in the Malaysian electricity generation industry, we employ the same dataset and the SFA estimation model used in See and Coelli (2012).[2] The remainder of the paper is structured in the following manner. The Malaysian electricity industry background is briefly discussed in Section 2, and several past TFP studies are discussed in Section 3. Section 4 describes the TFP measurement tools used in the study. Our empirical results are presented in Section 5, and some concluding comments are summarised in Section 6.

2. Malaysian electricity 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$6896 in 2009 (Malaysia Statistics Department, 2010). The electricity industry in Malaysia has been monopolised and vertically integrated since 1949. After the early 1990s, the electricity industry has been undergoing regulatory reforms. Firstly, the National Electricity Board (NEB) was corporatized into TNB in 1990 and subsequently became a public listed company on Malaysia's stock market in 1992. Secondly, the electricity generation sector has been partially liberalised by allowing private entry into the market after large-scale power failure in Peninsular Malaysia in 1992.

In general, a single buyer model is used in the Malaysian electricity industry and the industry structure is separated into three components, namely generation, transmission, distribution and supply. Fig. 1 depicts the structure of the electricity industry in Peninsular Malaysia. Tenaga Nasional Berhad, independent power producers (IPPs) and co-generators all generate electricity for final consumers in the Peninsular Malaysia. It is interesting to note that IPPs sell almost all of their electricity outputs to TNB under long term Power Purchase Agreement (PPA). However, the transmission and distribution businesses remain unchanged and monopolised by TNB.

After introduction of IPPs in 1995, TNB operates seven thermal power plants and three major hydro power plants. TNB has continued to be the main electricity producer with 9110 Megawatts (MW) of nameplate capacity and had contributed at least 41.77% of the total electricity generation in 2009 (Energy Commission, 2010). Meanwhile, IPPs are allowed to generate and sell electricity to TNB over 21 years. There were 12 privately-owned power plants (including Kapar Energy Ventures) that were generating electricity in 2009. While comparing them to publicly-owned power plants, privately-owned power plants mostly consume natural gas as their major supply to generate electricity.

[2] Although the SFA estimation and model for efficiency is identical in both papers, please note that the current study looks at TFP growth while the See and Coelli (2012) study looked at efficiency levels and its determinants.

3. Literature review

A large number of empirical studies offer useful insights into important policy questions, especially on the impact of reforms (i.e., liberalisation, privatisation etc). Several studies have been undertaken to investigate the linkages between the market reforms and the productivity growth (e.g., Atkinson and Halabi, 2005; Domah and Pollitt, 2001; Estache and Rossi, 2005; Hjalmarsson and Veiderpass, 1992; Weyman-Jones, 1991). However, the overall results tend to be mixed.

A considerable number of studies found that market restructuring or market reforms have been linked with improvements in the TFP growth. For instance, Kleita and Terrell (2001) employed bayesian stochastic frontier analysis (SFA) to study cost efficiency of 78 US power plants operating in 1996. The study found efficiency gains immediately after the deregulation and restructuring of the electricity industry in the US. Meanwhile, Atkinson and Halabi (2005) found that Chilean hydroelectric plants achieved improvements in technical efficiency and TFP growth after privatisation in 1985. Similar conclusions were made by Scully (1998) and Weyman-Jones (1991) in electricity distribution studies.

In contrast, a few studies found that market reforms had no impact on productivity. For example, Bishop and Thomson (1992) employed a weighted index approach to estimate the TFP of British nationalised industries, including the electricity industry from 1970 to 1990. The study did not find evidence of efficiency gains after the privatisation of the electricity industry. Meibodi (1998) comes to a similar conclusion in the case of Iran. The study suggested that market reforms, such as privatisation, were not a good choice to resolve their industry's problem and to reach the production frontier.

This particular point is recognised by Yunos and Hawdon (1997) in the case of Malaysia. This study is the only empirical study (that we know of) that has measured the TFP growth of the Malaysian electricity industry from 1975 to 1990. They measured the productivity of the electricity industry between National Electricity Board in Malaysia (now is known as TNB), Electricity Generating Authority of Thailand (EGAT) and Central Electricity Generating Board (CEGB) in the United Kingdom. From the results of their data envelopment analysis (DEA), they concluded that changes in ownership would not bring development to this industry without the existence of competition. Similar conclusions were also supported by Hjalmarsson and Veiderpass (1992) and Estache and Rossi (2005) for electricity distribution studies.

4. TFP growth measurement

A large number of the TFP measurement tools (e.g., SFA, DEA and Törnqvist indices) have been adopted in past empirical studies.[3] Each method has its own merits as described in Coelli et al. (2003). In general, the TFP methodology is often used in setting prices under incentive regulation. The results from a benchmarking analysis is generally used (along with other information) in calculating the X-factor in incentive based regulation.

Similar to See and Coelli (2012), on account of sample size, data noise and model specification, the SFA production frontier for TFP indices is the preferred choice. However, DEA Malmquist TFP indices and Törnqvist TFP indices are employed to cross check the SFA results in the latter part of the analysis. The following

[3] See, e.g., Atkinson and Halabi (2005), Coelli (2002), Meibodi (1998) and Rungsuriyawiboon and Coelli (2006).