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Building the measurement framework of technology efficiency with technology development and management capability – Evidence from the ASEAN countries

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ABSTRACT

In this paper, we present a research framework with data envelopment analysis (DEA) approach to evaluate a nation's technology efficiency and effectiveness in ASEAN countries. The study proposes two outputs, patents and licenses (PL) and technology exports (TE) along with three inputs, information and communication technology (ICT), R&D (RD), and governance capability (GC) in the model. Building on evidence from our research, we found that country has better outcome in PL can be derived from better application in ICT which in terms of TE to RD and GC as well. Additional findings also revealed the variable of ICT is mainly advantageous to technology efficiency in ASEAN countries. Further, from the viewpoint of country, our results indicate both Singapore and the Philippines are the most efficient countries among the variables in technology efficiency, scale efficiency, and window analysis as well. Moreover, our findings suggested some other countries may explore the suitable strategy to enhance their technology efficiency with benchmarking countries.

1. Introduction

The organization and structure of business processes in technological activities can be regarded as strategic tools to sustain the core competence of a nation's economy. As Raymond (1997) noted that technology plays a critical ingredient in the economic development of countries. Thus, continual investment in technology to build dynamic capabilities is one of the three sources of successful competition in the 21st century (Zahra, 1999). Wang (1999) also pointed out that the application of information and communication technology (ICT) has revolutionized the structure of both management and competition in the emerging global economy. Findings of his research indicated the effect of technology application (i.e. high technology efficiency) on economic growth can be achieved merely through strong national information infrastructure (i.e. technology development and management capability).

Additionally, prior works defined the core competence as bundles of skills and technologies (Prahalad & Hamel, 1990), or pools of experience, knowledge, and systems that can be considered to create and accumulate new strategic assets (Markides & Williamson, 1994). These strategic assets, which are imperfectly imitable, constitute a nation's competitive advantage. Therefore, following the above research, we have confidence that effective technology development and management capability are the determinant factors to sustain core competence for nations. In addition, to sustain national competitiveness and create value in the network economy, a rich body of prior research shows that technological competence of a country is not only to be given precedence but needs to be developed network competence to link with other alliances (Ritter & Gemunden, 2004). While the former capabilities are based on the integration of technology; the latter should be managed under a system of global integration to allocate resources within strategic alliance. Consequently, the strategic application of this principle must emphasize both "dynamic" and "capability" within management system to achieve technology efficiency (Schulz, 2001; Teece, 1998).

According to Ulrich and Lake (1991) argue that "competing from the inside out" requires a continuous effort in building appropriate technological skills with sufficient management resources. In this respect, how to advance technology efficiency by means of better technology development (e.g. improved information and communication technology, higher R&D expenditures, and more scientists and engineers in R&D) as well as management capabilities (e.g. higher education levels and a better socio-economic environment) are critical issues for researchers and authority of a nation.

Moreover, a variety of factors may be included in the category of technology development, management development and technology efficiency as well. With regard to the determinant factors of national competitiveness (Hämäläinen, 2003), enterprise competitiveness with the diamond model (Porter, 1990), the double

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diamond model (Moon, Rugman, & Verbeke, 1995), the national innovation system (Dosi, Freeman, nelson, Silverberg, & Soete, 1988; Freeman, 1982; Lundvall, 1992; Nelson, 1993), technology competitiveness (Roessner, Porter, Newman, & Cauffiel, 1996), macro-economic competitiveness (Ulengin, Ulengin, & Onsel, 2002), and the competitive advantage factors of an enterprise (Li & Deng, 1999), there are several notable research institutions and researchers have proposed evaluation models and frameworks to measure competitiveness for specific issues, such as world competitiveness yearbook – the International Institute for Management Development (IMD); the global competitiveness report – World Economic Forum (WEF).

According to the prior research models and frameworks, various factors are explored that related to the interrelationships among technology development, management capability, and technology efficiency in developed countries, respectively. However, few studies focus on these issues with regard to less-developed countries (Dahlman & Frischtak, 1993; Katz & Bercovice, 1993). Recently, National Cheng Kung University (NCKU) joined with the research in ASEAN countries and proposed a national competitiveness model in both developing and less-developed countries. Yet, it was still lack of official published reports both in developed and developing countries and limited their analysis in this region (Wang, Chien, & Kao, 2007).

Based on the past literature, technology development and management capability are the two factors that nations need to put more efforts in order to specialize in their technology efficiency and stimulate economic growth. Linn, Zhang, and Li (2000) emphasized that technology should not only fulfill the management needs of a specific set of technologies within a domain and inter-domain relationship, but develop a better management capability. In other words, how to implement strategies with available social resources (education, health, and welfare), current technologies, future markets, and socio-economic environment to improve technology efficiency is crucial for most nations. In addition, the synergy of technology development and management capability may sustain a nation's economic growth, and consequently, it is not surprising that few developed countries have previously engaged in technology investment under effective management capability to achieve their economic growth.

Unfortunately, there fails clear evaluation for technology efficiency in relation to national resources (e.g. education, technology investment, R&D, finance, health, and welfare). One definition could be made of resources in the attainment of technological goals, taking technological and managerial factors into account. Still, another problem in evaluating the technology efficiency of nations is lack of a good estimate of the production function (i.e. the functional relation between inputs and outputs) (Rousseau & Rousseau, 1997). To solve this problem, the "relative technology efficiency" of units was introduced (Farrell, 1957). However, Link (1996) argued the production function approach has a number of significant limitations which render its usefulness to an evaluation of government-sponsored research projects questionable (Farrell, 1957). Consequently, the measurement of technology efficiency will be undertaken in this study by using the technique of data envelopment analysis (DEA) approach.

DEA is an operations research-based method to measure the performance efficiency of decision units that are characterized by multiple inputs and outputs. In addition, DEA converts multiple inputs and outputs of a decision unit into a single measure of performance, generally referred to as relative efficiency. The research of Charnes, Cooper, and Rhodes (1978) was the first to propose the DEA method as an evaluation tool for decision units. Since then, DEA has been applied successfully as a performance evaluation tool in many research fields, e.g. in studies of scientific wealth of European nations (Rousseau & Rousseau, 1997), hospital administration, the organization of the US Navy Recruitment Command (Norman & Stoker, 1991), school districts, secondary education (Sherman, 1984), and universities (Degraeve, Lambrechts, & Van Puyenbroeck, 1996), respectively.

In DEA the performance of each unit under study is compared with that of every other one. Units which perform best use their inputs more optimally than the others and the most optimal units form a frontier, called the "efficiency frontier". Less performing units need more input to produce the same amount of output and are therefore situated at some distance of the frontier. Units situated on the efficiency frontier will have a relative performance rate of 1 (they are a 100% efficient), and the frontier is said to envelop all decision-making units (DMUs). In this study, we specifically designed the DMU be the ASEAN countries.

The organization of the study is organized as follows: in the section two, we present the research framework and data structure. Next, we describe the data sources and DEA. In the following sections, we provide the empirical studies of ASEAN countries, and the conclusions as well as suggestions are discussed in the final section.

2. The research framework and data structure

This section explains the construct of research framework and data structure. The categories of input and output include technology development, management capability and technology efficiency as well. From the logic of this research design, the research framework and data structure are will be explained as follows.

2.1. Research framework

From the theoretical viewpoint, DEA requires several input/output variables to measure the efficiency of the closed system. The framework is derived from Wang's model (Wang, 1999) and combines a management capability category so as to examine the influences of education investment and socio-economic support. The research framework includes three parts: technology development and management capability, technology efficiency outcome, and

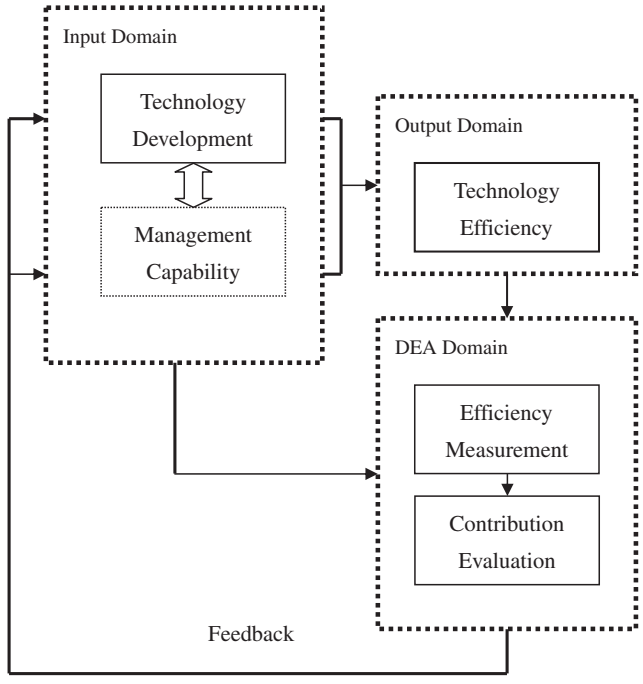

Fig. 1. The research framework of technology efficiency measurement.