Energy Economics 34 (2012) 677–685

Contents lists available at SciVerse ScienceDirect

Energy Economics

journal homepage: www.elsevier.com/locate/eneco

An analysis of factors that influence the technical efficiency of Malaysian thermal power plants

Kok Fong See *, Tim Coelli

School of Economics, University of Queensland, Australia

ARTICLE INFO

Article history:
Received 31 March 2011
Received in revised form 26 August 2011
Accepted 14 September 2011
Available online 22 September 2011

JEL Classification:
L33
L94

Keywords:
Efficiency
Electric utilities
Ownership

ABSTRACT

The main objectives of this paper are to measure the technical efficiency levels of Malaysian thermal power plants and to investigate the degree to which various factors influence efficiency levels in these plants. Stochastic frontier analysis (SFA) methods are applied to plant-level data over an eight year period from 1998 to 2005. This is the first comprehensive analysis (to our knowledge) of technical efficiency in the Malaysian electricity generation industry using parametric method. Our empirical results indicate that ownership, plant size and fuel type have a significant influence on technical efficiency levels. We find that publicly-owned power plants obtain average technical efficiencies of 0.68, which is lower than privately-owned power plants, which achieve average technical efficiencies of 0.88. We also observe that larger power plants with more capacity and gas-fired power plants tend to be more technically efficient than other power plants. Finally, we find that plant age and peaking plant type have no statistically significant influence on the technical efficiencies of Malaysian thermal power plants.

1. Introduction

The Malaysian electricity industry established the Central Electricity Board in 1949 (renamed later as National Electricity Board (NEB) in 1965) as a publicly-owned utility to generate, transmit and distribute electricity in Peninsular Malaysia. In line with the privatisation among government agencies to ease the government's burden, NEB as one of the agencies, was corporatized into Tenaga Nasional Berhad (TNB) in 1990 by the Electricity Supply Successor Act 1990 and subsequently became a public company on Malaysia's stock market.

Prior to 1993, TNB was the sole electricity provider to all categories of consumers (i.e., households, commercial, industries and public lighting) in Malaysia. As a result of the large-scale power failure in Peninsular Malaysia in 1992,[1] several immediate actions were taken to improve the quality of electricity supply by opening up the generation function of the industry to increase competition in the market, whilst the transmission and distribution functions remain unchanged. This incident resulted in the building of new electricity utilities, starting in 1995, by the private sector.

Theoretically, competition in the electricity industry is expected to result in an increase of efficiency and productivity. This expected relationship has been investigated in many empirical studies (e.g., Barros and Peypoch, 2007; Domah, 2002; Estache and Rossi, 2005; Mota, 2004; Yunos and Hawdon, 1998). Several empirical studies have examined technical efficiency among publicly-owned and privately-owned power plants but there has been little or no agreement on the relationship between ownership and technical efficiency. Yunos and Hawdon (1998) is the only empirical study (to our knowledge) that has measured the technical efficiency of the Malaysian electricity industry. Unfortunately, their data is rather dated, and hence does not reflect the current situation in Malaysia.

The technical efficiency of electricity utilities in Malaysia has not been measured since the introduction of independent power producers (IPPs). For that reason, our study is designed to investigate the relative performance of Malaysian electricity utilities, incorporating explanatory variables such as ownership, plant age, size, fuel types and etc. The estimation of technical efficiency in Malaysia conducted in this study will help to inform policy makers regarding the potential benefits of the privatisation, and also add to the existing empirical literature on the relative performance of electricity utilities in different ownership types. Section 2 elaborates the impact of explanatory variables on efficiency level, and Section 3 presents the efficiency measurement tool used in the plant efficiency study. Descriptive statistics and the results of the technical efficiency analysis are then presented in Section 4. Finally, some concluding remarks and policy insights are presented in Section 5.

2. Literature review

Since the early 1970s, a number of authors have been examining the determinants of power plant inefficiency but tended to focus

* Corresponding author. Tel.: +61 733469319; fax: +61 733657299.
E-mail address: k.see@uq.edu.au (K.F. See).

[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.

0140-9883/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.eneco.2011.09.005

more on the ownership questions. Other determinants, for instance, capacity utilisation and plant age, have less emphasis in past empirical studies. There have been a number of radical changes in the regulation of electricity sectors in many countries in recent decades. Hence, many efficiency studies have begun including other determinants of plant inefficiency in their analyses. Several explanatory factors, such as ownership, capacity utilisation, fuel type, plant size and plant age, have been used to investigate the influence of plant-specific variables on technical efficiency. Furthermore, external factors, such as regulatory mechanism and market share, have also been considered. A number of the determinants of technical inefficiency of power plants were employed in previous studies and are listed as below. For more details see Appendix A.

2.1. Ownership

Many empirical studies have undertaken investigations of the effect of ownership of power plants on technical efficiency, such as Färe et al. (1985, 1986), Diewert and Nakamura (1999), Hiebert (2002) and Pollitt (1995, 1996). Most of the empirical literature has shown that privately-owned utilities are more efficient because their objective is to maximise profit instead of focusing on public services (Bagdadioglu et al., 1996; Berg et al., 2005; Electricity Supply Association of Australia, 1994; Hiebert, 2002; Moore, 1970; Sarica and Or, 2007; Steiner, 2000). For example, Hiebert (2002) provided a comprehensive review of generation plant operating cost efficiency in US electricity utilities by adopting the stochastic frontier analysis (SFA) approach. The study used 432 coal fired power plants and 201 gas fired power plants during 1988–1997 to estimate the cost efficiency of each plant and to investigate possible reasons that can be used to explain the differences in plant efficiencies. The results from the study show that investor owned utilities (IOUs) are significantly more efficient in comparison to municipal utilities. In addition, the analysis also revealed that plant efficiencies are associated with a number of other important determinants, such as capacity utilisation and the number of units comprising the plant.

Although a number of the empirical studies suggest that private ownership increases technical efficiency, there are a small number of cases when publicly-owned utilities have been found to be more efficient (e.g., Färe et al., 1986; Khanna et al., 1999; Meyer, 1975; Neuberg, 1977). Furthermore, there are also some empirical studies that find no significant difference between publicly-owned and privately-owned electricity utilities in terms of their technical efficiency levels. For instance, the results of the Färe et al. (1985) study revealed that electricity utilities under difference ownership in the United States are found to be equally cost efficient over the period of study. Furthermore, Pollitt (1995) used their results to argue that publicly-owned power plants should perform equally as well as privately-owned plants in terms of technical efficiency.

Interest in ownership issues has not only focused on the US. The ownership issue has also been discussed in some other countries, including Turkey and India. Sarica and Or (2007) found similar results for Turkey. There were 65 Turkish thermal, hydro and wind power plants from 1999 to 2005 selected in the study. The results revealed that private ownership, fuel type, plant size have a significant effect upon technical efficiency. On the other hand, Khanna et al. (1999) used a SFA cost function to investigate the determinants of inefficiency for 66 thermal power plants in India from the period of 1987/88 to 1990/91. They argue that, in the case of India, the publicly-owned thermal power plants are more technically efficient than the plants operated by the private companies.

2.2. Capacity utilisation

In general, lower capacity utilisation is often associated with higher unplanned and planned outages, which implies higher repairs and maintenance costs, thus resulting in a lower technical efficiency level (Hiebert, 2002; Khanna et al., 1999). There are two common indicators of generation capacity utilisation (i.e., load factor and capacity factor) used in empirical studies (e.g., Electricity Supply Association of Australia, 1994; Hiebert, 2002; Khanna et al., 1999; Kumar and Managi, 2009; Olatubi and Dismukes, 2000; Pollitt, 1995). However, some authors (e.g., Khanna et al., 1999) have argued that capacity utilisation is highly correlated with technical efficiency levels and is not appropriate to be used in the study.

2.3. Plant age

A number of studies have used the age of a plant as a regressor in the production function or variable of an explanatory nature in the inefficiency model (e.g., Hiebert, 2002; Khanna et al., 1999; Pollitt, 1996; Sirasoontorn, 2005). In general, one would expect that newer generator units tend to be more efficient when it comes to fuel and maintenance (Electricity Supply Association of Australia, 1994). For example, Sirasoontorn (2005) adopted SFA and DEA approaches to measure the technical efficiency of state-owned electricity generation enterprise in Thailand from 1992 to 2001. The result of Sirasoontorn's study revealed that the plant age does significantly affect the technical inefficiency level in a positive direction. Barros (2008) comes to a similar conclusion in the case of Portugal. Conversely, different results are obtained by Pollitt (1996) in his cross country study of nuclear power plants. In his major study, Pollitt discovered that the older power plants are more efficient than the newer plants, because of the better adaptation in their existing generator units.

2.4. Fuel type

In the electricity generation industry, fuel variable is believed to have an impact on technical efficiency of the power plants. This is mainly due to the fact that the generating capability of a power plant depends on its thermal efficiency. However, the empirical results tend to be mixed and no clear evidence of differing performance between the fuel types can be viewed. For example, Diewert and Nakamura (1999) found that heavy fuel plants had a better performance in terms of technical efficiency than light fuel plants in the UK. In contrast, Pollitt's (1995) and Sarica and Or (2007) studies show that the gas fired power plants are more efficient than others. However, Hiebert (2002) claimed that there is a difference between gas fired and coal fired power plants.

2.5. Plant size

Plant size (or nameplate generating capacity) refers to the maximum continuous output level of a power plant. This factor has been included as a determinant of inefficiency in power plant studies (e.g., Diewert and Nakamura, 1999; Hiebert, 2002; Joskow and Schmalensee, 1987; Khanna et al., 1999; Meibodi, 1998). In a number of cases, a positive relationship between technical efficiency and plant size has been found. For example, Joskow and Schmalensee (1987) studied the determinants of thermal efficiency of coal fired power plants in the United States where the data was based on an unbalanced panel data of plants with capacity at least 100 MW from 1960 to 1980. They found that the plant size and experience contributed to plant technology and performance attributes. This view was also supported by Barros and Antunes (2011), Electricity Supply Association of Australia (1994) and Kumar and Managi (2009) studies. However, Sarica and Or (2007) come to different conclusions, finding the plant operators may have greater problems of coordination and management regarding the operation and maintenance of the larger plants.