Technological Forecasting & Social Change 78 (2011) 1389–1396

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

Returns to scale in DEA models for performance evaluations

Shih-Chi Chang *

Department of Business Administration, National Changhua University of Education, No. 1, Jin-De Road, Changhua City 500, Taiwan

ARTICLE INFO

Article history:
Received 11 May 2009
Received in revised form 24 February 2011
Accepted 14 March 2011
Available online 8 April 2011

Keywords:
DEA
Performance evaluation
Returns to scale

ABSTRACT

The technology industry is a major driving force in Taiwan's economic development. The Taiwan government employed technology development programs (TDPs) to stimulate industrial technology research and development to enhance industry competitiveness. This paper uses Data Envelopment Analysis (DEA), a nonparametric approach, to evaluate the relative efficiency of decision-making units (DMUs) that use multiple inputs to produce multiple outputs, to evaluate the relative managerial efficiency of TDPs. The inputs are human resources and expenditures. The outputs are patents and technology outcomes. We investigated TDP performance over the period from 1999 to 2003. This study uses CCR and BCC models, which are DEA model variants, to calculate efficiency indexes. CCR is adopted under the assumption of constant returns to scale. BCC is used to understand the variable returns to scale, including the constant, decreasing and increasing. We found that TDPs in the material and chemical engineering fields in 1999 and 2001, machinery and aerospace fields in 1999, and communication and optoelectronics fields in 2002 had better performance than the other TDPs. We provide potential improvements for inefficient DMUs.
© 2011 Elsevier Inc. All rights reserved.

1. Introduction

The technology industry has been vital to Taiwan's economic development over the past two decades. Taiwan is a major manufacturing base for global IT and communication products [1–4]. Technology innovation is one of the important factors in increasing industry competitiveness. In addition to the R&D efforts of high-tech enterprises, the government plays a key role by continually promoting industrial technology research, advanced technology R&D, technology foresight and technology evaluation.

Over the past two decades, the information technology (IT) industry has been the most important driver for Taiwan's economic growth. However, profit margins for PC related products have declined year by year. Many Taiwan IT manufacturers are trying to find other technology areas related to their core competences to sustain business growth. Meyer and Davis observed a fading of boundaries or a convergence. Physics, chemistry and biology are beginning to blend. In technology, the separation between information technology and bio-technology is fading [5]. As for the technology development path, Linstone separated the evolution of technology into three successive societies: industrial, information and molecular. The technology evolution seemed to have a pattern. Molecular technology is being built on the foundation of the information technology era just as information technology was built on the foundation of the industrial era. The convergence of information and molecular technologies may well revolutionize the innovation process and transform the role of forecasting and also the foresight and planning process [6]. The convergence of different technologies also stimulates Taiwan to put more emphasis on innovation and inter-disciplinary integration. For example, the biochip is a combination of semiconductor technology and biotechnology.

To enhance industrial technology and accelerate industry improvement, from 1979, the Ministry of Economic Affairs (MOEA) of Taiwan began setting aside budgets to fund research institution participation in industrial technology research and development projects. In 1993, Taiwan established the Department of Industrial Technology (DOIT) to implement the Technology Development Program (TDP). In 1998, Taiwan passed the "Action Plan for Building a Technologically Advanced Nation" allowing the government to

* Tel.: +886 4 7232105x7416; fax: +886 4 7211292.
E-mail address: shihchi@cc.ncue.edu.tw.

0040-1625/$ – see front matter © 2011 Elsevier Inc. All rights reserved.
doi:10.1016/j.techfore.2011.03.015

pool various resources, cooperate with different sectors and setup timetables to build a nation of science and technology. The 1999 "Fundamental Science and Technology Law" was a clear sign that announced R&D activities would be the foundation for Taiwan's industrial and technology policy [7]. The government has been even more active in promoting industrial technology research and development in six fields including communication and optoelectronics, machinery and aerospace, material and chemical engineering, biotechnology and pharmaceutical, common basic technology and innovation and foresight.

A TDP performance evaluation is critical for resource allocation over the next year. Therefore, a comprehensive measurement is necessary for DOIT to be able to understand performance in each field and make adjustments in government industry policies. However, it is not fair to judge TDP performances using a single indicator because the budget for each TDP is different. The relationship between input and output must be considered. Furthermore, different input and output indicators should be taken into consideration to create a more accurate performance index because the relationship between the inputs and outputs is complicated. In view of these issues, this study adopted Data Envelopment Analysis (DEA) as the methodology for analyzing TDP performance. DEA is a nonparametric approach for evaluating the relative efficiency of decision-making units (DMUs) that use multiple inputs and multiple outputs to determine a performance index. In 1978, Charnes et al. first proposed DEA to evaluate the efficiencies of DMUs [8]. There are numerous DEA applications for evaluating the performance of many different kinds of entities engaged in many different fields [9–15]. Phillips and Tuladhar considered the theoretical frameworks of micro-economics, evolution and general systems as possible solutions for a discussion of organizational flexibility. Phillips and Tuladhar computed a rough approximation of the general model and showed how a flexibility model works together with efficiency models, especially DEA models, to round out the characterization of corporate performance [16]. Anderson et al. proposed a modified DEA methodology to provide a complement to traditional forecasting methods. This methodology allowed for dynamic tradeoffs and the identification of key inflection points and provided more insight and details into the forecasting of micro-processors over and above the level that Gordon Moore predicted more than 30 years ago [17]. In short, DEA is an appropriate methodology to conduct performance evaluations and provide information for decision-making. It is important to discuss return to scales in research and development project performance evaluations. According to past researches [18–23], this study uses CCR and BCC models, which are DEA model variants, to calculate efficiency indexes. CCR is subject to constant returns to scale and BCC is used to understand the variable returns to scale, including constant, decreasing and increasing. In the rest of this paper, Section 2 describes the operation and management of TDP. Section 3 introduces the DEA models adopted in this research. Section 4 shows the research results and Section 5 presents conclusions and suggestions.

2. TDP operation and management

TDP operations are performed to meet the needs of industry policies and implemented by research institutions such as the Industrial Technology Research Institute, Marketing Intelligence Center and Bio-Technology Development Center, etc. The ultimate purpose of TDP is transferring research achievements to industry to strengthen Taiwan's industrial competitiveness in the world. TDP operation and management can be divided into four major stages [3] including the planning stage, review stage, implementation stage and promotion stage. The following would briefly address its resource allocations and outcomes.

2.1. Annual expenditure and allocation

From 1999 to 2003, the annual expenditures of TDP institutions increased from NT$13.42 billion to NT$14.08 billion. In 2003, communications and optoelectronics (CO) received the greatest amount of institutional TDP funding, by field, receiving NT$3.57 billion or 25.38% of total funding. This was followed by machinery and aerospace (MA) and material and chemical engineering (MC), each with 18.06%, representing NT$2.54 billion. The fourth field was the common technological (CT) field, which covers common special tools, common technology imported and common comprehension, with a share of 12.93%, equivalent to NT$1.82 billion. Biotechnology and pharmaceuticals (BP) received 12.88%, equivalent to NT$1.81 billion. The last field was innovation foresight (IF), including R&D service, information application, technology laws, intellectual capital, information communication security and technology administration, with a share of 12.7%, equivalent to NT$1.79 billion. Fig. 1 also shows the CO field has the greatest portion of institutional TDP funding. This implies the Taiwan government made effort to encourage TFT-LCD and communication industry research. We also found that BP received about half of the government research budget compared to CO. The BP development progress is therefore not as extensive as that for CO industry.

2.2. Annual RD work force and allocation

The work force devoted to TDP increased from 5494 employees in 1999 to 6640 employees in 2003. In 2003, 16.9% of R&D professionals held doctoral degrees, 52.7% held master's degrees and 16.6% held a bachelor's degree. Taiwan's core research work force is mainly professionals with master degrees.

2.3. TDP performance and benefit

In 2003, TDP had produced 508 patents in Taiwan, 289 patents in other countries and 450 patent applications. During that same year 1701 research papers were published in Taiwan, 489 research papers were published in the other countries, along with 4774 reports, 51 technology introductions and 352 technology transfers.

Download English Version:

https://daneshyari.com/en/article/897053

Download Persian Version:

https://daneshyari.com/article/897053

Daneshyari.com