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Decomposition of cost efficiency and its application to Japanese-US electric utility comparisons ☆

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Abstract

This paper presents a new formula for decomposing cost efficiency into technical, price, and allocative efficiencies in an environment marked by the fact that unit input prices differ among certain enterprises. We employed this formula in comparing cost efficiency between Japanese and US electric power companies, and found a significant difference in the price-based efficiency. However, negligible differences were found in the technical and allocative efficiencies.

Keywords: Cost efficiency; Technical efficiency; Price efficiency; Allocative efficiency; DEA

1. Introduction

Technology and cost are the wheels that drive modern enterprise; some enterprises have advantages in terms of technology while others have it in cost. Hence, management is eager to know how and to what extent their resources are being effectively and efficiently utilized, compared to other enterprises in the same, or similar, field. Under multiple input–output correspondences, data envelopment analysis (DEA) has created a new route map for this purpose.

Given the quantities of input resources and output products, the representative DEA models, e.g., CCR [1], BCC [2], and SBM [3], can evaluate the relative technical efficiency of a given enterprise, termed DMU (decision-making unit) in DEA terminology. Furthermore, if the unit prices of the input resources are known, the cost efficiency model can be utilized to explore the optimal input-mix that produces the observed outputs at minimum cost. Based on this solution, the cost and allocative efficiencies are obtained. For example, see Farrell [4] and Färe et al. [5].

However, these traditional cost and allocative efficiencies, which assume given uniform input prices, suffer from a critical shortcoming if the unit prices of the inputs are not identical across DMUs in the economy, as pointed out by Tone [6]. To cite a case, if two DMUs have the same inputs and outputs and the unit price for one DMU is twice that of the other, then the traditional cost efficiency model assigns the same cost efficiency

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to both. This is, however, unacceptable in analyzing an actual economic situation. After identifying this shortcoming, Tone [6] proposed a new scheme that is free from such inconsistencies.

The current paper can be positioned as an extension of Tone [6], as seek to decompose observed total cost into the global optimal (minimum) cost and loss due to input inefficiency, as follows:

$$\text{Actual cost} = \text{Minimum cost} + \text{Loss due to input inefficiency}.$$

Furthermore, we represent this loss due to input inefficiency as dependent on technical inefficiency, input price differences, and inefficient cost mix as follows:

$$\begin{aligned}\text{Loss due to input inefficiency} = {} & \text{Loss due to technical inefficiency}\\ & + \text{Loss due to input price difference}\\ & + \text{Loss due to inefficient cost mix}.\end{aligned}$$

Among these components, technical efficiency is measured using the traditional CCR model [1] within the technical production possibility set. Then, using the thus obtained optimal input value, we construct a cost-based production possibility set and solve the New Tech and New Cost models [6] on that set. This enables us to obtain two efficiency indices, i.e., the price efficiency index and the global allocative efficiency index. The former reflects the differences in input unit prices, while the latter evaluates the efficiency of the input cost mix, which we rate is not the same as allocative efficiency.

The remainder of the paper unfolds as follows. In Section 2, we develop our methodology, while in Section 3 we apply the scheme to electric power industries in Japan and the US and compare the efficiencies of their performance from 1992 to 1999. It is often considered that the price of electricity in Japan is higher than that in other countries; this may be due to productive inefficiency or higher input prices. Indeed, prior studies indicated that the productive efficiency of Japanese electric power companies was higher than that of their US counterparts.[1] It has also been mentioned that input prices in Japan are higher than those in the US. However, there exist few studies that have comprehensively examined the influence of productive inefficiency and higher input prices over the total cost.

This study will analyze and demonstrate the degree of loss caused by (1) technical inefficiency, (2) input price differences, and (3) suboptimal cost mixes between Japanese and US electric power companies. In Section 4, we develop some extensions of this model, and summarize the results, and conclude the paper, in the final section.

2. Methodology

In this section, we develop our scheme and discuss its rationale.

2.1. Data

Throughout this paper, we consider n DMUs, each having m inputs for producing s outputs. For each DMU_o $(o = 1, \ldots, n)$, we denote the input and output vectors by $x_o \in R^m$ and $y_o \in R^s$, respectively. The input and output matrices are defined as $X = (x_1, \ldots, x_n) \in R^{m\times n}$ and $Y = (y_1, \ldots, y_n) \in R^{s\times n}$, respectively. We assume that $X>0$ and $Y>0$. For each DMU_o $(o = 1, \ldots, n)$, the input factor price vector for input x_o is denoted by $w_o \in R^m$, and the input factor price matrix is defined as $W = (w_1, \ldots, w_n) \in R^{m\times n}$. For DMU_o, the actual total input cost C_o is calculated as follows:

$$C_o = \sum_{i=1}^{m} w_{io}x_{io}, \tag{1}$$

where x_{io} is the amount of the ith input utilized by DMU_o, and w_{io} is the input factor price. We assume that the elements $w_{1o}x_{1o}, \ldots, w_{mo}x_{mo}$ are denominated in homogenous units, viz., dollars, in order that the summation is measurable.

[1] See Goto and Tsutsui [7] and Hattori [8].