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Regulatory reforms and productivity: An empirical analysis of the Japanese electricity industry

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Abstract

The Japanese electricity industry has experienced regulatory reforms since the mid-1990s. This article measures productivity in Japan's steam power-generation sector and examines the effect of reforms on the productivity of this industry over the period 1978–2003. We estimate the Luenberger productivity indicator, which is a generalization of the commonly used Malmquist productivity index, using a data envelopment analysis approach. Factors associated with productivity change are investigated through dynamic generalized method of moments (GMM) estimation of panel data. Our empirical analysis shows that the regulatory reforms have contributed to productivity growth in the steam power-generation sector in Japan.

Keywords: Regulatory reforms; Productivity measures; Electricity industry

1. Introduction

The Japanese electricity industry has undergone regulatory reforms since the mid-1990s. These reforms started with the amendment of the Electricity Utility Industry Law in 1995 to promote competition. Since then, the law has been amended several times and the electricity industry has undergone structural change to encourage efficiency improvement. Considering whether there has been an impact on productivity is essential to evaluating the success of these reforms because productivity growth is a fundamental source of improvement in economic welfare. The purpose of this article is to measure productivity and examine the effect of reforms on productivity over the period 1978–2003, focusing on the Japanese steam power-generation sector, which is the core of the Japanese electricity industry.

There are several measures to estimate productivity. In this article, the Luenberger productivity indicator is used because this indicator has a more generalized form than the Malmquist productivity index, which is often used in the literature. There is no prior application of the Luenberger productivity indicator to the electricity industry. To estimate productivity measures, data envelopment analysis (DEA), which is a mathematical programming technique, is used. After estimating productivity, the factors associated with productivity change are investigated through econometric analysis. In the econometric models, serial correlation must be considered because the dependent variable is estimated using DEA. For this reason, dynamic generalized method of moments (GMM) estimation of panel data is used to correct for serial correlation. Our empirical results show that regulatory reforms in Japan have contributed to productivity growth in the steam power-generation sector.

This article is structured as follows. Section 2 reviews the regulatory reforms in Japan. Section 3 discusses the background. Section 4 presents productivity and econometric models. Section 5 describes the data, while Section 6 discusses the results. Finally, Section 7 provides concluding comments.

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2. Regulatory reforms in Japan

The electricity industry is considered to have the characteristics of a natural monopoly. The market structure of the Japanese electricity industry used to be local monopolies under the Japanese regulatory system. However, concern about inefficiency associated with this regulatory system increased and this system was subject to change commencing in the mid-1990s.

Regulatory reforms in the Japanese electricity industry started in 1995 with the amendment of the Electricity Utility Industry Law, which had been operative for about 30 years.[2] Before these reforms, no company could enter the power-generating markets. However, the amendment made it possible for other companies to enter into the generating market by introducing the competitive bidding system in the wholesale market. New entrants are called Independent Power Producer (IPP). The government also introduced yardstick regulation.[3] Note the yardstick regulation referred to the whole vertically integrated utility. Under the yardstick regulation, the electricity price of each electricity company is determined partly by comparing its performance with that of other companies. Companies with larger cost than others suffer losses, while those with smaller cost generate profits. Therefore, this system is expected to promote the cost cutting competition.

Partial liberalization in retail markets was introduced in 2000. The market was liberalized for received electricity through transmission lines over 20,000 V and where maximum power demand is over 2000 kW. This market accounts for almost 30% of the total electricity supply by electricity companies. This amendment also made it possible for the power producer and supplier (PPS) to enter the market. To realize this new market structure, a system was developed in which the transmission lines of electricity companies could be used by new entrants.

Furthermore, the 2003 amendment stipulated the extension of the boundary of liberalization. The markets for maximum power demand over 500 kW and over 50 kW were liberalized from April 2004 and April 2005, respectively.

3. Background

Productivity growth is a fundamental source of improvement of economic welfare and there has been a keen interest in correctly analyzing productivity, especially total factor productivity (TFP). Our interests are not only in productivity itself but also in its decomposed elements. When productivity change is observed, what is the driver of this change? TFP can be decomposed into efficiency change (EC) and technological change (TC). EC measures changes in the position of a production unit relative to the production frontier. If existing resources are not fully utilized in production initially, one expects a significant increase in EC. TC measures shifts in the frontier because of innovation. Recent work on productivity measures allows us to conduct this decomposition. Caves et al. (1982) form the basis of the Malmquist productivity index, and this index has been widely used in empirical analysis in the literature (e.g., after Färe et al., 1994). To estimate this index, one must choose either an input- or output-oriented approach in Shephardian distance functions. The choice depends on whether one assumes cost minimization or revenue maximization as the behavioral principle of the sample because the input-oriented measure has its dual in the cost-efficiency measure and the output-oriented measure has its dual in the revenue measure of efficiency (Färe and Primont, 1995).

On the other hand, the Luenberger productivity indicator does not require a choice between input and output orientations.[4] For graphical presentation of the difference between these two indexes, see Appendix A. This indicator consists of shortage functions introduced by Luenberger (1992a, b), and is able to account for both input saving and output increase.[5] The shortage function is dual to the profit function (Luenberger, 1992b; Chambers et al., 1998). Using a shortage function, Chambers et al. (1996) and Chambers and Pope (1996) introduced the Luenberger productivity indicator. Furthermore, when the behavioral principle for the sample is assumed to be revenue maximization or cost minimization, an output- or input-oriented Luenberger productivity indicator can also be estimated. Therefore, the Luenberger productivity indicator can be considered a generalization of the Malmquist productivity index (see Boussemart et al., 2003). For this reason, the Luenberger productivity indicator is measured and analyzed in this study.

These productivity measures are estimated using DEA, which was developed by Charnes et al. (1978) and Banker et al. (1984). The advantage of this approach is that the production technology is described without specifying functional forms.

Many studies address efficiency and productivity issues in the electricity industry (see Jamasb and Pollitt, 2001). In particular, DEA has often been used as a tool to estimate the efficiency of the electric utility and distribution sector (Majumdar and Marcus, 2001; Chen, 2002; Pacudan and de Guzman, 2002; Korhonen and Syrjänen, 2003; Pahwa et al., 2003; Nemoto and Goto, 2003; Vaninsky, 2006; Pombo and Taborda, 2006). For example, Jamasb and Pollitt (2003) present an international benchmarking study

[2]For further details of regulatory reforms in the Japanese electricity industry, see Nambu (2000).

[3]The yardstick regulation is not stipulated in the law, but this regulation is a part of the structural reform policies.

[4]In this paper, the term "indicator" is used for a difference-based measure of productivity, and "index" is used for a ratio-based measure of productivity. This distinction is often used. For example, see Briec and Kerstens (2004).

[5]This function is also called "directional distance function".