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# An Empirical analysis of efficiency and productivity changes in Malaysian public higher education institutions

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# An Empirical Analysis of Efficiency and Productivity Changes in Malaysian Public Higher Education Institutions

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# Certification

I, Mad Ithnin Bin Salleh, declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Economics, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Mad Ithnin Bin Salleh

3th December 2012

*To my loving wife and kids*

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## Abbreviations

| | |
|---|---|
| BCC | Banker, Charnes and Cooper (1984) formulation |
| CCR | Charnes, Cooper and Rhodes (1978) formulation |
| CRS | Constant Returns to Scale |
| DEA | Data Envelopment Analysis |
| DFA | Distribution Free Approach |
| DRTS | Decreasing Returns to Scale |
| DMU | Decision-Making Unit |
| FDH | Free Disposal Hull |
| FDI | Foreign Domestic Investment |
| FH | Fachhochscule |
| FTE | Full-Time Equivalent |
| GDP | Gross Domestic Product |
| GNI | Gross National Income |
| ICT | Information and Communication Technology |
| IMGP | Interactive Multiple Goal Programming |
| IPTA | *Institut Pengajian Tinggi Awam* (Public Universities) |
| IPTS | *Institut Pengajian Tinggi Swasta* (Private Universities) |
| IRTS | Increasing Returns to Scale |
| IUT | Institute of Technology |
| LAN | *Lembaga Akreditasi Negara* (National Accreditation Board) |
| MIOS | Mix-Invariant Optimal Scale |
| MOE | Ministry of Education |
| MQA | Malaysian Qualifications Agency |
| MQF | Malaysian Qualifications Framework |
| MFP | Multi Factor Productivity |
| NEP | New Economic Policy |
| NHESP | National Higher Education Strategic Plan |
| NIRS | Non-Increasing Returns to Scale |
| OECD | Organisation for Economic Co-operation and Development |
| OLS | Ordinary Least Square |

| | |
|---|---|
| OME | Output-Oriented Mix Efficiency |
| OSE | Output-Oriented Scale Efficiency |
| OTE | Output-Oriented Technical Efficiency |
| PFA | Production Frontier Analysis |
| PolyU | Polytechnic University |
| R&D | Research and Development |
| RM | Ringgit Malaysia |
| RTS | Returns to Scale |
| ROSE | Residual Output-Oriented Scale Efficiency |
| SFA | Stochastic Frontier Analysis |
| SFP | Single Factor Productivity |
| TFA | Thick Frontier Analysis |
| TFP | Total Factor Productivity |
| UK | United Kingdom |
| VRS | Variable Returns to Scale |
| QAD | Quality Assurance Division |
| WoS | Web of Science |

# Abstract

The efficiency and productivity of the higher education sector play crucial roles in the development and growth of a nation, both as a major source of human capital and as a main driver of the knowledge economy. During the last decade, the Malaysian government has placed greater emphasis on productivity improvement in the public higher education sector as means of promoting the development of quality human capital. This sector has undergone some fundamental changes, which have led to its rapid expansion. The implementation of the NHESP (National Higher Education Strategic Plan) in 2007 was the most important policy change in this area. This important policy focuses on the government's agenda to turn Malaysia into a major regional hub for higher education. Despite the allocation of a large volume of funding into the sector, there has been no empirical study to show how public universities have performed either before or after this policy reform.

The main aim of this study is to investigate empirically the measurement of technical efficiency and productivity changes in the Malaysian public higher education system from 2006 to 2009. By measuring technical efficiency and productivity changes among public universities in Malaysia, this study aims to address four main research questions related to the public higher education sector: a) What is the mean efficiency score of public higher education institutions in Malaysia? b) What is the total factor productivity (TFP) change for Malaysia's public higher education institutions? c) Has the implementation of the NHESP led to improvements in the efficiency and productivity of the public higher education sector? and d) What are the major determinants of efficiency or inefficiency Malaysian universities? In this study, a non-parametric approach known as Data Envelopment Analysis (DEA) is applied to the inputs and outputs of Malaysian public universities to analyse empirically their technical efficiency and productivity. In addition, this study is the first to use a bootstrapped

Malmquist method under the condition of variable Returns to Scale (VRS), as proposed by Simar and Wilson (1999), in the context of a developing country such as Malaysia. Furthermore, this study is also the first to employ a comprehensive decomposition of the Hicks-Moorsteen TFP index, developed by O'Donnell (2010b), to examine efficiency and productivity growth in the higher education sector.

The empirical findings indicate that no matter which techniques were applied, the *Universiti Sains Malaysia*, *Universiti Pendidikan Sultan Idris* and *Universiti Malaysia Pahang* were consistently found to be the most efficient institutions across all the periods. The empirical findings also indicate that the overall mean efficiency scores under the two approaches across all Malaysian public universities suggest that these universities are operating at a reasonably high level of efficiency relative to each other, even though there is room for improvement in a number of universities.

As well, the sector's efficiency level decreased during 2006–2007, then significantly improved soon after the implementation of the NHESP in 2007–2008 and slightly declined again during 2008–2009. However, the overall efficiency gained during the entire sample period showed a significant improvement. These results suggest that the current policies, particularly the NHESP, played important roles in improving efficiency levels in this sector during the years examined. Thus, policy makers in the Ministry of Higher Education should give greater priority to initiating innovative policy and the redesign of current policy to further improve and sustain high overall economic efficiency levels in the higher education sector.

In terms of productivity analysis the results indicate that under both approaches, the sector as a whole has experienced positive improvements in productivity during the period 2006–2009,

particularly over the post-NHESP era (2008–2009). Under the bootstrapped Malmquist TFP index approach the major significant component of the sectoral TFP changes in all periods were technology changes (Δ*Tech),* and not the efficiency changs (Δ*Eff*). Under the Hicks-Moorsteen TFP index approach the key components of ΔTFP in the sector were changes in mix efficiency in addition to technical changes (Δ*Tech*). These findings are useful because they point out that under both approaches a technical change (Δ*Tech*) appears to have played major roles in TFP improvement in the sector.

A general comparison of TFP changes in different sub-groups of universities reveals that in the pre-NHESP era (2006–2007) under both approaches, TFP improvements were achieved mainly within the focused universities, whereas in the post-NHESP period (2008–2009) all three university sub-groups (namely research universities, comprehensive universities and focused universities) benefitted from significant TFP rises. Therefore, one may conclude that the government's higher education policies in the post-NHESP period have indiscriminately influenced the productivity and efficiency of Malaysian public universities.

Overall, public universities in Malaysia have recorded a high level of improvement in productivity growth during the period of study, especially after the implementation of the NHESP. Moreover the DEA results also show improvements in technical efficiency. If these trends continue, the Malaysian public universities may move closer to the best practice exemplified by frontier universities. Nevertheless, the sector as a whole cannot attain its full potential if inefficiencies continue to exist. One may argue that the implementation of the NHESP in 2007 was probably the main driving force behind the enhanced efficiency and productivity growth of Malaysian public universities. Thus there are a number of important policy implications arising from the empirical university specific results of the present study

that could lead to sustainability in efficiency and productivity growth of the higher education sector of Malaysia.

In general, this thesis has made four significant contributions to fill the gap in the literature by providing empirical evidence related to the existing body of knowledge in regard to efficiency and productivity changes in the higher education sector. First, this study is the first to highlight the issue of efficiency and productivity change in the Malaysian public higher education sector using the DEA and TFP indices. Second, this is the first study to measure the efficiency of individual public higher education institutions in response to the significant policy changes initiated in 2007. Third, no previous study in developing countries has employed a bootstrapped Malmquist method under the assumption of VRS in the measurement of efficiency and productivity changes in higher education institutions. Lastly, to the best of my knowledge, this is the first study to use a new decomposition of the Hicks-Moorsteen TFP index in the context of higher education institutions so as to analyse efficiency and productivity changes.

# Chapter One

# Introduction

## 1.1 Background of the Study

Higher education has become a critical pillar of human development worldwide (World Bank, 2002). In today's era of globalisation, the role of knowledge as a primary factor of production, and a major driver of economic development and the information and communication revolution, has become more significant. According to the OECD (2010), effective creation, diffusion and application of knowledge are key factors in creating high-wage employment and enhancing a country's productivity growth. They also enhance country competitiveness in the global economy, which demands highly specialised and skilled human capital. Higher education institutions, as a major source of human capital, play crucial roles in a nation's development and growth.

Universities can support knowledge-driven economic growth strategies by (a) training a qualified and adaptable labour force; (b) generating new knowledge; and (c) building the capacity to access existing stores of global knowledge and to adapt that knowledge to local use (World Bank, 2002, p.2). The generation and application of knowledge is increasingly significant for development. The development and diffusion of technological innovations, mostly arising from basic and applied research undertaken in universities, is seen to be the cornerstone of greater productivity. Higher skill levels in the labour force, together with qualitative improvements that enable workers to use new technology, also boost productivity. The increase in workforce flexibility, which depends on the acquisition of general skills that facilitate adaptation, is also considered a crucial factor in economic development in the context of knowledge economies.

Developing countries, like Malaysia, are at risk of being outstripped in a highly competitive global economy if their higher education institutions and systems are not adequately developed and prepared to capitalise on the creation and diffusion of knowledge. In the most recent decade the Malaysian economy recorded impressive growth, with manufacturing as an engine of economic growth (Taylor, 2007). Nevertheless, sustaining this competitive advantage is not guaranteed, as other developing and transitioning countries are now entering the global economy. To transform itself into a knowledge economy, Malaysia can no longer rely on low cost mass production, and on relatively unskilled and low paid workers (World Bank, 2007). Malaysia needs an economy that is driven by knowledge as the main source of national prosperity and wealth, where the nation's human resources are intimately engaged in the development, adaptation and diffusion of innovation in the economy, and where science and technology are embedded in production processes.

As prime producers of knowledge, universities have become key institutions in the knowledge-based economy (Reichert, 2006). According to Azman, Sirat and Karim (2010), as elsewhere in the world, the universities in Malaysia are the main drivers of the knowledge economy and the main producers of quality human capital. Over the past decade, the Malaysian government has placed greater emphasis on improved efficiency and productivity in the public higher education sector as an engine for promoting quality human capital for a knowledge-based economy. This sector has undergone some fundamental changes, which have led to its rapid expansion. Importantly, the government raised the share of research and development in GDP from 1.5% in the Eighth Malaysia Plan (2000–2005) to 4.9% in the Ninth Malaysia Plan (2006–2010). The public universities were the recipients of these national research and development funds (Ministry of Higher Education, 2007). As a result, there is a need to monitor the performance and productivity of public universities to see if the government's objectives are being met (Johnes, 2008). From the public perspective, the

performance and productivity of higher education institutions are assessed by how much individuals and the society as whole benefit from invested resources. On the other hand, from the government perspective, it is important to understand whether universities are efficient in their jurisdiction, since this sector obtains a large amount of its income from public funds. This makes it essential, in the interest of accountability, to measure the sector's efficiency and productivity (Johnes, 2006a). This signifies the need for a robust and comprehensive monitoring role in the higher education sector. A more efficient higher education production process could provide Malaysia's human resources with the skills required to reach a high level of technology adaptation and innovation, which can in the future lead to higher overall growth rates and generate overall productivity gains to the economy.

## 1.2 Statement of the Problem and its Significance

In measuring the efficiency and productivity of the higher education sector, it is critical to consider the nature of the sector itself. Johnes (2008) admitted that the process of measuring efficiency and productivity in universities is problematic. According to Lindsay (1982, p. 176) some characteristics of the higher education sector, such as the "lack of profit motivation, goal diversity and uncertainty, diffuse decision making and poorly understood production technology", differentiate this sector from other industries and make the measurement of efficiency and productivity even more complicated. Johnes (2006a, 2008) also mentions other difficulties in measuring the efficiency and productivity of higher education, including the facts that it is non-profit, there is an absence of output and input prices and it produces multiple outputs from multiple inputs. A variety of methods have been applied in the higher education sector to address these difficulties, from the application of the OLS regression method to the use of advanced methods such as DEA or SFA (Johnes, 2006a). Of these approaches the frontier method is particularly appropriate in the context of

this thesis because it does not require a knowledge of output and input prices, nor does it require any specific behavioural assumption about the universities under consideration (Coelli, Rao and Battese, 1998).

This dissertation focuses on an in-depth measurement of efficiency and productivity in the public higher education sector by employing various DEA-based TFP indices. This is particularly important in the case of Malaysia, as up to now no research work has been performed to evaluate the NHESP, which aimed to transform the Malaysian higher education sector into a major regional hub for education. Another significant factor in examining the Malaysian public higher education institutions' efficiency and productivity is that, although Malaysia's economic development has recorded impressive progress in the last two decades, the potential of the higher education sector is still not fully exploited. Malaysia has come a long way from being a low-income economy that relied on the agricultural sector to a high middle income, export-oriented economy that has been fuelled by the manufacturing sector (Mahadevan, 2007). Nevertheless, to prevent a middle-income trap, Malaysia cannot depend heavily on its comparative advantage based on cheap and unskilled human capital and FDI. Instead, Malaysia needs to transform its economy, which primarily depends on labour-intensive technology, into a quality skilled workforce. To achieve this transition it needs a highly efficient and productive higher education system.

In Malaysia, the higher education sector is divided into two major categories: the public sector, IPTA, and the private sector, IPTS. Both sectors are essentially focused on tertiary education. IPTA and IPTS come under different management systems, although both sectors share distinctive challenges and both aim to meet the country's higher educational requirements. Consequently, efficiency and productivity are highly scrutinised to maintain a competitive edge. For this purpose, the Malaysian IPTA and IPTS need to consider strategies

to enhance their efficiency and productivity, generate additional revenue and sustain their service quality to keep the momentum going. Both sectors need a high quality mechanism to monitor their efficiency and productivity to provide excellent services to their customers.

The IPTA sector consists of 20 public universities, which are categorised into three sub-groups: research universities, comprehensive universities and focused universities. The research universities are all research-focused and are well-established institutions; they include *Universiti Malaya*, *Universiti Sains Malaysia*, *Universiti Kebangsaan Malaysia*, *Universiti Putra Malaysia* and *Universiti Teknologi Malaysia*. Comprehensive universities, also called multi-disciplinary universities, focus on a wide cross-section of courses and fields of study (*Universiti Islam Antarabangsa Malaysia*, *Universiti Malaysia Sarawak*, *Universiti Malaysia Sabah* and *Universiti Teknologi MARA*). In contrast, the focused universities concentrate on specified disciplines linked to the original objective of their establishment. These include the *Universiti Utara Malaysia*, *Universiti Pendidikan Sultan Idris*, *Universiti Malaysia Terengganu*, *Universiti Sains Islam Malaysia*, *Universiti Tun Hussein Onn*, *Universiti Teknikal Melaka Malaysia*, *Universiti Malaysia Pahang* and *Universiti Malaysia Perlis*.

## 1.3 Objectives of the Study

The main aim of this study is to conduct an empirical investigation into the Malaysian public higher education institutions, focusing on measuring their technical efficiency and productivity changes. Furthermore, this study aims to address the following four questions:

1. What is the mean efficiency score of public higher education institutions in Malaysia?

The aim of this research question is to analyse the efficiency of Malaysian public higher education institutions by calculating their efficiency scores. More specifically, this will determinate whether public higher education institutions in Malaysia are efficient.

2. What is TFP change in Malaysia's public higher education institutions?

   This question examines the nature of productivity changes by means of bootstrapped Malmquist and Hicks-Moorsteen TFP indices. In other words, this aspect of the current study will use two different TFP indices to measure productivity change and to decompose change in productivity into efficiency change and technical change over the period 2006–2009. There are three main reasons why two different TFP indices have been employed in this study. First, these methods can analyse the productivity changes under the assumption of VRS compared to the popular Malmquist indices, which assume CRS conditions. Second, the bootstrapped Malmquist index enables the decomposition of technical changes into changes of pure technology (frontier shifts), and changes in the scale of technology (changes in the shape of frontier). The traditional Malmquist index, on the other hand, is unable to analyse these changes in the shape of the technology frontier. Third, the application of the Hicks-Moorsteen TFP index enables the decomposition of efficiency changes into three different measures: changes in technical efficiency, scale efficiency and mix efficiency.

3. Has the implementation of the NHESP led to an improvement in efficiency and productivity growth of the Malaysian public higher education sector?

   This thesis investigates the effect of current government policies, specifically the 2007 NHESP, on changes in technical efficiency and productivity growth.

4. What are the major determinants of efficiency or inefficiency in Malaysian public universities?

One of the main objectives of this study is to identify the major sources of efficiency or inefficiency. More specifically, by employing the decomposition of the Hicks-Moorsteen TFP, it is possible to identify the main source of improvement or deterioration in efficiency and, therefore, the individual universities' productivity levels.

These research questions will be answered by conducting an empirical analysis of the data of compiled from the Malaysian public higher education institutions, and on that basis some relevant policy recommendations can be formulated.

## 1.5 Structure of the Study

This thesis consists of eight chapters, which are briefly outlined as follows. Chapter Two provides an overview of the Malaysian public higher education institutions, including the history and development of these institutions from 1962 to the present. This chapter begins with a general overview of Malaysia and its economic performance based on several indicators, with a focus on the higher education sector. It then provides the background to the development of Malaysian public universities during the last 50 years. Finally, the chapter concludes by reviewing a number of important initiatives and higher educational policies designed and implemented in Malaysian public universities.

Chapter Three describes the conceptual and theoretical framework in the measurement of efficiency and productivity in the context of higher education institutions. This chapter first provides a number of important concepts of efficiency, such as technical efficiency, allocative efficiency and scale efficiency, leading to a discussion on different approaches to productivity and efficiency measurement, including parametric and non-parametric methods. The chapter also provides a justification for the use of the DEA technique in this study for

measuring efficiency and productivity changes. Chapter Three concludes with a discussion of the empirical framework for measuring productivity change over time.

Chapter Four reviews the literature on efficiency and productivity change in the higher education sector for both developing and developed countries. This chapter summarises the most relevant and frequently cited research that contributes to an understanding of this field. In particular, the literature review is organised around two main issues: (1) the application of DEA in measuring higher education sector efficiency; and (2) productivity change studies in universities.

Chapter Five presents the methodology for measuring efficiency and productivity change. In particular, this chapter presents a framework of efficiency measurement using DEA. In addition, the theoretical framework on the application of the bootstrapped Malmquist index and Hicks-Moorsteen TFP is also reviewed in detail in this chapter. This chapter discusses the important issue of input/output selection data compilation.

Chapter Six presents the key findings of the study, which are analysed in a pattern consistent with the methodology in the previous chapter. These findings focus in particular on four main components: first, the estimates are presented for bootstrapped technical efficiency scores for the public higher education sector as a whole as well as for individual universities during the sample period; second, productivity change and its decomposition over the period 2006/2007–2008/2009 are analysed; third, the Hicks-Moorsteen approach is employed to estimate the technical efficiency, scale efficiency and mix efficiency; and fourth, the decomposition of the Hicks-Moorsteen TFP index is described.

Chapter Seven presents the key policy implications of the study. This chapter provides policy implications and recommendations based on the empirical findings reported in Chapter Six. The eighth and final chapter presents the conclusions of the entire study and reiterates its contribution and significance. The chapter ends with some discussion of recommendations for future studies.

## 1.6 Contributions of the Study

According to the objectives and questions discussed above, the current thesis makes four significant contributions to the literature of efficiency and productivity change in higher education institutions. First, this thesis is the first to examine the issue of efficiency and productivity change in Malaysian public higher education institutions. Empirical evidence is provided by employing the DEA and TFP indices on multiple inputs and outputs of Malaysian public universities in the period 2006–2009. Second, this is the first study to measure Malaysian public higher education institutions' efficiency in response to significant policy changes in the Malaysian higher education sector implemented during 2007. The effect of the NHESP on the performance of the Malaysian higher education institutions over the period 2006–2009 is investigated. Third, no previous study in developing countries has employed a bootstrapped Malmquist method under the assumption of VRS in the measurement of efficiency and productivity changes in higher education institutions. Lastly, to the best of my knowledge, this is the first study to use a new decomposition of the Hicks-Moorsteen TFP index in the higher education sector to analyse efficiency and productivity change.

# Chapter Two
# Public Higher Education Institutions in Malaysia

## 2.1 Introduction

This chapter provides the general background of Malaysia, its economic background and its performance. The focus of this chapter is on the development of the higher education sector, particularly the public higher education sector. Strong macroeconomics management and political stability have led to remarkable development in Malaysia's economy, represented by high GDP growth, substantial reduction in poverty and enhancement of living standards (World Bank, 2007). Nevertheless, the competitive advantages that Malaysia has at present, which are fuelled by FDI and based primarily on mass production, low-cost manufacturing efficiency, relatively unskilled workers and low wages, cannot be sustained.

In order to prevent the Malaysian economy from falling into the middle-income trap, Malaysia needs an economy that specialises more in science, technology and engineering, and needs to achieve technological leadership and economies of scale. Therefore there is a need for skilled workers who have embodied knowledge, creativity and innovation and are able to fulfil society`s demand. In order to produce better-educated, skilled workers and achieve the nation's aspiration to become a developed country by the year 2020, the government of Malaysia, through the Ministry of Higher Education, needs to improve the efficiency and productivity of the higher education sector.

The remainder of this chapter is organised as follows: Section 2.2 presents an overview of the background and performance of the Malaysian economy, based on important macroeconomic indicators. This section also illustrates the current condition of the higher education sector in

Malaysia using several indicators. Section 2.3 describes the development of the higher education system in Malaysia, including the historical development of public higher education institutions. This section will focus on both the public and private higher education sectors, which play a crucial role in Malaysia's process of transformation into a knowledge-based economy. Section 2.4 describes the policies and initiatives in the Malaysian higher education system. Finally, Section 2.5 provides a brief summary of the chapter.

## 2.2 Overview of the Malaysian Economy

### 2.2.1 General Background

Malaysia is a federal constitutional monarchy located in Southeast Asia. The form of governance used is a parliamentary system, with Tuanku Abdul Halim Mu'adzam Shah as the 14th Head of State and Dato' Mohd Najib Tun Abdul Razak as Prime Minister. It has 13 states and three federal territories; Kuala Lumpur is the capital city and Putrajaya is the seat of federal government. It shares land borders with Thailand, Indonesia and Brunei, and maritime borders with Singapore, Vietnam and the Philippines. It has a total landmass of 329,847 square kilometres, and is separated by the South China Sea into two regions: the peninsulas of Malaysia and West Malaysia. Malaysia has a population of 28.3 million people, of which 67.4% are Bumiputera[1], 24.6% are Chinese, 7.3% are Indian and 0.7% are other ethnic minorities. The median age of the Malaysian population is 26.2 years.

Islam is identified as the state religion in Malaysia, with 61.3% of the population practising this religion. Nevertheless, the practice of other major religions such as Buddhism (19.8%), Hinduism (6.3%), Christianity (9.2%), Taoism (1.3%) and atheist (0.7%) are freely allowed. *Bahasa Melayu* (Malay language) is recognised as the official language. However, English is

[1] *Bumiputera* is a term from the Sanskrit word *Bhumiputra*, which can be translated literally as "son of land" which includes Malays and other indigenous people and is constituted under article number 160 (2) of the constitution of Malaysia.

widely used in commerce and administration, and other languages such as Cantonese, Mandarin, Hokkien, Hakka, Tamil, Telugu, Malayalam, Punjabi and indigenous dialects (Iban, Dusun, Kadazan) are widely spoken.

### 2.2.2 Economic Background

Generally, in the early years following independence from the British, Malaysia's economy depended on agriculture and natural resources. During that time raw materials such as rubber and tin were the main exports and main source of income for the country. Since the mid-1980s, Malaysia's economic growth has been greatly influenced by a high level of foreign and domestic private investment, which is driven by the industrial sector as the nation's engine of growth. These conditions are closely related to the economic growth of industrial countries, which are the main importers of Malaysian goods. According to Taylor (2007), by the early 1990s, the manufacturing sector had displaced the agricultural sector as the main contributor to Malaysia's GDP. Table 2.1 shows Malaysia`s significant economic development growth, giving the major economic indicators from 1985 to 2009.

Table 2.1 demonstrates that Malaysia's economic growth from 1985 to 2009 has shown an encouraging development pattern. During the 1980s, Malaysia's economy demonstrated positive development, despite experiencing a world commodity price crisis during 1984–1985, with the GDP growth in 1985 slowing to 1.2%. Nevertheless, based on the diversity strategy plan implemented by the government, GDP growth increased from 1.2% in 1986 to 5.4% in 1987, then to 9.9% in 1988 and to 9.1% in 1989. This trend mostly indicates growth in the manufacturing, service and construction sectors (Central Bank of Malaysia, 1999). During the 1990s, Malaysia recorded an impressive economic performance, with economic growth registering not less than 6%, with the exception of 1998, when growth fell 7.4% as a result of the Asian financial crisis. During this period, the value of the private sector

deteriorated due to decreases in share prices and asset values, increases in interest rates, difficulties in obtaining bank credit, constricted cash flow and financial and political instability. In addition, Malaysia's major economic partners, particularly in East Asia, experienced a significant deterioration in their economic growth. These conditions directly affected the international demand for Malaysian exports.

**Table 2.1: Malaysia's Economic Indicators (1985–2009)**

| Year | Change in Real GDP (%) | Inflation Rate (%) | Income Per Capita (RM) | Current Account Balance (RM Million) |
|---|---|---|---|---|
| 1985 | -1.2 | 0.3 | 4,531 | -1,522 |
| 1986 | 1.2 | 0.7 | 4,092 | -316 |
| 1987 | 5.4 | 0.3 | 4,537 | 6,642 |
| 1988 | 9.9 | 2.5 | 5,069 | 4,739 |
| 1989 | 9.1 | 2.8 | 5,624 | 698 |
| 1990 | 9.0 | 3.1 | 6,299 | -2,483 |
| 1991 | 9.5 | 4.4 | 6,919 | -11,644 |
| 1992 | 8.9 | 4.7 | 7,492 | -5,622 |
| 1993 | 9.9 | 3.5 | 8,379 | -7,926 |
| 1994 | 9.2 | 3.5 | 9,251 | -14,770 |
| 1995 | 9.6 | 3.4 | 10,252 | -21,647 |
| 1996 | 10.0 | 3.3 | 11,429 | -11,226 |
| 1997 | 7.3 | 2.7 | 12,309 | -16,697 |
| 1998 | -7.4 | 5.3 | 12,135 | 37,394 |
| 1999 | 6.1 | 2.8 | 12,305 | 47,895 |
| 2000 | 8.3 | 1.6 | 13,378 | 32,252 |
| 2001 | 0.5 | 1.4 | 12,859 | 27,687 |
| 2002 | 5.4 | 1.8 | 13,722 | 30,494 |
| 2003 | 5.8 | 1.2 | 14,838 | 50,627 |
| 2004 | 6.8 | 1.4 | 17,577 | 56,511 |
| 2005 | 5.0 | 3.1 | 18,966 | 75,681 |
| 2006 | 5.9 | 3.6 | 20,841 | 93,642 |
| 2007 | 6.3 | 2.0 | 23,103 | 99,300 |
| 2008 | 4.7 | 5.4 | 25,274 | 129,513 |
| 2009 | -1.7 | 0.6 | 25,721 | 112,139 |

**Source**: Central Bank of Malaysia (2009), edited by author.

In the 2000s, Malaysia's economic growth was more moderate. Generally it recorded an expansion of more than 5% per year, with the exception of 2001 and 2009, with growth of 0.5% and -1.7%, respectively. Slow growth in 2001 was associated with the slow progress in the US economy, continuing recession in Japan and contraction in the global electronics industry. Malaysia is the largest exporter of semiconductor components and devices, electrical goods and information and technology (ICT) goods, and the industry slowdown caused negative export growth for Malaysia's electronic manufacturing production. The 2009

negative growth was due to the Global Financial Crisis and recession. This period saw significant contractions in exports, with a consequent negative impact on domestic demand.

Based on these observations, it is noted that Malaysia's economic growth rate during the 1990s was faster than that during the 1980s and 2000s. On average, during the 1980s (1985–1989) Malaysia's annual growth rate was around 4.88% per year; during the 1990s (1990–1999) it was 7.21% per year; and during the 2000s (2000–2009) it was 9.0% per year. It is clear that in general, Malaysia experienced positive economic growth during the period 1985–2009. Malaysia experienced major economic difficulties due to the global commodity price crisis in 1984–1985 and the Asian Financial Crisis in 1997–1998. However, the government has successfully managed the economy and stimulated growth by means of a number of medium- to long-term development plans, such as the New Economic Policy (1970–1990), the National Development Policy (1991–2000), the National Vision Plan (2001–2010) and the successive five-year Malaysia Plans (1966–1970, 1971–1975, 1976–1980, 1981–1985, 1986–1990, 1991–1995, 1996–2000, 2001–2005, 2006–2010).

As shown in Table 2.1, Malaysia has also experienced a high rate of inflation for the 25 years from 1985–2009. Inflation increased to more than 4% per year on four occasions during this time. The first was in 1991, with a 4.4% inflation rate; the second was in 1992, with a 4.7% inflation rate. Factors that influenced these events were increases in aggregate demand, high financial growth, constraints in supply and overseas growth. The third time Malaysia experienced high inflation was in 1997, with a 5.3% inflation rate, which was caused by the Asian currency crisis. During this period, declines in the value of the Ringgit Malaysia (RM) resulted in increases in food prices and decreases in the prices of local export products such as palm oil (Bank Negara, 1999). The fourth time Malaysia experienced a high rate of inflation was in 2008, due to increases in global oil and food prices. The lowest inflation rates

recorded during the period 1985–2007 were in 1985, with 0.3%, and 1986, with 0.7% inflation rate. During the years 2000 to 2004, the level of inflation in Malaysia was stable, with an average rate of 1.2% to 1.8% per year. It can be concluded that the inflation rate in Malaysia is controlled, and also that it is associated with world economic growth.

Table 2.1 also demonstrates a large improvement in Malaysia's GNI per capita during the period from 1985 to 2009. The table demonstrates that per-capita income increased nearly sixfold from RM 4.531 in 1985 to RM 25.721 in 2009. However, there are two years – 1998 and 2001 – in which per-capita income decreased. In 1998, the per-capita income figure was RM 12.135, which is approximately RM 174 less than the previous year (RM 12.309). This is in line with the increase in value of 0.5% of the GNI at the same time as an increase of 2.3% in the total population for the year 1998. In terms of purchasing-power parity during this period, per-capita income also declined due to relatively high inflation and the depreciation of the Ringgit. Similarly, in 2001, income per capita decreased by RM 519.00 from the previous year, due to a 1.8% decline in GNI growth concurrent with a 2.1% increase in the population. However, in terms of purchasing-power parity, per-capita income increased due to a lower inflation rate over the previous year. In conclusion, the growth of income per capita depends on the GNI generated by the GDP and increases in the total population.

Based on the economic indicators presented in Table 2.1, it is undeniable that Malaysia’s economic performance over the last three decades has been impressive. This rapid economic growth has led to structural change in the Malaysian economy. Malaysia has experienced major transformation from a commodity-export-based economy, depending on natural resources (tin, oil and timber) and agricultural products (rubber, cocoa and palm oil), to an economy based on large-scale manufacturing (Hill, 2012). Nevertheless, with the changing pattern in the global economy, as more and more economies turn to export-led growth,

Malaysia needs to reposition itself and embrace major structural transformation. Malaysia must discover a new source of growth, enhance its competitive advantages in the global arena, strengthen its regional linkages, energise its domestic sector, move up the value chain in manufacturing and make its service sector the main growth engine to transform itself into a knowledge-based economy (Hill, 2012).

Human capital and technology development are viewed as essential in order to transform into a knowledge based economy (Mahadevan, 2007). According to Mokshein, Ahmad and Vongalis-Macrow (2009), the growth of a knowledge-based economy requires a higher level of education across the population to raise workers' productivity, and to create the culture of innovation and dynamism needed to strengthen both individual and institutional capacities. Malaysia also needs human capital that can assess knowledge, technology and skills and support its institutions. This is essential to achieve its long-term target of becoming a developed nation by 2020. This major structural transformation from large-scale manufacturing economy to knowledge-based economy will allow Malaysia to avoid the middle-income trap.

Human capital development (through formal education) has been always a key priority of the Malaysian governments, as outline in the various five-year Malaysia plans. In all of Malaysia Plans education has been treated as a factor of human capital formation (Taylor, 2007). Malaysia experienced significant increases in education expenditure from 1970 to 2010. This occurred after the implementation of the New Economic Policy in 1970 when Malaysia started expanding education sector (Taylor, 2007). This rapid expansion in education from 1970 to 2010 has been motivated by the strong social demand for access to primary, secondary and tertiary education for the growing population in Malaysia (Taylor, 2007). As shown in Table 2.2, public expenditure on education recorded an increase from RM521

million in the 1970's to RM 20.022 million in the 2000's. For the period of 2000 to 2010, government expenditure on education was further increased to RM 49.867 million. This increasing trend can be seen in Table 2.2. Public spending on education is between 13 and 25 percent of total government expenditure and has been uniformly high during the period of 1970 to 2010 (Taylor, 2007).

**Table 2.2: Total Government Education Expenditure (1970–2010)**

| Year | Total Government Development Expenditure for Education (RM Million) | Total Government Operating Expenditure for Education (RM Million) | Total Government Expenditure for Education (RM Million) |
|---|---|---|---|
| 1970 | 44 | 477 | 521 |
| 1971 | 86 | 536 | 622 |
| 1972 | 112 | 798 | 910 |
| 1973 | 142 | 805 | 947 |
| 1974 | 187 | 1,051 | 1,238 |
| 1975 | 212 | 1,158 | 1,370 |
| 1976 | 227 | 1,261 | 1,488 |
| 1977 | 274 | 1,750 | 2,024 |
| 1978 | 252 | 1,791 | 2,043 |
| 1979 | 339 | 1,918 | 2,257 |
| 1980 | 558 | 2,228 | 2,786 |
| 1981 | 791 | 2,726 | 3,517 |
| 1982 | 1,082 | 2,991 | 4,073 |
| 1983 | 988 | 2,915 | 3,903 |
| 1984 | 1,009 | 3,183 | 4,192 |
| 1985 | 872 | 3,473 | 4,345 |
| 1986 | 1,064 | 3,743 | 4,807 |
| 1987 | 810 | 3,839 | 4,649 |
| 1988 | 865 | 4,115 | 4,980 |
| 1989 | 1,242 | 4,407 | 5,649 |
| 1990 | 1,634 | 4,962 | 6,596 |
| 1991 | 1,285 | 5,782 | 7,067 |
| 1992 | 1,205 | 6,854 | 8,059 |
| 1993 | 1,117 | 7,361 | 8,478 |
| 1994 | 2,010 | 8,098 | 10,108 |
| 1995 | 2,044 | 8,559 | 10,603 |
| 1996 | 2,091 | 10,398 | 12,489 |
| 1997 | 2,521 | 10,360 | 12,881 |
| 1998 | 2,915 | 10,528 | 13,443 |
| 1999 | 3,865 | 11,458 | 15,323 |
| 2000 | 7,099 | 12,923 | 20,022 |
| 2001 | 10,363 | 14,422 | 24,785 |
| 2002 | 12,436 | 16,982 | 29,418 |
| 2003 | 10,193 | 19,033 | 29,226 |
| 2004 | 4,316 | 21,517 | 25,833 |
| 2005 | 3,736 | 23,058 | 26,794 |
| 2006 | 5,349 | 25,589 | 30,938 |
| 2007 | 6,271 | 30,443 | 36,714 |
| 2008 | 7,892 | 36,528 | 44,420 |
| 2009 | 10,840 | 39,318 | 50,158 |

**Source**: Central Bank of Malaysia (2009), edited by author.

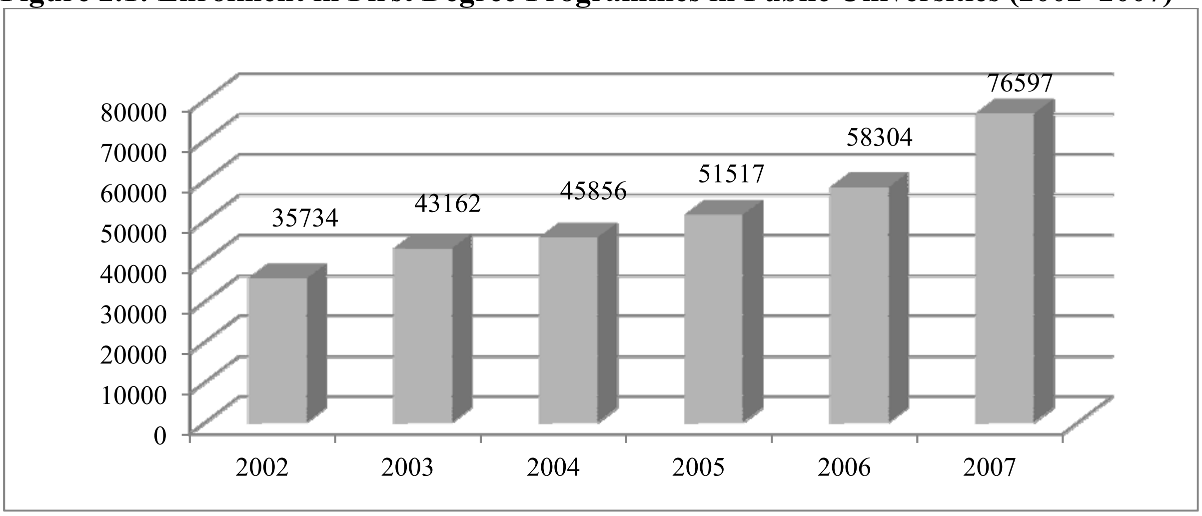
The policy priority for each educational sub-sector is indicated by the level of expenditure. Higher education experienced larger increases in total government education allocation, compared to primary and secondary education. This specifically starts from the fourth Malaysia Plan (1985–1990), when the government granted a special role to the higher education sector for development of the Malaysian labour market, reflecting the changing economic structure of the labour force and the demand for particular skills (Taylor, 2007). This is shown in Table 2.3.

**Table 2.3: Shares in Public Expendiure for Various Education Sectors (1966–2005)**

| | 1966–1970 | 1971–1975 | 1976–1980 | 1981–1985 | 1986–1990 | 1991–1995 | 1996–2000 | 2001–2005 |
|---|---|---|---|---|---|---|---|---|
| Primary | 14.8 | 14.8 | 19.6 | 16.9 | 14.9 | 16.2 | 16.8 | 15.5 |
| Secondary | 51.5 | 41.8 | 18.8 | 24.6 | 14.1 | 22.3 | 25.7 | 17.5 |
| Technical | 8.5 | 11.6 | 4.1 | 6.5 | 13.2 | 5.7 | 3.6 | 8.6 |
| University | 8.2 | 23.5 | 43.9 | 45.7 | 49.3 | 42.8 | 35.6 | 47.7 |
| Teacher training | 7.7 | 0.8 | 7.2 | 3.4 | 5.4 | 2.4 | 5.6 | 1.6 |
| Other programmes | 9.3 | 7.5 | 6.4 | 2.9 | 3.1 | 10.6 | 12.7 | 9.1 |
| Total percentage | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

**Source**: Taylor (2007, p.167), edited by author.

**Figure 2.1: Enrolment in First Degree Programmes in Public Universities (2002–2007)**

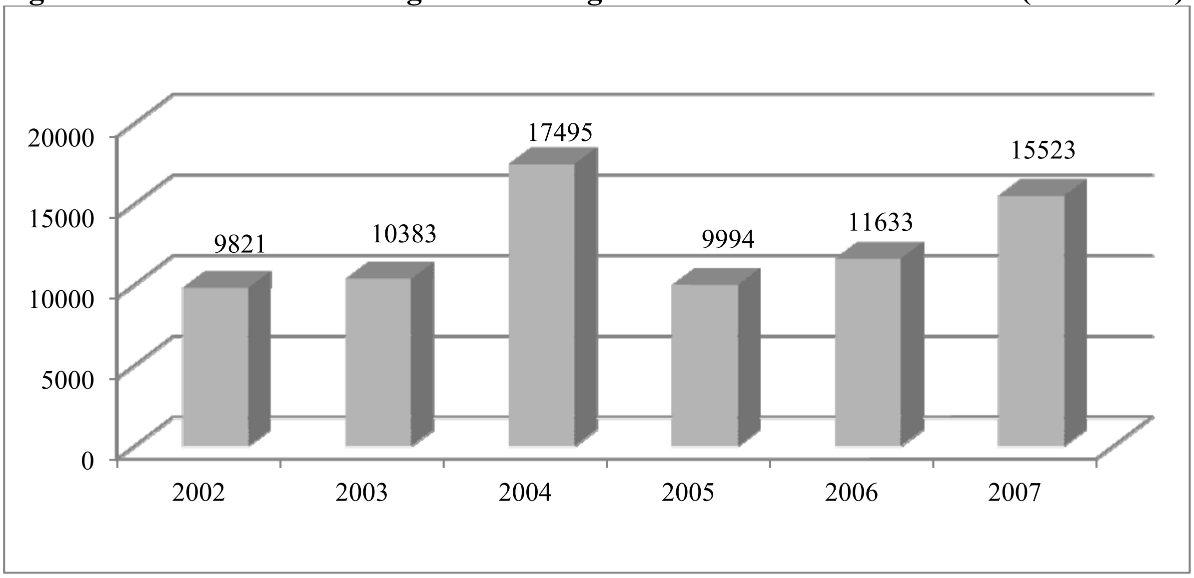



**Source**: Ministry of Higher Education (2006, p.2), edited by author.

The expansion of the higher education sector is indicated not only by increasing educational expenditure, but by significant increases in the number of enrolments. Enrolments in the

higher education sector have shown tremendous increases every year. The rate in 2004 was 7.9%, compared to only 3.7%, in 1994 (Bakar & Tuah, 2006). Figure 2.1 shows the remarkable jump in enrolments in first degree programmes in Malaysian public universities from 2002 to 2007.

**Figure 2.2: Enrolment in Postgraduate Programmes in Public Universities (2002–2007)**




**Source**: Ministry of Higher Education (2006, p.2), edited by author.

Another indicator is the increasing variety of courses offered by public universities, not only at the undergraduate but also at the postgraduate level. Figure 2.2 shows the rising number of enrolments in postgraduate programmes from 2002 to 2007, with the number enrolled in postgraduate programme increasing from only 9,821 in 2002 to 15,523 in 2007.

The emphasis on the government's investment in higher education is evident by the initiatives put forward by the various Malaysia Plans. It can be argued that Malaysian economic growth is partly indicated by the expansion of its education sector. The higher education sector is one of the main components of the education sector, and it plays a significant role in developing and producing knowledge-rich human capital to fulfil the nation's aspiration to become a developed nation by the year 2020. Thus, the measurement of efficiency and productivity in

higher education is essential in allowing the government to accurately monitor the sector's performance.

## 2.3 Development of the Malaysian Higher Education System

This section presents an historical review of public universities and their significance in the higher education sector in Malaysia. It begins by analysing the historical development through three stages: 1) post-independence (1957–1980), 2) the progressive years (1981–2000) and 3) the 21st century (2001–present). It is therefore important to outline the historical framework of Malaysian public universities to indicate the establishment and development of this sector. This historical background will help to understanding the current university system and provide information regarding the relevant changes during the expansion of this sector.

### 2.3.1 Historical Overview of Public Higher Education in Malaysia

#### 2.3.1.1 The Post-Independence Years (1957–1980)

Malaysia gained independence in 1957, and at that time the country had no universities. *Universiti Malaya*, the first university in Malaysia, was established 1 January 1962. As Malaysia had been a British colony, this university followed the basic features of the British university model. From 1962 to 1969, the Malaysian higher education system centred around this university, which played a crucial role in the development of human capital for a newly independent nation. During this period, this was the only university that produced manpower for the needs of the country (Ismail and Musa, 2007, pp. 20). However, in the first Malaysia Plan (1966–1970), the funding for higher education was a mere RM 30 million, compared to RM 232.1 million and RM 54.6 million for secondary and primary education, respectively.

This was due to the fact that during this period the Malaysian government's priorities were nation-building, universal literacy and economic development (Azman & Ahmad, 2006).

By the end of the 1960s, there was a change in trend of the higher education sector when the government started to place more emphasis on the higher education sector and establish more public universities to increase access to tertiary education. After the racial riots in 1969, the second Malaysia Plan (1970–1975) was introduced to implement the New Economic Plan (NEP), which aimed to restructure Malaysian society by eliminating the identification of race within particular industries. One of the main thrusts of this policy was to promote higher education as the main instrument for social justice and social mobility through the implementation of an ethnic-quota system for student admissions. In addition, the plan also acknowledged the central role of the higher education sector in fulfilling the human-resource demands of a modern, progressive economy (Symaco, 2010). Thus, a second university, *Universiti Sains Malaysia*, was established in 1969 specifically to produce professionals in science and related fields.

A third university, *Universiti Kebangsaan Malaysia,* was established in 1970. It was intended to be the centre of Malay intellectual discourse, and was the first university to use *Bahasa Malaysia* (Malay language) as a medium of instruction in all fields of study. This was followed by the establishment of *Universiti Pertanian Malaysia* in 1971 and *Universiti Teknologi Malaysia* in 1972. *Universiti Pertanian Malaysia* (later known as *Universiti Putra Malaysia*) was established with a mandate to produce skilled human capital for the agricultural sector. To balance this, the *Universiti Teknologi Malaysia* was established with the aim of providing higher education in the field of engineering and technology.

#### 2.3.1.2 The Progressive Years (1981–2000)

During the 1980s there was a transformation in global financial trends that affected the need for further expansion of public higher education in Malaysia. This expansion took place during the Fourth Malaysia Plan period (1980–1985), with the establishment of two more universities, bringing the total number to seven. *Universiti Islam Antarabangsa Malaysia*, established in 1983, specialised in Islamic degree courses, and *Universiti Utara Malaysia*, established in 1984, focused on providing management courses. The establishment of these two universities reflected a shift in the policy articulated in the Fourth Malaysia Plan towards a focus on an export-oriented and industrialised production structure (Taylor, 2007).

In 1990, the Malaysian government, under Dr. Mahathir Muhammad's leadership, unveiled Malaysia's aspirations towards achieving developed-nation status by 2020. The objective of Vision 2020 was to achieve the status of an industrialised and developed country in terms of economy, national unity, social cohesion, social justice, political stability, system of government, quality of life, social and spiritual values, national pride and confidence (Muhamad, 1991). Since the announcement of Vision 2020, education has been given greater importance in national development. The sixth Malaysia Plan (1991–1995) also highlighted that the government of Malaysia aimed to expand educational opportunities, increase access to all levels of education and strengthen and improve the quality of education. To increase access to, and ensure equity in, public higher education, the government of Malaysia established a further two public universities in East Malaysia: *Universiti Malaysia Sarawak* in 1992 and *Universiti Malaysia Sabah* in 1994.

In order to meet domestic and national manpower demand for skilled and quality workers, the government continued to highlight the importance of the higher education sector as the main focus in developing quality human capital. Effort was made during the Seventh Malaysia

Plan (1996–2000) to expand physical facilities at existing campuses and upgrade two institutes to full universities, as well as establishing new universities. This change involved the *Institut Pendidikan Sultan Idris* being upgraded to a full university (known as *Universiti Pendidikan Sultan Idris*) in 1997 as part of the government's plan to increase the number of teachers in both primary and secondary schools. The other upgraded institute was *Institut Teknologi MARA* (later known as *Universiti Teknologi MARA*), which became a full university in 1999.

In 2000, the government of Malaysia continued to provide more access and improve equity in the higher education sector with the establishment of three more universities: *Kolej Universiti Islam Malaysia* (later known as *Universiti Sains Islam Malaysia*), *Kolej Universiti Teknologi Tun Hussein Onn* (later known as *Universiti Tun Hussein Onn*) and *Kolej Universiti Teknikal Kebangsaan Malaysia* (later known as *Universiti Teknikal Malaysia Melaka*). The *Universiti Sains Islam Malaysia* was established as part of a government effort to accommodate the national need to allow students from religious schools to pursue theology studies without having to go to West Asia. This measure also reduced the government burden of sending students abroad for further studies in Islam as well as helping Malaysia to develop as a centre of intellectual excellence that would produce scholars of Islam. In terms of technical education, the establishment *Universiti Tun Hussein Onn* and *Universiti Teknikal Malaysia Melaka* in 2000 aimed to develop a new education system with more concentration on practical and application-oriented teaching and learning methods, with a strong partnership with the business and industrial sectors. This move by the government was based on international models including the German FH, the French IUT and the Hong Kong PolyU, which provides application-related, hands-on intensive education (Kennedy & Zain, 2008).

#### 2.3.1.3 The 21$^{st}$ Century (2001–Present)

A new shift in the need for knowledge workers began at the turn of the 21st century, when Malaysia was transforming its economy from an industrial or production-based economy to a new, or knowledge-based, economy. In order to produce the knowledge workers needed to fuel the growth of the nation, the government has begun giving more focus on producing knowledge workers instead of training skilled workers (Kaur, Sirat and Azman, 2008). In addition, the forces of globalisation have significantly affected trade in educational services. During the Eighth Malaysia Plan (2001–2005), the government faced significant challenges as a result of increasing globalisation and liberalisation, as well as the rapid development of technology, particularly ICT. In order to increase the supply of quality workers and to facilitate the development of a knowledge-based economy, the government continued to expand and reorient the Malaysian public higher education system. The agenda of constructing the national technical university system continued during this plan with the establishment of two other technical universities: *Kolej Universiti Kejuruteraan Utara Malaysia* in 2001 (later known as *Universiti Malaysia Perlis*) and *Kolej Universiti dan Kejuruteraan dan Teknologi Malaysia* in 2002 (later known as *Universiti Malaysia Pahang*).

Later, in 2007, these institutions were rebranded as technical universities rather than technical university colleges, as part of the government's attempt to correct the public perception that university colleges were not of the same standing as public universities (Kenedy & Zain, 2008). The Government of Malaysia also upgraded *Kolej Universiti Terengganu* to *Kolej Universiti Sains dan Teknologi Malaysia* in 2001 (later known as *Universiti Malaysia Terengganu*), which was established to provide academic and professional education in the disciplines of science, technology and natural resources management to fulfil the needs of the nation for a highly trained and skilled workforce.

The public higher education system underwent further expansion during the Eighth Malaysia Plan (2001–2005) specifically in 2004, when the ruling government received a strong mandate in the general elections. One important move was the establishment of a new ministry specifically for higher education (before 2004 public higher education institutions had been administered by the Department of Higher Education under the Ministry of Education) (Kaur et al., 2008). This move was to ensure the expansion and sustainability of public higher education in Malaysia. In addition, it was also designed to achieve the government's aim to promote Malaysia as an education hub.

During the Ninth Malaysia Plan (2006–2010), the government of Malaysia placed a greater emphasis on providing more access to higher education. To support the government's aim to achieve a knowledge-based economy, higher education has been identified as an avenue for creating a quality critical mass of trained, skilled and knowledgeable human capital. One new university (*Universiti Malaysia Kelantan*) was established in 2006, and two higher education institutes have been upgraded to full university status (*Kolej Agama Sultan Zainal Abbidin*, later known as *Universiti Sultan Zainal Abidin*, in 2006, and *Akademi Tentera Malaysia*, later known as *Universiti Pertahanan Nasional Malaysia*, in 2007). The establishment in 2006 of *Universiti Malaysia Kelantan*, focusing on entrepreneurship, agro-industry and heritage art, was raised during the tabling of the Ninth Malaysia Plan. At the same time, the move to upgrade Kolej *Agama Sultan Zainal Abbidin* to *Universiti Sultan Zainal Abidin* was mandated to give more accessibility to higher education in various fields, including Islamic contemporary studies, management and biotechnology. Similarly, the change to promote *Akademi Tentera Malaysia* to *Universiti Pertahanan Nasional Malaysia* was aimed to cater for the needs and development of modern armed forces in Malaysia.

In 2005, under the Ninth Malaysia Plan, the government also made an effort to restructure the public university system to increase the competency and credibility of these universities. Furthermore, it helped these universities to become more efficient, transparent and effective in fulfilling their functions and roles. Based on this new system, all public universities were assigned a specific role within a total system. Public universities are divided into three categories: research universities (which are all research-intensive and well-established institutions), focused universities (which concentrate on specific disciplines linked to the original objective of their establishment) and comprehensive universities (also called multi-disciplinary universities, which focus on a wide range of courses and fields of specialisation). At present there are 20 public universities, of which five are research universities, 11 are focused universities and four are comprehensive universities. This new system allows each university to pursue clear objectives and avoid duplication of effort (Azman et al., 2010).

In summary, it is clear that the Malaysian public higher education sector has become one of the important sectors in producing quality human capital, as well as becoming an important engine to drive Malaysia’s economy forward. In order to keep up with the domestic and international demand for human capital, which had shifted from a skilled and trained workforce to knowledge workers, the development of a public higher education sector was supported by several government policies. It is evident that the higher education sector in Malaysia had expanded tremendously, concurrently with economic globalisation. The next section of this chapter will identify and clarify higher education policies that have been designed and implemented in the public sector across the three phases. This section also acknowledges the role and contribution of the government in these policy responses.

## 2.4 Policies and Initiatives in the Malaysian Public Higher Education System

### 2.4.1 Corporatisation of Public Universities

During the 1990s, there was a significant global trend in restructuring education systems through cultural diffusion and institutional isomorphism (Lee, 2004). Since globalisation had affected the economy, politics, social matters and culture either directly or indirectly in Malaysia, the government had to react by incorporating higher education policies that met these global trends. Sirat and Kaur (2010) point out a central feature underlying the idea of the restructuring process in higher education as a redefinition of the relationship between the university, the state and the market, and a further reduction of university or institutional autonomy. In 1998, the Malaysian Government took a step to corporatise some public universities. *Universiti Malaya* was corporatised on 1 January 1998, followed by *Universiti Kebangasan Malaysia*, *Universiti Sains Malaysia*, *Universiti Putra Malaysia* and *Universiti Teknologi Malaysia* on 15 March 1998. According to Lee (2004), the corporatisation of these public universities is very much consistent with the worldwide trend of transforming universities into enterprises and establishing corporate culture and practices that allow these institutions to compete in the marketplace.

The main objective of a corporatisation policy in public universities is to make sure these institutions are independent and sustainable (Kaur & Manan, 2010), and is characterised by two features: 1) the implementation of a corporate management structure; and 2) the university as a business. With corporatisation, public universities would be administrated under a corporate management structure and corporate style of good governance, which, it was argued, would improve their efficiency and transparency (Sato, 2007). The vice chancellors of corporatised universities were given the role of chief executive officer, which gave them greater power in decision-making. In addition, the Malaysian university council,

which had previously had 16 members, was replaced with a board of directors comprising of eight members: the Chairperson, Vice Chancellor, a representative from the local community, two representatives from the government and three people from the private sector. Also, the number of senate members was reduced from 200 to 40 people. As a consequence, fewer people were involved in the decision-making process; thus it took less time to discuss administration matters.

At the same time, the corporatised universities were given a mandate to generate their own income. These institutions were authorised by the government to engage with business-related services, which took the form of, for example, entering into business ventures, raising endowments, setting up companies and acquiring and holding investments (Lee, 2002). In principle, these public universities gained more institutional autonomy; however, ownership of most of their existing assets as well as development funds for expensive capital projects were still with the government. In other words, these corporatised universities were still holding the heavy burden of a major portion of operating costs (Mok, 2010). Nevertheless, the idea was that these changes in management systems and the adoption of corporate-like approaches would result in increased administration efficiency and cost savings, as well as improving accountability, efficiency and productivity.

### 2.4.2 Quality Assurance in Public Higher Education

For the past several decades, quality assurance has become one of the main concerns for global stakeholders in the higher education sector. The government of Malaysia has acknowledged the significance of this issue, and points out the importance of their direct involvement in the construction of a quality regulatory framework. The government is also aware that better regulatory frameworks aligned with national policy objectives and contexts would help to monitor the quality of domestic and international students, whether such

monitoring is by local or international providers (Knight, 2010). Prior to 1996, all public higher education institutions were considered to be self-accrediting, with various bodies such as the National Higher Education Council, the Ministry of Education Committee on Higher Education, the Committee of Vice-Chancellors and the Committee of Deans responsible for overseeing quality. In contrast, no formal accreditation system existed for the private higher education institutions.

In 1996, under the *Lembaga Akreditasi Negara* Act a statutory body known as the National Accreditation Board (or LAN) was established to accredit certificate, diploma and degree programs provided by private higher education institutions. For public universities, in 2002 the MOE established a QAD to manage and coordinate the quality assurance system. Later, under the Malaysia Qualification Act 2007, both institutions were dissolved and their functions were taken over by the Malaysia Qualification Agency (MQA). This agency is responsible for observing and supervising quality assurance practices and accreditation of higher education for both the public and private sectors. The main objective of the establishment of MQA was to implement the MQF, which was designed as a point of reference and a guide for quality assurance in the Malaysian higher education sector. The MQF guarantees that the standard of all qualifications awarded by higher education providers are consistently based on a set of criteria that is used as a national benchmark, and which has been benchmarked against international standards.

By implementing this unified quality assurance framework into the practice of higher education institutions, Malaysian universities can review their performances as well as transform the local workforce into knowledgeable human capital and globally competitive workers. At the same time it also encourages the universities to produce people who can work efficiently in any global workplace.

### 2.4.3 The National Higher Education Strategic Plan

The idea of transforming the higher education sector into a regional hub for higher educational excellence has been outlined since the development of Vision 2020 in 1991. In 2020, the government hopes to achieve the policy target of having 60% of high-school students enrolled in public universities, and the other 40% admitted to private universities. In addition, it also hopes that young adults aged 19–24 would be enrolled into the higher education sector. The ninth Malaysia plan (2006–2010) had similar aims with respect to higher education and establishing a knowledge-based economy. These aims prompted the government to establish the foundation for a long-term development plan for the higher education sector.

To achieve this, the NHESP was established in August 2007 with the vision of transforming the Malaysian higher education sector into an international hub of excellence. The aims of this strategic plan are to produce quality human capital that can fulfil the government's aspirations to improve the nation's knowledge capability and level of innovation, as well as stimulating a first-class mentality. This plan was prepared based on several significant inputs specifically related to the higher education sector: the Report by the Committee to Study, Review and Make Recommendations Concerning the Development and Direction of Higher Education in Malaysia, 2005; the Document on Higher Education Transformation, 2007; and the report by the Economic Planning Unit and The World Bank on "Malaysia and the Knowledge Economy: Building a World Class System of Higher Education".

The input from the Committee to Study, Review and Make Recommendations Concerning the Development and Direction of Higher Education in Malaysia enabled the government to recognise and lay out a new direction in higher education to ensure that the nation remains competitive in the era of globalisation (Ahmad, Kaur & Sirat, 2007). Besides the

recommendations of this committee, the NHESP also received valuable input from Document on Higher Education Transformation (2007), which in particular provided strategic initiatives for the expansion of first-class human capital that is consistent with the needs of the Ninth Malaysia plan. In contrast, the report by the World Bank and Economic Planning unit revealed the current situation of the Malaysian higher education system, and clarified the issues and problems that the government needs to overcome in achieving a world-class university system.

NHESP is a long-term plan that has been divided into four different phases of implementation: laying the foundation (2007–2010), strengthening and enhancement (2011–2015), excellence (2016–2020) and glory and sustainability (Beyond 2020). This plan outlines seven major reformation objectives: widening access and increasing equity; improving the quality of teaching and learning; enhancing research and innovation; strengthening higher education institutions; intensifying internationalisation; enculturating lifelong learning; and reinforcing the Ministry of Higher Education's delivery system (Ministry of Higher Education, 2007).

By widening access and enhancing equity, the government hopes to minimise the imbalance among social classes, gender, age, ethnicity, region or physically capability. In terms of improving the quality of teaching and learning, the implementation of the NHESP aspires to ensure more effective and holistic learning experiences for all university students. In the move to ensure enhancement of research and innovation in the higher education sector, NHESP lays out several plans of action, including building a critical mass of researchers, increasing research and development (R&D) activity and improving efficiency in R&D governance as well as upgrading infrastructure, facilities and R&D equipment in universities. As well as enhancing research and innovation, the NHESP is also recommending the move to

enhance higher education institutions by promoting a culture of professionalism among academics, improving universities' infrastructure, generating revenue for public universities and consolidating universities' governance structure. For the goal of assimilating lifelong learning, NHESP aspires to instil a lifelong learning culture that can produce quality human capital. In response to the effect of globalisation, NHESP aims to reinforce internationalisation in the higher education sector to ensure Malaysia possesses a world-class university system and transforms into a regional hub for higher education.

Table 2.4 summarises the policies and initiatives in the Malaysian public higher education system.

**Table 2.4: Summary of Policies and Initiatives in the Malaysian Public Higher Education System (1996–2007)**

| Year | Action |
|---|---|
| 1996 | • Under the *Lembaga Akreditasi Negara* Act a statutory body known as the National Accreditation Board (LAN) was established to accredit certificate, diploma and degree programs provided by private higher education institutions. |
| 1998 | • A corporatisation policy was implemented in some public universities including:<br>1. *Universiti Malaya*<br>2. *Universiti Kebangsaan Malaysia*<br>3. *Universiti Sains Malaysia*<br>4. *Universiti Putra Malaysia*<br>5. *Universiti Teknologi Malaysia* |
| 2002 | • The Ministry of Education established the QAD to manage and coordinate the quality assurance system. |
| 2007 | • Under the Malaysia Qualification Act 2007, both LAN and QAD were dissolved, and their functions were taken over by the MQA, which was now responsible for observing and supervising quality assurance practices and accreditation of higher education for both the public and private sectors. |
| 2007 | • The NHESP was implemented, with seven strategic thrusts towards achieving excellence in education:<br>1. Widening of access and increasing equity;<br>2. Improving of the quality of teaching and learning;<br>3. Enhancing research and innovation;<br>4. Strengthening higher education institutions;<br>5. Intensifying internationalisation;<br>6. Enculturating lifelong learning; and<br>7. Reinforcing the Ministry of Higher Education's delivery system. |

## 2.5 Summary

This chapter has presented a general overview of the Malaysian economy using a number of economic indicators, with a focus on the higher education sector. Based on these economic

indicators, the Malaysian economy began at the time of independence (1957) as an economy dependent on agriculture and natural resources, and then rapidly changed in the last two decades of the 20th century from a low-income to a middle-income country. Nevertheless, the competitive advantages possessed by the Malaysian economy –primarily, low-cost manufacturing, unskilled human capital and low wages – are not assured. The same situation is faced by many other developing countries, like Thailand, the Philippines and Indonesia. Malaysia also faces growing competition from other countries with plentiful, low-cost human capital, such as India and China. In addition, the role of knowledge is becoming more significant in the global economy, with technologies becoming more complicated and economic growth being steered by knowledge-based industries. Thus, Malaysia has invested heavily in higher education, as this sector is able to produce a large pool of high quality, skilled human capital, and can develop a better research and development (R&D) system that will enable the generation of new knowledge and new technologies needed by industries.

The chapter also has provided an overview and evolution of the Malaysian public higher education system from its beginnings in 1962 until the present day. During the last three decades, Malaysian public higher education experienced several changes, both in organisational structure and policy, as a result of the shift in economic structure and the need for quality human capital competitive in the global knowledge-based economy. Today, the Malaysian public higher education system consists of 20 universities: five research universities (*Universiti Malaya*, *Universiti Sains Malaysia*, *Universiti Kebangsaan Malaysia*, *Universiti Putra Malaysia* and *Unversiti Teknologi Malaysia*), 11 focused universities (*Universiti Utara Malaysia*, *Universiti Pendidikan Sultan Idris*, *Universiti Malaysia Terengganu*, *Universiti Sains Islam*, *Universiti Tun Hussein Onn*, *Universiti Teknikal Melaka Malaysia*, *Universiti Malaysia Pahang* and *Universiti Malaysia Perlis*) and four

comprehensive universities (*Universiti Islam Antarbangsa Malaysia*, *Universiti Malaysia Sarawak*, *Universiti Malaysia Sabah* and *Universiti Teknologi MARA*).

In addition, this chapter has outlined several government initiatives and policies that have been designed and implemented in the public higher education sector across the two decades from 1990 to 2010. The chapter has also shown that the higher education policies designed and implemented by the government have significantly affected the structure of public higher education institutions, generating an improvement in this sector. Nevertheless, there has been no formal evaluation of the outcome of the higher education policy changes, particularly NHESP. A comprehensive study to examine the effectiveness of the changes in NHESP is critical at this stage to monitor the performance of this long-term plan. Thus, the measurement of productivity and efficiency in this sector, which this study is undertaking, is essential to ensure the outcomes of the NHESP. The following chapter provides an overview of the theoretical framework that supports the concept of productivity and efficiency, and the methods to measure them.

# Chapter Three

# Productivity and Efficiency: Concepts and Measurement in Higher Education Institutions

## 3.1 Introduction

Productivity and efficiency measurement are widely used to complement other commonly used management performance measurement approaches, including standard cost system, ratio analysis, profit and return on investment measures and best-practice analysis. Recently, researchers have been interested in the issue of productivity and efficiency in the service sector, as there has been tremendous growth in the service economy and greater recognition that service industries are particularly difficult to manage using more common and accessible management techniques (Sherman & Zhu, 2006). The purpose of this chapter is to review the concepts related to efficiency and productivity, and the measurement of efficiency and productivity growth, focusing more on higher education institutions.

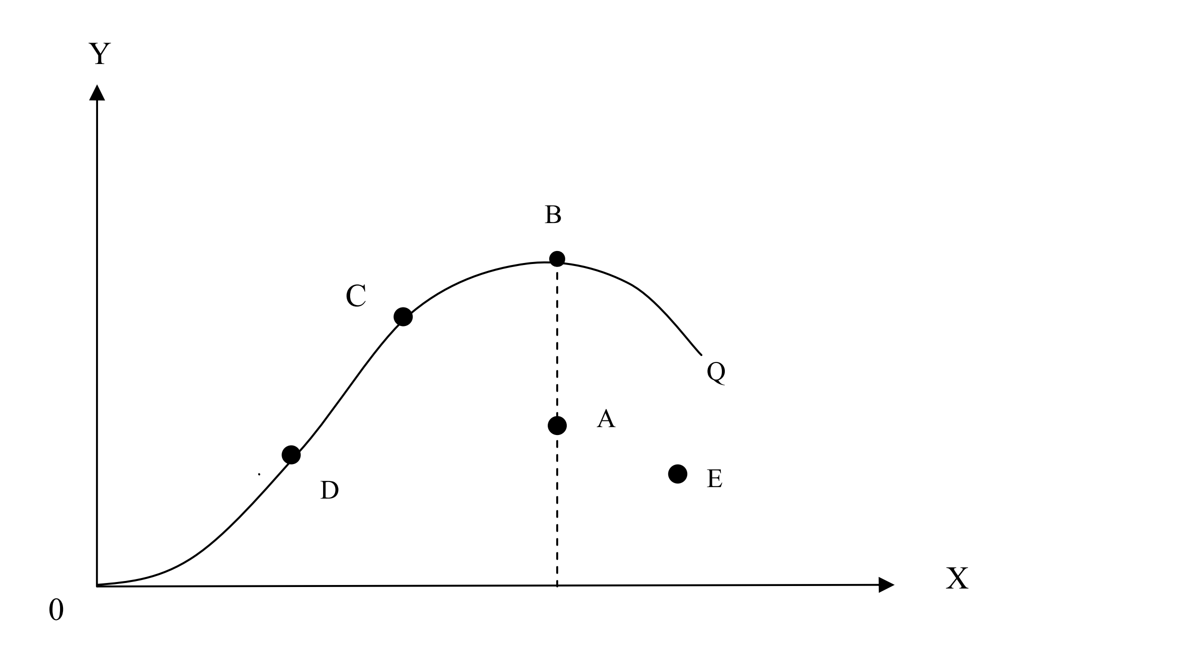
Section 3.2 provides an overview of several productivity concepts. Section 3.3 examines the methods that can be adopted in measuring productivity in the higher education sector, focusing more on parametric and non-parametric approaches. Section 3.4 provides a general review of DEA. An additional explanation of the methodology applied in this study will be presented in greater detail in Chapter 5. While DEA is used in this study, it is important to note that the selection of each model in empirical studies relies on the aims and types of questions being examined, and there is no general agreement on the ideal technique of how productivity should be measured. Finally, Section 3.5 summarises the chapter.

## 3.2 Productivity Concepts

Productivity is commonly defined as the relation between outputs and inputs, and can be regarded as a natural measure of performance (Coelli, Rao, O'Donnell and Battese, 2005). A firm can accomplish productivity increases by using either a minimum amount of input to produce a given level of output or by producing greater output from a given level of input. In this case, the productivity of a firm can be defined as the ratio of the output(s) produced to the input(s) used (Avkiran, 2001)

According to Sherman and Zhu (2006), the terms "efficiency" and "productivity" have been used interchangeably in many contexts. Coelli et al. (2005) demonstrate that these terms are not precisely the same thing. By using a simple production process, they illustrate that a single input produces a single output, as shown in Figure 3.1. The curve 0Q represents the production frontier, which specifies the maximum possible level of output that can be accomplished using inputs at maximum efficiency. Therefore, the production frontier portrays the recent state of technology in the industry under review (Coelli et al., 2005). In this figure, points A, B, C, D and E represent current levels of production of a particular DMU. The mixture of inputs and outputs on and below the production frontier are considered as the feasible production set of all feasible input-output combinations (Coelli et al., 2005). A firm with a mixture of inputs and outputs on the production frontier is classified as technically efficient. On the other hand, a firm with a mixture of inputs and outputs under the production frontier can be classified as technically inefficient. Firms B, C and D are technically efficient, while firms A and E are technically inefficient. In order to illustrate the distinction between efficiency and productivity, Coelli et al. (2005) use the graph in Figure 3.2.

**Figure 3.1: Production Frontier and Technical Efficiency**



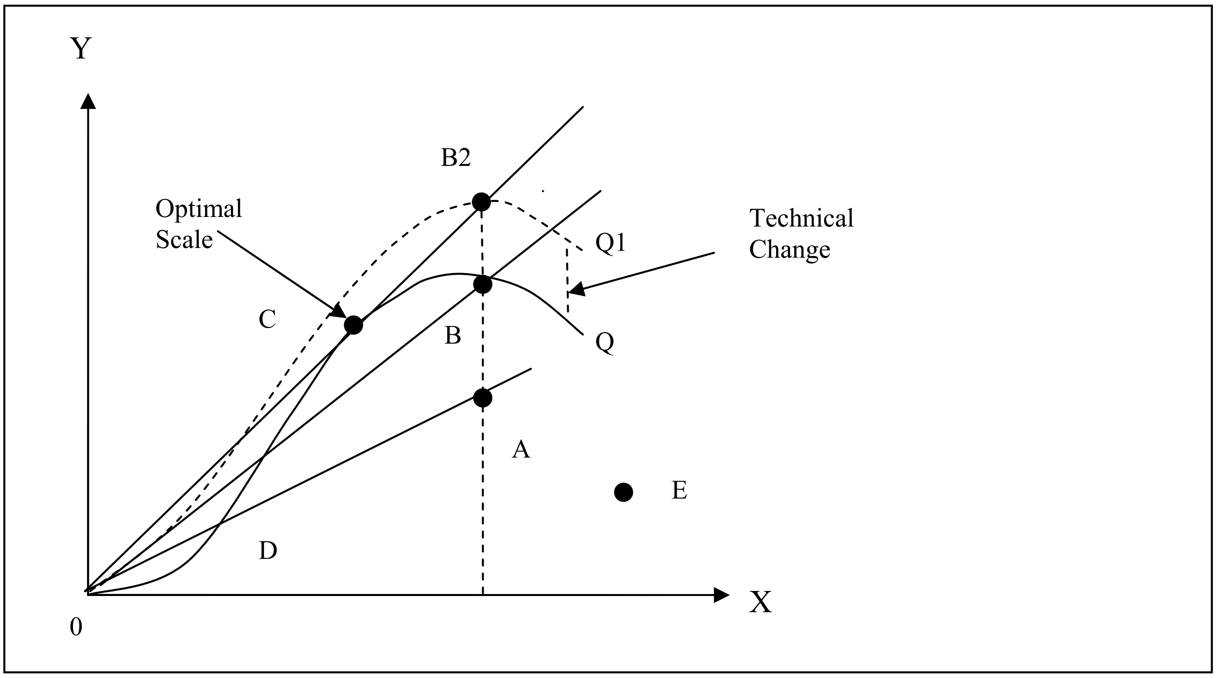

**Source**: Coelli et al. (2005, p.4), edited by the author.

The slope of the ray *n* from the origin to an individual data point can be applied to measure productivity, since productivity is defined as the ratio of outputs that the firm produces to the inputs it uses. For firm A to accomplish the technically efficient output level experienced by firm B, which has a ray of greater slope, Firm A has to obtain a better level of productivity. Even though firm B is operating as a technically efficient firm, it can still attain the same level of productivity experienced by firm C, which has the highest output-to-input ratio, and is classified as having an optimum scale of production. At point C, the ray is tangential to the production frontier; hence the slope is highest. Any firm that operates at a level other than point C on the production frontier, which is the point of maximum possible productivity, must have a lower productivity condition. Accordingly, any firm that wishes to maximise productivity and be identified as economically efficient needs to position itself at the point of optimal scale of production on the production frontier. Although all other firms on the production frontier are technically efficient, they are not allocatively efficient.[2]

[2] A firm`s capability to use the optimal mix of inputs to produce products or services.

As illustrated in Figure 3.2, only one firm (firm C) achieves an optimal scale condition. While firms B and D are identified as technically efficient, they are not efficient in their scale of production, and therefore those firms are not fully economically efficient. Thus, firms B and D need to search for improvement in allocative efficiency. For instance, firm B can achieve an economically efficient condition by moving to point C, either by reducing both input and output, or by moving to point B2 without increasing input. This action is identified as a RTS, or exploiting the scale efficiency in economics.

**Figure 3.2: Productivity, Technical Efficiency and Scale Economies**




**Source**: Coelli et al. (2005, p.5), edited by the author.

The firms have three different options by which to accomplish the optimal scale of operation. The first approach involves CRS, which exists when all inputs are increased by a certain percentage and output then increases by that same percentage. The second approach involves an IRTS, which exists if output rises proportionately more than the percentage increases in all inputs. The third approach to achieving an optimal scale of operation is a DRTS, which exists if output rises proportionately less than the percentage increase in all inputs (Banker, 1984).

The effect of the Returns to Scale relies on the firm's features, such as firm size, nature of the industry and overall economic environment (Avkiran, 2001).

Manipulations of the scale of production in a firm can frequently be hard to achieve in the short run, where all inputs may be different. In the long run, increases in both technical efficiency and technical change will result in productivity improvement. Technical change that stems from advancement in technology can be denoted by an upward shift in the production frontier. If there are issues such as cost or profits in the productivity of the firm, it is possible to consider allocative efficiency. Allocative efficiency reflects the capability of a firm to choose an input mix to produce an output mix at minimum cost (Sherman & Zhu, 2006). The combination of allocative efficiency and technical efficiency can provide a measure of total economic efficiency (Coelli, et al., 2005).

The productivity concept is closely linked with the issue of efficiency, and includes a number of efficiency components such as price, allocative, technical and scale efficiency (Sherman & Zhu, 2006). These components are based on an economic foundation for analysing a firm's overall productivity level, as every firm relies on all these components. In a competitive market, one of a firm's aims is to achieve enhancement in productivity and efficiency to in turn enhance the firm's performance. The measurement of the firm's efficiency and productivity provides vital information about its performance.

Measuring productivity is straightforward if only one single output is created with a single input SFP. However, if there are multiple outputs created by multiple inputs, productivity can be measured by using either partial factor productivity (PFP), defined as the ratio of output measured in specific units to the input of one factor expressed in specific units, or TFP or MFP, defined as the ratio of the total outputs of all products or services to the total resource

inputs used in an operation. TFP/MFP measures the overall input factors required to create the overall outputs. On the other hand, PFP estimates specific operational features such as return on assets, expenses as a percentage of total assets and total revenue per labour unit in the production process. To estimate the TFP/MFP, the index number method and productivity frontier analysis can be applied. The major methods used for measuring TFP/MFP are discussed in Section 3.3.

## 3.3 Production Frontier Analysis

Among the existing methods for measuring productivity and efficiency, there are a number of techniques employed in empirical studies, including production frontier analysis (PFA). Researchers have applied the PFA method using observed data to estimate firms' efficiency and productivity growth. To develop the production frontier, both parametric (econometric) and non-parametric (linear programming) methods can be applied (see Kumbhakar & Lovell, 2003; Murillo-Zamorano, 2004; Coelli et al., 2005; Fried, Lovel and Schmidt, 2008). The parametric or statistical approach assumes a particular form of production frontier, whereas the non-parametric approach makes no assumption regarding the distributions of inefficiencies or the functional form of the production frontiers (Johnes, 2006a).

De Borger, Kerstens and Costa (2002) recognised four benefits in applying PFA as an instrument in estimating productivity and efficiency. First, PFA allows one to distinguish between efficient and inefficient firms in a given industry. Second, PFA allows the measurement of inefficiency by taking into account the best-practice standard in the industry as a benchmark. Third, PFA allows the decomposition of productivity changes over time from changes in efficiency. Lastly, PFA allows the implementation of different production features such as scale and scope economy, compared to average-practice functions.

### 3.3.1 Parametric Method

In the parametric method, there are three common techniques that can be applied in measuring efficiency and productivity: SFA, the DFA and the TFA. SFA, which is a parametric approach, generally uses econometric techniques by specifying a stochastic production function that assumes that the error term is composed of two elements, one representing statistical noise (or randomness) and the other representing inefficiency (Worthington, 2001). DFA also specifies a functional form for the frontier; however, it separates the inefficiencies from the random error in different ways. There is no strong assumption regarding the specific distribution of inefficiency and random error in DFA. Unlike SFA, TFA assumes that production levels may deviate from the frontier because of measurement errors or factors beyond the control of the firm’s management, besides inefficiency (Wagenvoort & Schure, 2006). TFA specifies a functional form that deviates from the frontier, but it assumes the random error term as a deviation from predicted performance values within the highest and lowest performance quartiles of observation (Berger & Humphrey, 1997). TFA also assumes inefficiency terms as deviations in predicted performance between the highest and lowest quartiles of observation.

In general, parametric methods have the following features or assumptions:

- Parametric methods use a particular form for the production frontier; thus, the shape of the production frontier is pre-supposed (Bauer, 1990; Cokgezen, 2009).
- Parametric methods need to make assumptions about the functional form of the production frontier (Abbott & Doucouliagos, 2003).
- It is difficult to apply parametric methods when there are multiple inputs and multiple outputs (Johnes, 2006a).

- Parametric methods need to make assumptions about the specific distribution for the inefficiencies term (Worthington, 2001; Johnes, 2006a).
- The sample sizes play a significant role in the outcome of parametric methods. Estimated parametric methods may present wrong information in terms of errors of measurement and specification, if the sample is not big enough to offer a sufficient number of observations for measuring the variables to develop the production frontier (Cohn, Rhine and Santos, 1998).

### 3.3.2 Non-Parametric Approach

In non-parametric methods, DEA and FDH are the main methods for estimating efficiency and productivity. In contrast to the preceding parametric methods, non-parametric methods are not based on prior specific functional form, and avoid the need to make distributional assumptions. DEA is a linear programming model where the best-practice units are compared to other DMUs, with the simple restriction that all DMUs lie on or beneath the production frontier (Seiford & Thrall, 1990). Using the linear programming model, DEA is constructed as a frontier (or piecewise linear surface) that joins the set of best-practice DMUs, producing a convex feasible production set. FDH is an option specification of the DEA methods. It involves dropping the assumption of convexity of the production possibility set by excluding the point on the line connecting the DEA vertices.

In general, non-parametric approaches have the following features/assumptions:

- Non-parametric methods do not require explicit specification of a particular form of functional relationship for the inputs and output relations (Ahn & Seiford, 1993).
- Deviations from the production function are deterministic, and hence are a consequence solely of inefficiency (Worthington, 2001; Johnes, 2006a).

- No measurement error is involved in constructing a non-parametric frontier (Avkiran, 2001).
- Non-parametric methods are not sensitive to price information (McMillan & Datta, 1998).

A more detailed discussion of non-parametric methods is provided in Chapter 5.

### 3.3.3 Choice of Frontier Analysis Methods

Both parametric and non-parametric methods possess advantages as well as disadvantages. Nevertheless, non-parametric methods, specifically DEA, have been widely accepted in the higher education sector. Johnes (2006) identifies two advantages of DEA that make this method appropriate for measuring the efficiency and productivity of higher education institutions: there is an absence of input and output price, which are often unknown, and in addition higher education institutions produce multiple outputs from multiple inputs. In situations where government bodies operate in the higher education market, which is distorted by regulated prices, subsidies and lack of contestability, DEA is a favoured method in assessing the production frontier analysis (Abbott & Doucouliagos, 2003). More importantly, for a sector such as higher education, where the production process is mostly unknown, it is hard to specify the functional form and behavioural assumptions regarding the university under consideration using parametric methods (Avkiran, 2001). Thus, DEA methods are attractive in measuring the efficiency and productivity of this sector.

### 3.3.4 Data Envelopment Analysis

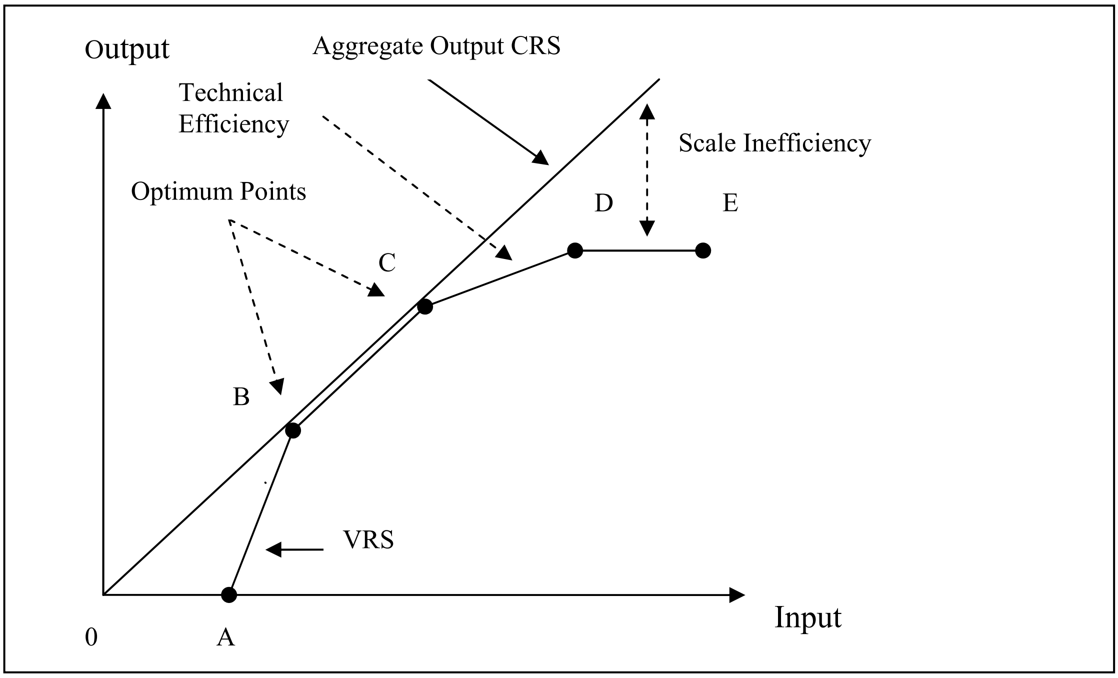
DEA is a performance measurement method that uses a mathematical programming form without a pre-defined functional form, and that can handle large numbers of variables (inputs and outputs) and constraints. DEA measures the comparative productivity of DMUs. It

envelops the observation data to identify the best-practice DMU's location, and then uses the frontier to estimate productivity index measures for each DMU. The DEA model was originally developed by Charnes, Cooper and Rhodes (1978), and is known as the CCR model. It identifies the efficiency for any DMU by maximising the ratio of weighted outputs to weighted inputs, subject to the condition that the comparable ratios for every DMU be less than or equal to unity. As a result, efficient DMUs are identified by having a ratio equal to one, and inefficient DMUs are identified by having a ratio less than one.

The most commonly applied DEA models in empirical studies are the CCR model and the Banker, Charnes and Cooper (BCC) model, developed in 1984. The BCC model was subsequently extended into the CCR model by including an additional convexity constraint. During the process of enveloping the observation data in the CCR model, the shape of the piece-wise surface is determined. Contrasting with the CCR model, the BCC model applies variables of the Returns to Scale condition (increasing, decreasing or constant to scale) in identifying the shape of piece-wise surfaces.

To illustrate the shape of piece-wise technology frontiers between the CCR and BCC models, Coelli et al. (2005) use a single input and output in Figure 3.3. In this graph, performances of six DMUs are denoted by the points A, B, C, D, E and F. In constructing the piece-wise technology frontier, the CCR model assumes that the scale of operation of the DMUs is at the optimal condition, known as CRS. The piece-wise technology frontier for the CCR model can be identified in the graph as the line extending from the origin through points B and C. On the other hand, the BCC model makes no assumption regarding the scale of operation, and proposes a convexity condition to the basic CCR model that can remedy all size-related problems. In Figure 3.3, the BCC model piece-wise technology frontier is denoted by the curve that joins points A, B, C, D and E.

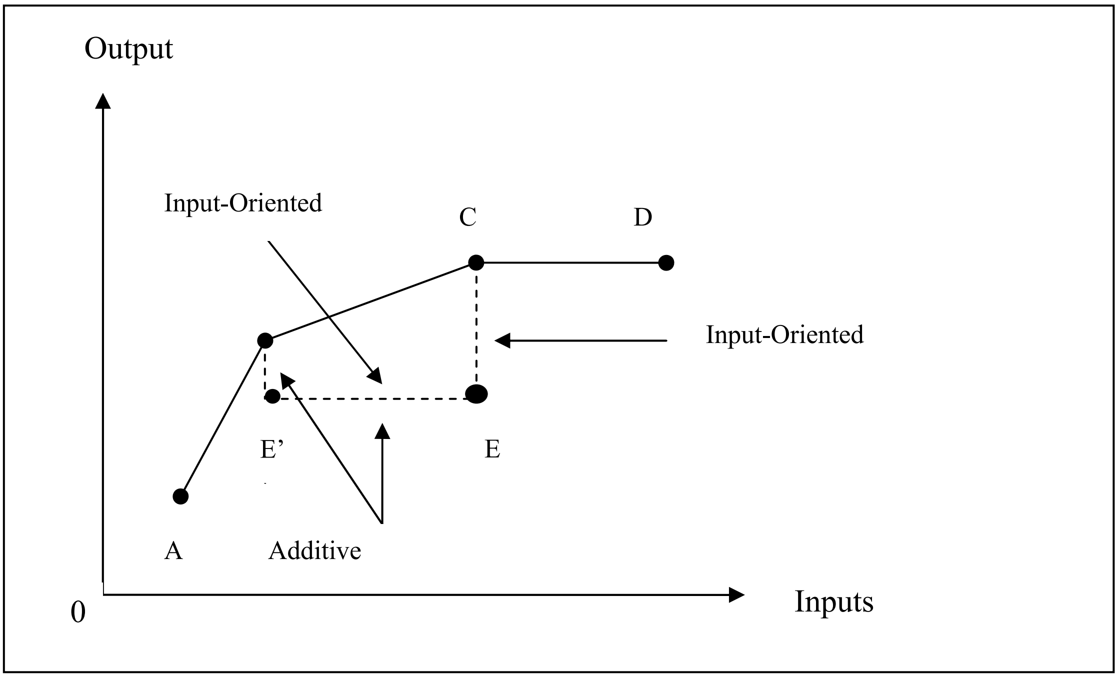
**Figure 3.3: Technical Efficiency and Scale Efficiency**




**Source**: Coelli et al. (2005, p. 174), edited by author.

The CCR model ignores the DMUs' scale of operation, where it assumes CRS conditions. The assumption of Returns to Scale in the operation of a firm may be due to certain circumstances such as constraints in finance, government regulations and imperfect competition (Coelli, et al., 2005). As a result, the CCR model enables a comparison in efficiency between a small firm and a larger firm. In contrast, the BCC model takes into consideration the firm's scale of operation in measuring its efficiency. The inclusion of the convexity condition makes it possible to determine whether the firm operated in the region of IRTS, DRTS or CRS. Thus, efficiency estimation in the CCR model refers to the technical efficiency, while in the BCC model it refers to pure technical efficiency, which considers both the scale and technical effects on the firms' performance. The distinguishing characteristic between the BCC and CCR models is that the estimated efficiency score is represented by scale efficiency.

**Figure 3.4: Projection for Inefficiencies of DMUs**




**Source**: Cooper et al. (2007, p. 105), edited by the author.

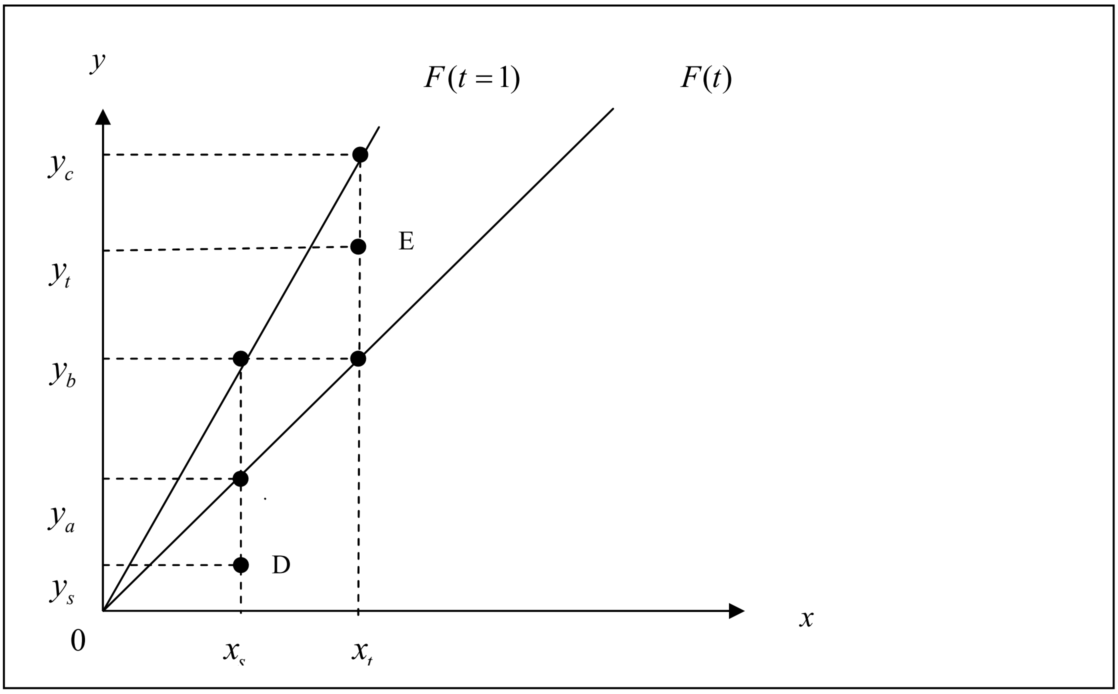
In measuring efficiency and productivity, DEA provides three different projections for the inefficient DMUs to the linear piece-wise technology surface: the input-oriented model, the output-oriented model and additive models (Figure 3.4). The input-oriented model aims to proportionately reduce the usage of the inputs while keeping at least the current level of outputs. In contrast, the output-oriented model aims to maximise the output level for a given level of inputs. The third choice, represented by the additive model, deals with the input excesses and output shortfalls simultaneously in a way that maximises both (Cooper, Seiford and Tone, 2007).

## 3.4 Productivity Growth

Productivity is an essential concept, and the measurement of productivity can be used to compare the performance of firms at given points of time (Coelli et al., 2005). Nevertheless, it is also essential for a firm to measure and compare the productivity performance between two time periods. To measure the productivity growth or change over time in a situation

where a firm uses multiple inputs and multiple outputs, TFP/MFP can be applied. Färe, Grosskopf, Norris and Zhongyang (1994) define productivity growth as the product of efficiency change and technical change. The movement of the firm towards the production frontier over time (catching up) is a representation of improvement that is derived from the efficiency change. The improvement of technical change can be detected through the shift of the production frontier upwards as more outputs are produced from the same level of inputs.

**Figure 3.5: Productivity Growth under CRS Assumption**

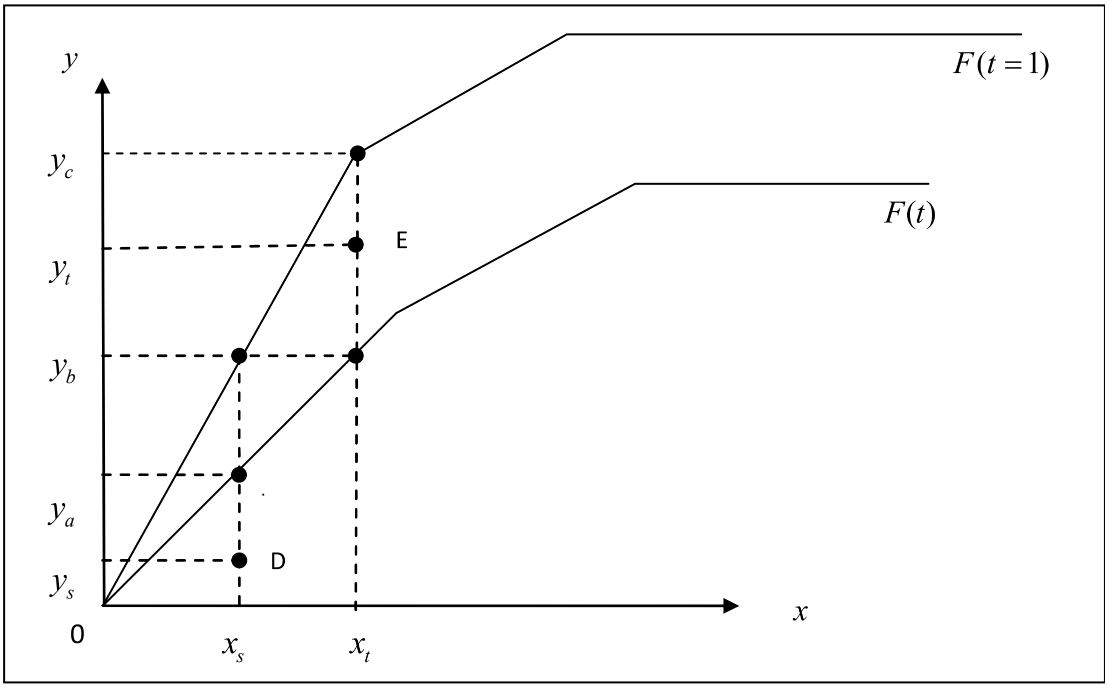



**Source**: Ray (2004, p. 290), edited by author.

To illustrate the framework of productivity growth, Ray (2004) portray a CRS technology that uses a single input and single output, as in Figure 3.5. In this diagram, the efficiency level of output (*y*) that can be generated from a given level of input (*x*) in time (*t*) is designated by the production frontier F(*t*), with the assumption that this frontier can shift over time. Similarly, the production frontier F(*t*+1) represents the RTS production frontier, indicating the efficiency level of output (*y*) that can be generated from a given level of input (*x*) in time (*t*+1). In period (*t*), the firm produces at point D, while in period (*t*+1) the firm produces at point E. Both firms can be classified as operating at an inefficient level that is

below the technology capability in both periods. A similar explanation can be provided in the case of VRS technology. However, the VRS frontier is more flexible and envelops data more tightly than the CRS. Because of the greater curvature of the VRS frontier, usually more firms have efficiency estimates equal to unity. Productivity changes under VRS will be described in more details in section 5.5. In this inefficiency condition, the relative movement of the firm over time will depend on either the firm's capability to catch up the frontier (efficiency change) or the frontier itself shifting up (technical change) over time.

**Figure 3.5: Productivity Growth**




**Source**: Ray (2004, p. 290), edited by author.

In the situation where a time dimension exists, it is possible using the Malmquist productivity index, as defined by Caves et al. (1982), to decompose this productivity growth into technical change and efficiency change. A more detailed discussion on the Malmquist productivity index is provided in Chapter 5.

## 3.5 Summary

This chapter has outlined an overview of the theoretical framework that supports the concept of productivity and efficiency, and the methods of productivity and efficiency measurement. First, this chapter has described a number of important concepts in productivity and efficiency, such as technical efficiency, allocative efficiency and scale efficiency. In the second part of this chapter described one of the widely adopted methods in measuring productivity and efficiency, the production frontier analysis. Based on this framework, which used observed data to construct a production frontier, the discussion continued with a review of two main approaches that use parametric and non-parametric methods. Next, the chapter presented the justification for the DEA applied in this study. This is based on several desirable properties, despite its inherent limitations, that make the DEA suitable for measuring higher education productivity and efficiency. Lastly, the chapter outlined the framework for measuring productivity change over time.

Within the process of measuring productivity and efficiency, although the same dataset is applied, each method will generate a different estimation. The fundamental assumption behind each method influences the result. The parametric method, for example, is based on a pre-specified functional form that makes an assumption regarding the shape of the piece-wise linear surface. In this case, the process of model specification is very important. If the process of specification is not performed properly, the result will be biased due to misspecification.

On the other hand, non-parametric approaches, specifically DEA, offer less structure in the piece-wise linear surface, with no assumptions regarding distributional issues. Although it has no statistical inference to measure error compared to parametric methods, it allows for the measurement of institutions that produce multiple outputs from multiple inputs. DEA is also suitable for a small sample size, as it enforces fewer constraints on the optimisation problem.

DEA is applied in this study based on several characteristics, explained earlier, that make the DEA the most favoured method in measuring productivity and efficiency in the higher education sector. A detailed discussion of the DEA model is presented in Chapter 5.

The next chapter reviews empirical studies of applications of DEA in the higher education sector.

# Chapter Four
# DEA and Malmquist Productivity Index: Non-Parametric Approaches to Efficiency and Productivity Measurement

## 4.1 Introduction

This chapter focuses on DEA, a tool for measuring service productivity and efficiency. DEA has been used to measure the efficiency and service productivity of different DMUs in the higher education sector such as universities, departments, research centres and programs of study, all of which convert multiple inputs into multiple outputs (Fu & Huang, 2009). It is important to pay particular attention to the methods used and variables selected, and to the generic and local factors that determine higher education institution efficiency and productivity. This chapter provides a detailed analysis of the literature to identify the gap in the existing literature on higher education institution service productivity and efficiency, and to formulate the aims and objectives of this thesis.

Section 4.2 reviews the studies that use DEA to measure the efficiency and productivity of the higher education sector. It also discusses several methodological issues in the application of DEA, including the issues of homogeneity of DMU, different specifications of DEA, limitations in the number of inputs and outputs, model specification, choice of inputs and outputs, the aspect of quality aspect in input and output variables and statistical inference for estimated efficiency. Section 4.3 reviews the studies that use DEA to measure productivity change in the higher education sector. Finally, Section 4.4 provides a brief summary.

## 4.2 Overview of Higher Education Institutions' Productivity and Efficiency Studies Using DEA

The use of DEA to assess the efficiency and productivity of DMUs in the services sector, specifically in the higher education sector, has been widespread since its development in 1978 (McMillan & Datta, 1998). Gattoufi, Oral and Reisman (2004) found 1,809 articles in refereed journals worldwide in addition to books, conference proceedings and various types of monographs related to DEA during the period 1951–2001. This indicates that DEA is influential and widely used as an approach to measuring the efficiency of DMUs. The ability to use DEA for measuring the efficiency and productivity of non-profit organisations, which produce multiple outputs from multiple inputs, encourages the application of DEA in studies on the higher education industry (Johnes, 2006a).

Cokgezen (2009) and Worthington (2001) performed two literature surveys on the applications of the DEA method in measuring efficiency and productivity in the higher education sector. These reviews indicated that only a few studies used DEA to focus on efficiency and productivity in developing countries. However, with the impact of globalisation and competitiveness in the higher education sector, it is important to understand and assess the overall performance of higher education institutions in developing, as well as developed, countries.

The literature falls into two broad streams: examinations of methodological issues and of empirical issues. Studies that discuss methodological issues have carefully examined developments in DEA as a tool of measuring efficiency in higher education institutions. These studies also explain developments in the application of DEA and overcome weaknesses in traditional DEA models in measuring efficiency and productivity. In contrast, the literature that reviews empirical issues has mostly addressed government policies and

managerial decision-making processes. The next section reviews methodological issues addressed in existing studies and the implications for measuring efficiency and productivity in higher education institutions.

### 4.2.1 Methodological Issues in the Application of DEA in Higher Education Institutions

#### 4.2.1.1 Homogeneity of DMU

The definition of a DMU is significant in applying the DEA method. Its definition in the higher education sector differs depending on the nature of the study. However, there are a number of significant studies on the higher education sector that have used departments, research centres and programs of studies as their DMUs. The rationale for this was to compare the characteristics of DMUs (Glass, McCallion, McKillop, Rasaratnam and Stringer, 2006). However, as most government policies and strategies have focused more on efficiency and productivity at the institutional level, the aim of this research is to examine whether DEA-based efficiency measurement scores can be used for both policy evaluation and funding assistance in Malaysia.

Another difficulty relating to the homogeneity in DMUs is where the sample consists of DMUs from various environmental backgrounds. The classification of this study's sample with similar characteristics will help resolve this problem. Subsequently, individual production frontiers can be developed for each category to estimate efficiency. Ahn, Charnes and Cooper (1988) illustrate a way of using sub-groups based on a common feature for developing piece-wise production frontiers by categorising universities according to whether they have medical schools. In addition, Ahn and Seiford (1993) suggest using sub-groups in the process of constructing production frontiers for each cluster by categorising universities as private or public. McMillan and Datta (1998), on the other hand, divide universities into

three categories: comprehensive with a medical school, comprehensive without a medical school and primarily undergraduate. Recently, Johnes (2006a) divided British universities into three groups on the basis of their historical background: pre-1992 universities, post-1992 universities and Standing Conference of Principal Ltd (SCOP) colleges. In the current study, the classification of Malaysian public universities is based on the categories used by the government of Malaysia during the implementation of the NHESP in 2007: research, focused and comprehensive universities (Ministry of Higher Education, 2007 p.90).

#### 4.2.1.2 Different Specifications of DEA

Different DEA models deal with dissimilar issues of productivity. These models have tried to overcome the constraint of the original DEA models (the Charnes et al. (1978) formulation, also called the Charnes, Cooper and Rhodes, or CCR, model). In higher education sectors the CCR model and the Banker, Charnes and Cooper (1984) formulation (also called the BCC model) have mainly been applied to estimateefficiency and productivity. Since the rigidity of the input environment in higher education limits the flexibility of decision-makers, most researchers have measured efficiency and productivity based on an output-oriented DEA model. Only a few studies have applied input-oriented models. Furthermore, the CCR model assumption is suitable only when all universities are operating at an optimal scale. If not, technical efficiencies will be confused with scale efficiencies (Glass et al., 2006). Nevertheless, this condition is not applicable in real-life situations. Hence, output-oriented models are more appropriate for assessing efficiency and productivity in the higher education sectors (Johnes, 2006b; McMillan & Chan, 2006).

Another important issue in DEA-based studies lies in the selection of a RTS setting. Ahn et al. (1988) established that the VRS model is the most suitable postulation in the higher education sector, as it depends on the mix of inputs and outputs at the point where the

analysis is affected. When the BCC model was compared with the econometric approach it was concluded that the efficiency score of the BCC model was more robust in terms of minimising misspecifications (Cooper et al., 2007). On the other hand, Avkiran (2001) argues that the CCR model allows comparisons between small and large universities. The CCR model has demonstrated that there is no relationship between scales of operation and efficiency. However, using the CCR and BCC models at the same time allows the researcher to decompose technical efficiency into pure technical efficiency and scale efficiency. Hence, most of the efficiency and productivity measurements of higher education apply to both the CCR and BCC models. The use of both models allows a decomposition of the efficiency calculation into overall technical efficiency, pure technical efficiency and scale efficiency.

#### 4.2.1.3 Number of Inputs and Outputs

In the DEA approach, the number of inputs and outputs is always constrained by the number of DMUs in the sample. The capability of DEA in differentiating between efficient and inefficient universities depends on a number of inputs and outputs included in the DEA model. For this reason, there is a need for the number of inputs and outputs to be smaller than the number of DMUs in the sample (Avkiran, 2001). As a guideline, Sinuany-Stern, Mehrez and Barboy (1994) proposed that the sum of the number of inputs and outputs must be no more than one-third of the sample. In addition, McMillan and Datta (1998) advise that it is wise to keep the number of variables less than one-third of the number of observations. However, the restriction on variables included may also produce understated relative efficiency assessments.

#### 4.2.1.4 Model Specification

Model specification is another essential issue in DEA. The absence of a formal test of significance in variable choices in the DEA model could lead to a difference between the DEA and the econometric approach. Many analysts have used sensitivity analysis to test the significances of input and output variables in DEA. In the process of testing the significance of inputs and outputs in the DEA model, Johnes and Johnes (1993) recommend that in any application of DEA it is crucial to test the sensitivity of the results to changes in input-output specifications. They also pointed out that the relative efficiency score achieved by a DMU could be sensitive to the number of specified inputs and outputs.

Sinuany-Stern et al. (1994) also tested the sensitivity of their model to changes of variables and concluded that variable disaggregation could cause an already efficient DMU to appear inefficient. Likewise, McMillan and Datta (1998) ran nine sets of different specification DEA models and concluded that the consequences of including additional or different variables can be significant to DEA analysis. More recently, Johnes (2006a) has used the test developed by Pastor, Ruiz and Sirvent (2002) for assessing the significance of nested models in DEA. Although the application of this test is rare in the higher education sector, it could give alternative options to overcome weaknesses in model specification in DEA application in a higher education scenario.

#### 4.1.2.5 Choice of Inputs and Outputs

One of the issues still to be resolved in DEA studies of the higher education sector is which inputs and outputs should be included in the DEA model specification (Ahn et al., 1988). A number of options are available for choosing input and output variables for DEA analysis in the higher education sector. In practice, analysts have selected different variables even when using identical approaches. A problem related to the input/output specification arises when

selecting the appropriate method of measurement. Two main measurement approaches to inputs and outputs could be incorporated in the DEA model: teaching measures and research measures (Johnes & Johnes, 1995; Emrouznejad & Thanassoulis, 2005). The majority of researchers in higher education have applied both these measures due to readily available information, which reflect the overall university production process that includes teaching, research and community services.

Input variables used in higher education efficiency and productivity at the institutional level can be divided into two categories: human input and physical-capital input (Ahn et al., 1988; Johnes, 1996). The human input refers to staff who help students to gain knowledge. The physical-capital input refers to a wide range of products used in the operation of the university, including land, building, plant, space and equipment. In the literature on efficiency and productivity, an important focus has been on what determines the most appropriate variables with reference to capital. Some analysts have incorporated a measure of capital input that includes land, building and equipment in their studies (Ahn et al., 1988; 1989). In contrast, Abbott and Doucouliagos (2003) have applied the value of non-current assets as a proxy for capital stock. Nevertheless, the measurement of current capital stock or its use during the period of study is not frequently used as an input factor because of the difficulty associated with obtaining suitable data (McMillan & Chan, 2006).

In the human-input category, it is accepted practice to include a variable that measures the value of teaching input. In some studies, the number of staff members, which is usually referred to as FTE staff, is the variable of choice for inputs. Some studies have divided staff into teaching and non-teaching components. Johnes and Johnes (1993; 1995) also examined the difference among different types of labour, although the total staff number was divided into teaching/research and research. As an alternative, Beasley (1990; 1995) used expenditure

on salaries as input measures. This is consistent with the argument of Ahn et al. (1988) that faculty rank and ability are well reflected by salaries.

In higher education efficiency and productivity studies, there are a number of researchers incorporate expenditure as one of their input measures. Ahn, Charnes and Cooper (1989) and Ahn and Seiford (1993) used overhead expenses as an input in their studies. However, McMillan and Datta (1998) combined various amounts encompassing general operating expenditure into a single value as one of the input measures, although this is uncommon. Meanwhile, Johnes (2006a) chose a different approach, dividing the expenditure into two categories – expenditure on administration and expenditure on library and computer facilities – as their input measures. Researchers generally regard expenditure costs as input variables to ensure continuity and the ability to produce a desirable output in higher education institutions.

For higher education institutions, there seems to be a general agreement that outputs in this sector are based on three sub-groups: 1) teaching, 2) research and 3) community services (see Ahn et al., 1988; Ahn et al., 1989; Ahn & Seiford, 1993; McMillan & Datta, 1998; Avkiran, 2001; McMillan & Chan, 2006). Although there is a broad consensus among analysts in the higher education sector regarding these output classifications, there are still issues that need to be resolved, such as data availability, measurement suitability and quality issues, that will reflect characteristics for each of these clusters in an operational manner.

Some studies have used number of FTE student enrolments as a teaching output variable. However, there are also studies that divide FTE student enrolments into undergraduate and postgraduate FTE enrolments and consider them as input variables. In contrast, there are studies that use the total number of degrees awarded or the graduation rate as a teaching

output variable. Madden and Savage (1997) argued that simply counting the number of student enrolments as the output factor can produce misleading output data, and that it is more appropriate to include the number of students who successfully graduated, as it is a simple way to incorporate quality in teaching outputs. Ahn and Seiford (1993) also argued that the number of degrees awarded is the result of the number student years, and is thus a more appropriate way to capture effectiveness of higher education institutions than the number of enrolments. Furthermore, McMillan and Datta (1998) believed that the measures of degrees awarded and level of completion neglect the education of those who attend but do not graduate, whereas this is captured by FTE enrolments. Consequently, the aggregation or separation of multiple variables may change the efficiency rating of the unit studies (Ahn & Seiford, 1993).

In the process of selecting a suitable proxy to reflect teaching output measures, different researchers use different factors. Sinuany-Stern et al. (1994), used student credit hours as their proxy, whereas Bessent, Bessent, Cooper and Thorogood (1983) and Abbott and Doucouliagos (2000) chose student contact hours. Nevertheless, there are advantages in both approaches in reflecting the teaching input effectively; these advantages are generally due to the obvious differences in courses undertaken by students. For example, there are differences in the total credit hours and contact hours of a science student compared to a humanities student who only focuses on lectures and tutorials. This clearly shows that there are weaknesses in the approaches of using student credit hours and contact hours as proxies for teaching input measures.

The process of identification and measurement of research output is more complicated compared to the two other main clusters of outputs in higher education institutions. In principle, research outputs should consist of the creation of new knowledge or the validation

and correction of existing knowledge (Ahn & Seiford, 1993). Nevertheless, it is not possible to acquire a totally acceptable and effective measurement of knowledge increase in the higher education sector. Thus, a variety of quantified mechanisms in research, such as published refereed articles, conference papers, discussion papers, research reports, patents, inventions, artworks, manuscripts and other research related works, have been used as the proxies. Furthermore, the dimension of quality – traditionally very difficult to measure – must also be incorporated into research-output measures.

Many analysts used external funding secured by the university (grants) as a proxy of research output measures, as there is a lack of reliable, satisfactory and easily accessible data on output measures in research. In view of the fact that a research grant reflects the recent market value of the research performed, Johnes and Johnes (1993) proposed that this funding can be included as a research-output proxy. However, there are a number of researchers who classify a research grant in the higher education sector as a measure of input (Ahn et al., 1988; Ahn & Seiford, 1993; Beasley, 1990). The confusion in classifying a research grant as either an input or output measure may generate double-counting in efficiency measurement. Furthermore, Johnes and Johnes (1993) underline that not all research grants are spent for the purpose of research. A portion of it is spent on research facilities, which should be classified as an input.

In Australia, research quantum, rather than research grants, has been used as a research-output proxy (Avkiran, 2001; Abbott & Doucouliagos, 2003). Research quantum is a government funding scheme to facilitate each university based on their performance in a composite research index. Abbott and Doucouliagos (2003) defended the use of research quantum as reflecting research output, asserting that although research quantum is not a perfect proxy, it is both adequate and, in Australia, more readily available. Nonetheless, a

different approach has been adopted in the UK. Athanassopoulos and Shale (1997) and Johnes and Johnes (1993), used research output data from the University Funding Council (UFC) to develop a weighted index for research output as proxy for research-output measures in universities. Its shortcoming is that it is based on a value judgement, which can cause bias in representing the official weight scheme.

Apart from research grants, research quantum and weighted index for research output, total publications have also been included as a popular research-output proxy in many higher education efficiency and productivity studies (for example, Tomkins & Green, 1988; Beasley, 1990, 1995; Johnes & Johnes, 1995; Sinuany-Stern et al., 1994; Sarafoglou & Haynes, 1996; Madden & Savage, 1997; Haksever & Muragishi, 1998; Ng & Li, 2000; Johnes & Yu, 2008; Worthington & Lee, 2008; Cokgezen, 2009). Some analysts have classified total publications as one output measure, while there are also a large number of analysts who have placed publications into different categories including core journal publications, working papers, books, edited books, book chapters, short works and refereed artworks. Using comprehensive bibliographic information, Johnes and Johnes (1995) presented a more detailed typology of publication, defining eight categories: papers in academic journals, letters in academic journals, articles in professional journals, articles in popular journals, authored books, edited books, published official reports and contributions to edited works. By contrast, Worthington and Lee (2008) and McMillan and Datta (1998) argued that this method is better suited to the analysis of university departments where publication venues are more homogenous. Furthermore, lengthy and variable lead times between acceptance of an article and its actual publication mean one cannot easily put together corresponding data for a particular year.

Community services in the higher education sector consist of a wide range of activities related to the provision of continuing-outreach types of education (Ahn et al., 1988; Ahn et

al., 1989). These activities consist of humanities programs, community aid, sports and other activities. It is not appropriate to put together such a mixture of activities into a single value for community service, as this does not account for the increasing numbers of categories that will represent community services in the higher education sector (Ahn et al., 1988). Furthermore, most studies on higher education efficiency and productivity cannot deal with this large number of categories in community services, and differences between institutions in community services have led to researchers excluding these services.

#### 4.2.1.6 Quality Aspects in Input and Output Variables

There is a difficulty in finding input variables that take into account quality dimensions in higher education efficiency and productivity. Athanassapoulos and Shale (1997) attempted to incorporate the quality dimension in their study by including the A-level scores of incoming students for UK universities as a separate input. Cokgezen (2009) used a weighting, derived from a percentile rank of candidates successful in qualifying to be considered for a placement in higher education, as a proxy for the quality of the student. These two approaches enabled the authors to use quality as one of the comparable inputs in the higher education efficiency and productivity study. Instead of dividing the quality and quantity of input into separate groups, Johnes (2006b) captured the dimension of quantity and quality in a composite input by considering the product of the number of undergraduates and the average A-level score of the undergraduate entrant. It is important to acknowledge the issue of the quality dimension in efficiency and productivity studies, as higher education institutions with high output can receive higher efficiency measures although the outputs produced are low in quality. Furthermore, there is a need for quality-adjusted data on teaching input to produce high quality outputs in universities (Abbott & Doucouliagos, 2003).

As in the case of input variables, it is also difficult to incorporate the quality dimension in output variables. By incorporating the quality aspect, the organisation can develop better productivity measures. Many researchers have tried to incorporate various quality variables in output measures in the higher education sector. Quality in this context refers to non-operational factors with an impact on the efficiency of higher education institutions. To incorporate research quality, McMillan and Datta (1998) used a measure of grant support base on the priority and availability of funding between the arts and science departments. By using this output measure, the value of the grant for acknowledgment to a superior scholarship can be determined. Cokgezen (2009) used a weighted method to classify articles published to incorporate quality in output measures of the research in higher education. Beasley (1990; 1995) and Post and Spronk (1999) have developed several prior formulated constraints regarding the input-output weight values, which are incorporated in order to take into account the dimension of quality in the output measures of the higher education sector. Nevertheless Post and Spronk (1999 pp.480) argue that "prior formulated constraints require a substantial amount of articulated preference information, involving unappealing and possibly redundant hypothetical choices and trade-off issues". Furthermore, they pointed out that the weighting process to these research output measures is based on a value judgement.

#### 4.2.1.7 Statistical Inference for Estimated Efficiency

One of the weaknesses in the basic DEA analysis is that there is no statistical verification for the significance of the estimated efficiency score. Most researchers use descriptive statistics to make assumptions about the efficiency score calculated. These descriptive statistics, however, are not sufficient to prove the confidence interval in the calculated efficiency score. In order to overcome this weakness, some analysts have applied a statistical approach such as the bootstrapping procedures developed by Simar and Wilson (1998). Although the

application of this statistical inference for an efficiency score is rare in studies of the higher education sector, Johnes (2006a) and Bradley, Johnes and Little (2010) applied this approach to generate a 95% confidence interval for the technical efficiency estimation of UK universities. Worthington and Lee (2008) also believed that this bootstrapping procedure may resolve the problem of statistical inferences for the estimated efficiency in the applications of DEA to the higher education sector.

### 4.2.2 Government Policy Issues in Application of DEA in Higher Education Institutions

There are many DEA studies on higher education institutions addressing government policy issues. The higher education sector receives particular attention regarding its expenditure because public education is funded by taxpayers' money, and therefore government policies are implemented to improve productivity in the sector to justify the expense. There is a need to evaluate these policies to assess their effectiveness, and DEA has proven to be a powerful tool in this process.

Since the early 1990s, the UK higher education sector has undergone several policy changes related to the university structure and funding mechanisms. Many previous studies have focused on these policy changes, which have related to both structure and funding (see Athanassapoulos & Shale, 1997; Flegg, Allen, Field and Thurlow, 2004; Johnes, 2006a; Glass et al., 2006; Johnes, 2008). Athanassapoulos and Shale (1997) applied DEA to examine the comparative efficiency of the UK higher education sector. Their preliminary comparison indicated that more effort is needed to channel research funding to institutions that are more efficient. They also stated that the use of DEA as a performance indicator can increase efficiency and enhance the quality of higher education institutions by using a selective funding research method. Flegg et al. (2004) examined the technical efficiency of 45 UK

universities over the period 1980/81–1992/93, when a major change in public funding was implemented. The results indicated that the enhanced efficiency of UK universities during the period of study was not solely caused by policy changes.

In 1992, the UK government implemented policy changes in relation to the structure of the UK higher education sector where it was divided into three broad groups based on historical backgrounds (Johnes, 2006a). Instead of using these three broad groups (Pre–1992 universities, post 1992 universities and Standing Conference of Principals Ltd (SCOP) universities) (Athanassapoulos and Shale, 1997), Johnes (2008) also included all SCOP types in her analysis. No significant difference was found between the different types of higher education institutions in terms of efficiency of output production. The result showed there were no significant differences across the sub-groups relating to the structural change in government policy.

Since the late 1980s, the Australian government has aimed to increase efficiency and productivity in its higher education sector. Many studies have focused on policy changes relating to the consolidation of higher education institutions into a smaller number of large universities, and the introduction of competitive allocation for research funding (see Madden & Savage, 1997; Abbott & Doucouliagos, 2003; Worthington & Lee, 2008). Madden and Savage (1997) compared the initial and subsequent performance of economic departments during the implementation of these policy changes, finding that the overall performance of universities improved significantly. Nevertheless, new universities require productivity improvement to become more efficient. Similarly, Abbott and Doucouliagos (2003) estimated the technical and scale efficiency of 35 Australian universities and found that the same government policy changes led to high overall technical efficiency in the Australian university system during the period of study. To examine the impact of policy changes in

Australia, Worthington and Lee (2008) applied DEA and found that among the 35 universities investigated over the period 1998–2003, small, new universities had greater productivity improvement compared to larger, older universities. These studies demonstrate that DEA enables policy makers and university executives to distribute limited resources and improve productivity in higher education institutions.

Studies in other countries have also focused on the success of policy changes related to education reform. As previously mentioned, the main objective of policy changes in education reform is to improve the efficiency and productivity of higher education. Most previous studies have concluded that there are some improvements in efficiency and productivity following education reform. Ng and Li (2000) indicated that in the mid-1980s, China experienced large-scale education reform to fulfil the great demand for skilled workers and more educated individuals. They examined the effectiveness of these policy changes and applying DEA, and concluded that the performances of higher education institutions in terms of research output improved. In Italy, Agasisti and Bianco (2009) analysed the effect of teaching reforms introduced in 1999, also known as the Bologna Process, which changed the entire organisation of university courses. The DEA score showed that overall efficiency improved from 1998/1999 to 2003/2004, although this reform had led to worsened conditions in the first year before showing improvement in productivity.

Agasisti and Johnes (2009) applied DEA to compare the technical efficiency of Italian and European higher education institutions to determine the effect of teaching reform. They found that Italian universities, compared to other European higher education institutions, were relatively low in efficiency. Nevertheless, there was a positive improvement over the period of study. This clearly shows that DEA is a tool that can help in making decisions regarding

the efficiency and productivity of higher education institutions with respect to the implementation of education reform.

**Table 4.1: Summary of Findings from Previous Studies: Application of DEA**

| Author | Country | Years | Approach | Sample | Main Conclusions |
|---|---|---|---|---|---|
| Ahn et al. (1988) | US | 1984–1985 | DEA | 161 US public and private doctoral-granting institutions | There are significant differences in the characterisations of efficiency and inefficiency between universities with medical schools and those without. |
| Ahn et al.(1989) | US | 1981–1985 | DEA | 37 public senior college and universities in Texas | DEA offers promise as a tool for evaluating the efficiency of educational performance in institutions of higher learning. |
| Ahn & Seiford (1993) | US | 1985–1986 | DEA | 153 US public and private doctoral-granting institutions | Public universities in United States are more efficient than private universities; closely monitored output variables are used for evaluation. |
| Breu & Raab (1994) | US | 1992 | DEA | 25 "best" US News and World Report-ranked universities | The "best of the best universities" do expend resources to enhance reputation and prestige, but such efforts do not necessarily result in higher student satisfaction. |
| Abel & Raghu (2002) | US | 2002 | DEA | 42 academic units housed in the seven colleges of Xavier University | 50% of the departments in the university have an efficiency rating of 1. |
| Bessent et al. (1983) | US | 1980–1981 | DEA | The occupational technical education program in San Antonio College in the US | DEA provides the decision-maker with a new way of evaluating a proposal for a change in an existing program by revealing the extent to which the change can increase or decrease that program's efficiency relative to other operating units. |
| Haksever & Muragishi (1998) | US | 1979–1983 | DEA | The top 20 MBA programmes in the US | The most efficient MBA programme is not necessary the best choice for everyone. |
| Colbert, Levary & Shaner (2000). | US | 1997 | DEA | 24 MBA programs from Business Week's top 25 programs in the US | The reduction in the number of output or input variables used caused efficiency scores to decrease or remain the same. |
| Tomkins & Green (1988) | UK | 1985–1986 | DEA | 21 identifiable department of accounting in the UK | DEA, if carefully and sensitively used, can offer additional insight on performances not available from other methods of assessment. |
| Beasley (1990) | UK | 1986–1987 | DEA | All chemistry and physics departments in the UK | The DEA model is quite flexible and can be used to reflect any view policy makers might take as to the relative importance of departmental input/output measures. |

**Table 4.1: Summary of Findings from Previous Studies: Application of DEA**

| Author | Country | Years | Approach | Sample | Main Conclusions |
|---|---|---|---|---|---|
| Beasley (1995) | UK | 1986–1987 | DEA | All chemistry and physics departments in the UK | Study establishes a model, based upon DEA, for jointly determining teaching and research efficiency for university departments. |
| Johnes & Johnes (1993) | UK | 1984–1988 | DEA | 36 departments of economics in the UK | DEA lacks a conventional test for identifying the most satisfactory model for assessing the research performance of UK departments of economics. |
| Johnes & Johnes (1995) | UK | 1989 | DEA | 36 departments of economics in the UK | The successful execution of a DEA requires appropriate and consistent data. The data also need to be available at the desired level of analysis in the construction of sensible performance indicators for the efficient operation of higher education systems. |
| Post & Spronk (1999) | UK | 1986–1987 | DEA and IMGP | 50 physics departments of UK universities. | IDEA selects performance benchmarks from the DEA production possibility set and retains some of the strengths of the conventional DEA methodology. |
| Athanassapoulos & Shale (1997) | UK | 1992–1993 | DEA | 45 universities in the UK | Six universities were identified as a possible source of best operating practice in terms of both cost and outcome efficiency. DEA and its value-judgement extension were used to enhance the insights offered by the analysis of the performance of higher education. |
| Emrouznejad & Thanassoulis (2005) | UK | 1994–1998 | DEA | 15 UK universities | The dynamic model tries to overcome the problem of inter-temporal input output dependence manage to capture the efficiency better than the static model. |
| Johnes (2006a) | UK | 2000 /2001 | DEA | 100 higher education institutions in England | The level of efficiency in England is high and consistent with other studies of efficiency in the higher education sector. |
| Glass et al. (2006) | UK | 1996 | DEA | 98 non-specialist UK universities | The policy evaluations of efficiency and RTS, in UK higher education, are evidently very different depending on the orientation and measures chosen in DEA-based efficiency modelling. |
| Madden & Savage (1997). | Australia | 1987–1991 | DEA | 29 economics departments at Australian universities | The 24 economics departments in the sample achieved an input efficiency score of unity in 1987, while only 11 were input efficient by 1991. |
| Avkiran (2001) | Australia | 1995 | DEA | 36 Australian universities | The Australia universities are already operating at respectable |

**Table 4.1: Summary of Findings from Previous Studies: Application of DEA**

| Author | Country | Years | Approach | Sample | Main Conclusions |
|---|---|---|---|---|---|
| | | | | based on 1995 data collected from DEETYA | levels of technical and scale efficiency. |
| Abbott & Doucouliagos (2003) | Australia | 1995 | DEA | 36 Australian universities based on 1995 data collected from DEETYA | Overall the level of technical efficiency in Australian universities appears to be high. However, it cannot be concluded that there is no scope for improvement in efficiency. |
| Sinuany-Stern et al. (1994) | Israel | 1988 | DEA | 21 departments in Ben-Gurion University in Israel | Deleting variables and combining variables can change the DEA result drastically. |
| Sarafoglou & Haynes (1996) | Sweden | 1983–1988 | DEA | Departments of business and economics from seven universities in Sweden | It is clear that DEA has some drawbacks as a method of research evaluation. |
| Arcelus & Coleman (1997) | Canada | 1996 | DEA | 32 academic departments of the University of New Brunswick, Canada | Half the departments in the University of New Brunswick exhibit some degree of inefficiency. |
| McMillan & Datta (1998) | Canada | 1992–1993 | DEA | 45 Canadian universities. | The relative efficiencies are quite consistent across the nine different specifications of inputs and outputs, and the overall efficiency scores are relatively high. |
| McMillan & Chan (2006) | Canada | 1992–1993 | DEA, SFA | 45 Canadian universities | Comparison of efficiency outcomes from parallel DEA and SFA models against one another revealed considerable variation. |
| Hanke & Leopoldseder (1998) | Austria | 1993 /1994 | DEA | 11 Austrian universities | Those universities that are most frequently publicly accused of working inefficiently are efficient. |
| Warning (2004) | Germany | 1998 | DEA | 73 publicly funded universities in Germany | Universities differ in their strategic orientation, as indicated by differences in efficiency. |
| Martin (2006) | Spain | 1999 | DEA | 52 departments in the University of Zaragoza. | Ensuring efficient management of resources has become essential for improving the competitiveness of the university so they can provide a quality services. |
| Korhonen, Tainio & Wellenius (2001) | Finland | 1996 | DEA | 18 research units at the Helsinki School of Economics | One cannot use a BCC model to determine the most preferred solution and then use the CCR model for value efficiency analysis. |

**Source:** As described above.

## 4.3 Productivity Change in Higher Education Institutions

The following section will review existing studies that address the issues of productivity change in the higher education sector. It is important to note that DEA can only present productivity and efficiency measurement of institutions compared to the best-practice institutions in the study sample. Hence, it is also important to find productivity changes between the two periods of time. Thus, the subsequent stage in measuring productivity and efficiency is to identify whether the performance of an individual university or the higher education sector as a whole has improved or deteriorated over time.

Thus, one way to assess the performance of a higher education institution is by looking at the productivity change over time. Productivity growth is a condition in which "the amount of output growth exceeds the input growth in a particular time" (Carrington et al., 2005, p. 160). The Malmquist index has been employed as an indicator for assessing productivity growth in several studies in the higher education sector (see Flegg et al., 2004; Carrinton, Coelli and Rao,, 2005; Bradley et al., 2010; Castano & Cabanda, 2007; Fernando & Cabanda, 2007; Worthington & Lee, 2008; Agasisti & Bianco, 2009).

Flegg et al. (2004) employed a panel dataset from 45 British universities to assess total factor of productivity in this sector between 1980/81 and 1992/93. Over the period, they estimated the increment of total productivity to be 51.5%. An outward movement of frontier caused impressive productivity growth in efficiency piece-wise rather than by improvement in technical efficiency. This impressive rise in TFP was derived from the impact of financial and managerial reform in the British higher education sector during 1980.

Due to the absence of studies relating to the performance of the further-education sector in the UK, Bradley et al. (2010) investigated the level of efficiency and change in productivity

over the period 1999–2003, using more than 500 further-education providers. The results revealed that productivity growth for the entire period had increased almost 17%, of which 10% was due to technology change and 7% to technical efficiency. Nevertheless, productivity growth across all types of providers indicated that there is a wide variation among providers, which may be due to the problem of categorising different types of providers in academic and vocational education.

Over the period of 1996/97 to 2004/05, Johnes (2008) used DEA to derive a Malmquist index and examine the efficiency and productivity of 112 United Kingdom higher education institutions. The results indicated that yearly average productivity growth for the entire period was around 1% but varied widely between institutions, and was mainly due to technology changes rather than technical efficiency changes. This result is consistent with other previous studies (Flegg et al., 2004; Worthington & Lee, 2008).

In Australia, Carrington et al. (2005) investigated the productivity growth, technical efficiency and scale efficiency of 35 universities between 1996 and 2000. They found that university productivity growth was 1.8% per year, which caused an average frontier movement of 2.1% per year, an average technical efficiency decline of 0.7% per year and an average scale efficiency improvement of 0.4% per year. Although the results revealed that there was positive productivity growth, these findings only reflect an average, as productivity growth in each university differs.

For the period 1998–2003, Worthington and Lee (2008) examined productivity change over time in 35 Australian universities. The results indicated that the annual average productivity change over time is approximately 3.3% for all the universities in Australia, with productivity

growth for individual universities ranging from -0.18% to 13%. The average productivity growth in this research was predominantly due to technological changes.

Fernando and Cabanda (2007) used DEA and the Malmquist productivity index to calculate productivity growth at 13 colleges in the University Of Santo Tomas Philippines, between 1998 and 2003. The results revealed that productivity growth in 12 out of 13 colleges was due to technical efficiency. In contrast, only one college demonstrated productivity growth due to technological change, which was potentially derived from the implementation of a computerised teaching approach. Using samples of 30 private higher educational institutions over the period 1999–2003, Castano and Cabanda, (2007) applied DEA and Malmquist indices to investigate whether technical inefficiency in private higher education institutions in the Philippines is systematically related to age, ownership and gender. The result disclosed that while efficiency in private higher education institutions was deteriorating, they showed technological progress over that time, which led to positive productivity growth. The study inferred that technical inefficiency in private higher education institutions in the Philippines was systematically related to age and ownership, but not to gender.

A recent study by Agasisti and Johnes (2009) investigating productivity growth in higher education in Italy used data 2000 to 2003 for measuring productivity growth in 74 Italian higher education institutions. The study found that annual average productivity growth was approximately 1.17% per annum during the whole period of study. This is consistent with previous studies (Flegg et al., 2004; Johnes, 2008; Worthington & Lee, 2008) that indicated the major reason for productivity growth in higher education institutions is technological changes rather than technical efficiency changes. Although average productivity growth was higher in Italy throughout the entire period, in 2002–2003 average productivity growth deteriorated due to education reform and poor technology, which needed to be modernised.

Existing literature shows that the Malmquist productivity index has been used in higher education efficiency and productivity studies to decompose various components of estimated efficiency. This has permitted the concurrent analysis of changes in total productivity, which can potentially have a catching-up effect or frontier movement. Generally, the major consequence for productivity growth in higher education institutions is changes in technology, rather than in technical efficiency. Thus, it is the objective of this research to analyse whether productivity changes in Malaysian higher education institutions are derived from technological changes or technical efficiency changes.

**Table 4.2: Summary of Findings from Previous Studies: Application of Malmquist Productivity Index**

| Author | Country | Years | Approach | Sample | Main Conclusions |
|---|---|---|---|---|---|
| Agasisti & Johnes (2009) | Italy | 1998/1999 – 2003/2004 | DEA and Malmquist index | 74 Italian universities | The analysis of Malmquist indices demonstrate that in the years following the reform, the level of teaching efficiency grew in Italy. |
| Johnes (2008) | UK | 1996/7 – 2004/5 | DEA and Malmquist index | 112 English higher education institutions | Malmquist productivity index rose by an annual average of 1% relative to the base year 1996/7, due to a combination of positive annual average technology change and negative annual average technical efficiency change; the finding of negative technical efficiency change is new. |
| Worthington & Lee (2008) | Australia | 1998–2003 | DEA and Malmquist index | 35 Australian universities | The largest productivity growth improvement has been found in smaller, older universities. |
| Flegg & Allen (2007) | UK | 1994/5–2003/4 | DEA and Malmquist index | 45 older UK universities | The evidence on whether expansion causes congestion is rather mixed. Certainly, congestion was present throughout the decade under review, and in a wide range of universities, but whether it increased or decreased depends on which model one looks at. |
| Flegg et al. (2004) | UK | 1980/1–1992/3 | DEA and Malmquist index | 45 British universities | The typical university was getting closer to the best practice exemplified by frontier universities. |
| Carrington et al.(2005) | Australia | 1996–2000 | DEA and Malmquist index | 35 Australian universities | The university sector was relatively efficient, and the productivity growth was superior to most other sectors of the economy for the period 1996–2000. |

**Table 4.2: Summary of Findings from Previous Studies: Application of Malmquist Productivity Index**

| Author | Country | Years | Approach | Sample | Main Conclusions |
|---|---|---|---|---|---|
| Fernando & Cabanda (2007) | Philippines | 1998–2003 | DEA and Malmquist index | 13 colleges at the University of Santo Tomas, Philippines | The Santo Thomas colleges are operating at a fairly high level of efficiency relative to other colleges, although there is still room for improvement within the university. |
| Castano & Cabanda, (2007) | Philippines | 1998–2003 | DEA, Malmquist index and SFA | 30 private higher education institution in Philippines | The private HEIs had declining efficiency but showed technological progress over the period that led to positive productivity growth. |
| Bradley et al. (2010) | UK | 1999–2003 | DEA and Malmquist index | 500 UK further-education providers | Productivity change over the period was around 12%: , 8% technology change and 4% technical efficiency change. |

**Source:** Author's review of the literature.

## 4.4 Summary

This section summarises previous studies that have applied DEA and empirical and methodological issues relating to DEA in the higher education sector. Several important issues have been discussed to acknowledge the existing research gap that may be filled by this research.

Overall, the application of DEA in the higher education sector in developed countries is quite substantial, but not in developing countries. More studies are required, particularly on increasing the efficiency and productivity of the higher education sector to enable the implementation of government policies and strategies. This implementation would generate a sector that is competitive and able to produce quality graduates and universities that comply with international standards (as aspired to by the Malaysian government). Therefore, it is crucial to research a specific country.

Although previous researchers have indicated the importance of DEA in analysing efficiency and productivity in the higher education sector, several issues still need to be addressed: the

different specifications in DEA, selection of the DEA model, number of inputs and outputs, input output specifications, definition of input and output and input and output measurement and quality issues. In general, the quality issue has not been given enough attention due to the difficulty in measuring this dimension.

The current statistical techniques are considered able to overcome the existing constraints in the traditional DEA model. The ability of the bootstrapping procedure in verifying the significance of efficiency scores can improve calculations of the reliability estimated efficiency and thus produce a robust, reliable and consistent model. A few empirical studies have applied DEA in assessing efficiency and productivity of the higher education sector after education reform. DEA applications and the Malmquist index show clear improvements after the transformation of this sector. As there are different approaches between countries, it is difficult to determine the outcome of the education reform undertaken; hence there is a need to perform this research for the Malaysian higher education sector.

Most studies have focused on the impact of education reforms, and only limited research has focused on the factors that caused the deterioration/improvement of the higher education sector after reforms were initiated. The shifting of international competitiveness and structural change in the higher education sector may be one such factor. Thus, the objective of this research is to analyse the efficiency and productivity of the higher education sector due to the implementation of the NHESP, which was introduced in 2007, and to uncover the factors that have contributed to the failure/success of the implementation.

# Chapter Five
# Methodology

## 5.1 Introduction

The common methods of measuring performance in higher education institutions often take the form of ratios such as return on capital employed, return on total assets and market to book value ratio; but such measures do not adequately describe differences in institutional environments and cannot capture the complete performance of an institution across the breadth of its activities (Johnes, 2004). As a result, a number of techniques have been developed and applied in the context of higher education, in an effort to construct a true measurement of institutions' performance. For instance, statistical (parametric) techniques have been developed based on OLS regression to SFA, while non-statistical techniques (non-parametric) have been advanced from simple ratios to composite ratios derived from linear programming methods. Nevertheless, there is no general agreement in the literature regarding the preferred technique of analysis, since both types of techniques have some well-recognised advantages and drawbacks: in parametric techniques the functional form of the efficient frontier is pre-specified, whereas in non-parametric techniques no functional form is predefined, but is calculated from a sample of observations in an empirical way. Generally, the non-parametric techniques possess a more flexible structure on the frontier function, although they have the disadvantage of assuming no random errors.

This study uses a four-year panel dataset (2006–2009) for analysing the performance of 17 Malaysian public universities. This study considers all public universities operating in the sector, with the exception of three (*Universiti Malaysia Kelantan*, *Universiti Pertahanan Nasional Malaysia* and *Universiti Sultan Zainal Abidin*) due to the unavailability of data. All

17 universities are categorised into three main sub-groups: 1) research universities[3]; 2) comprehensive universities[4]; and 3) focused universities[5]. The input and output data were manually extracted from Malaysia's Ministry of Higher Education (2009) and Elsevier's Scopus database.

Non-parametric DEA models are employed to estimate efficiency and productivity changes in Malaysian public higher education institutions. The most significant advantage of the DEA approach pertains to its ability to handle cases with a small sample size, as in this study. As there are only 17 universities in the study's sample, parametric (econometric) techniques were not deemed appropriate. Several studies have possessed small sample sizes (e.g. Tomkins & Green, 1988; Sinuany-Stern et al., 1994; Sarafoglou & Haynes, 1996; Hanke & Leopoldseder, 1998; Haksever & Muragishi, 1998; Korhonen et al., 2001; Emrouznejad & Thanassoulis, 2005). The second advantage of DEA relates to the fact that there is no need to define a production function in the analysis. Since no functional forms are specified, DEA avoids the problems of misspecifications in both the production function and the distribution of inefficiencies. Third, DEA can also be applied in the higher education production function where multiple outputs are usually produced from multiple inputs. Finally DEA allows each DMU under analysis to select its own weight assigned to inputs and outputs, rather than using value judgements on their relative importance. In non-profit sectors (such as the higher education sector) there are no prices for input and output component; thus this technique is an ideal choice to measure the relative importance of the inputs and outputs.

[3] These universities are all research-intensive and well-established institutions.
[4] These institutions are also called multi–disciplinary universities that focus on a wide range of courses and fields of specialisation.
[5] These institutions concentrate on specific disciplines linked to the original objective of their establishment.

The remainder of this chapter is structured as follows: Section 5.2 discusses the basic framework for measuring efficiency using a DEA model. Section 5.3 outlines the measurement of scale efficiency and the nature of Return to Scale economy. The choices of the input-orientation approach versus the output-orientation approach are discussed in Section 5.4. The theoretical background of Malmquist indices, their measurement and their decomposition are presented in Section 5.5. A formulation of the bootstrapping technique is presented in Section 5.6. The new Hicks-Moorsteen TFP index developed by O'Donnell (2008) and its decomposition are presented in Section 5.7. Section 5.8 deals with the specification of inputs and outputs used in the measurement of efficiency and productivity. Finally, Section 5.9 summarises this chapter.

## 5.2 Measurement of Efficiency Using DEA

DEA was initially proposed by Charnes, Cooper and Rhodes in 1978 as a mathematical programming method for evaluating the relative efficiency of homogenous operating units, called DMUs. It involves the construction of a discrete piece-wise linear frontier, or efficiency frontier, on which the relative performance of all DMUs in the sample can be compared. If DMUs hold an efficiency score of one (lie on the efficiency frontier), they will be treated as best-practice institutions; whereas DMUs under the efficiency frontier are considered inefficient and have values somewhere between zero and one. The aim of DEA is to distinguish best practice and worst practice, given its inputs and outputs relative to all remaining DMUs under consideration.

Twenty years after Farrell (1957) introduced the idea of productive efficiency measurement, Charnes, Cooper and Rhodes (CCR) (1978) reintroduced and extended Farrell's work by applying linear programming to estimate an empirical production technology frontier. Since

then there has been an impressive growth of the method in both theoretical development and empirical application of the ideas to practical situations. A comprehensive quantitative survey by Emrouznejad, Parker and Tavares (2008) highlighted that as of 2007 there were more than 4,000 research publications that had applied the DEA technique in various industrial and non-industrial context. This survey also pinpoints that the education sector (including higher education) was found to be one of the most popular application areas.

Charnes et al. (1978) provided the original DEA CRS model, which had an input orientation and assumed CRS. This CRS assumption is only justifiable when all DMUs are operating at an optimal scale. However, in a practical situation DMUs might face either economies or diseconomies of scale. Many factors, such as imperfect competition, regulatory environment, legal framework and financial burden, put constraints on DMUs' ability to function at the optimal scale. As a result, if one uses the CRS specification when not all DMUs are operating at optimal scale, the computed measures of technical efficiency will be confounded by scale efficiency. In order to relax the CRS assumption in the CCR model, Banker et al. (BCC) (1984) suggested a major extension of the original CCR model. The BCC model allows VRS assumption and separates pure technical efficiency from scale efficiency. In this study the VRS model will be employed because it is difficult to change university scale of operation in the short term.

The CCR model developed by Charnes et al. (1978) can be described as follows. Assume there are data for $K$ inputs and $M$ outputs for each of $N$ DMUs. For the $i$–th DMU, $K$ and $M$ are denoted by column vector $x_i$ and $y_i$, respectively. The $K \times N$ input matrix, $X$, and the $M \times N$ output matrix, $Q$, symbolise the data for all $N$ DMUs. To obtain a measure of the ratio of all weighted outputs over all weighted inputs for each DMU, such as $u' y_i / v' x_i$, where $u$ is a $M \times 1$

vector of output weights and $v$ is a $K\times 1$ vector of input weights, the following mathematical the programming problem gives the optimal weights:

$$\max_{u,v}(u' y_i / v' x_i),$$
$$st \qquad u' y_j / v' x_j \leq 1, \quad j = 1, 2, ..., I,$$
$$u, v \geq 0 \qquad (5.1)$$

By finding values for $u$ and $v$, the efficiency measure for the $i$–th DMU is maximised subject to the given constraint that all the efficiency measures must be less than or equal to it. This linear programming is solved for each of the $N$ DMUs in the sample; thus each DMU is assigned a set of weights most suitable to them. Nevertheless, the above ratio form yields an infinite number of solutions. For example, if $(u^*, v^*)$ is optimal, then $(\alpha u^*, \alpha v^*)$ is another optimal for $\alpha > 0$. In order to prevent this problem, one can impose the constraint $v' x_i = 1$, which can transform the fractional programming problem into a linear programming problem known as a *multiplier* form.

$$\max_{\mu,v}(\mu' y_i),$$
$$st \qquad v' x_i = 1,$$
$$\mu' y_j - v' x_j \leq 0, \qquad j = 1, 2, ..., I,$$
$$\mu, v \geq 0 \qquad (5.2)$$

where the change of variables from ($u$, $v$) to $(\mu, v)$ is a result of transformation. Using the dual linear problem outlined above, an equivalent *envelopment* form of this problem can be expressed as follows:

$$\min_{\theta,\lambda} \theta, ,$$

$$\begin{aligned} st \quad & -y_i + Y\lambda \geq 0, \\ & \theta x_i - X\lambda \geq 0, \\ & \lambda \geq 0, \end{aligned} \tag{5.3}$$

where $\theta$ is a scalar and $\lambda$ is a $N\times 1$ vector of constants. The optimal solution of $\theta$ denotes the efficiency score for the *i*–th DMU, and to estimate this value for each DMU, the linear programming process must be repeated *I* times, once for each DMU in the sample. According to Farrell's (1957) interpretation, DMUs for which $\theta < 1$ are inefficient, while DMUs for which $\theta = 1$ are boundary points. Hence the DMU is classified as technically efficient if it is on the boundary and the slacks are zero. The envelopment form of the DEA linear programming problem is simpler to solve than the ratio and multiplier forms due to fewer constraints, and hence is generally the preferred form to solve (see for example Coelli et.al, 2005; Cooper et al., 2007 and Fried et al., 2008).

Banker et al. (1984) highlighted that the CRS model provides distorted technical efficiency scores when compared to a DMU of a significantly different size. Thus, they have proposed an extension formulation of DEA that can take into account VRS assumptions and rectify all size-related issues. The extension model, also known as the BCC model, uses the same envelopment model as the dual for the CCR model, but with an additional constraint $N1'\lambda = 1$, which makes it possible to estimate whether the DMU activity was operated in the regions of increasing, constant or decreasing scale (nature of scale economies). This constraint is important, as it ensures the inefficiency scores are only compared against DMUs of similar size. The input-oriented BCC-DEA formulation is given in Equation (5.4).

$$
\begin{aligned}
&\min_{\theta,\lambda} \theta, \\
st \quad & -y_i + Y\lambda \geq 0, \\
& \theta x_i - X\lambda \geq 0, \\
& N1'\lambda = 1 \\
& \lambda \geq 0, \qquad (5.4)
\end{aligned}
$$

where $N1$ is an $N \times 1$ vector of unity. This method has its production frontiers spanned by the convex hull of the existing DMUs, which envelop the data points more tightly, and thus provides technical efficiency scores that are greater than or equal to those derived using the CRS model.

## 5.3 Measurement of Scale Efficiency and the Nature of Scale Economies

To measure the scale efficiency for each DMU in the sample, both CRS and VRS models must be estimated. The technical efficiency score obtained from the CRS model will be then decomposed into two elements: scale inefficiency and pure technical efficiency. According to Cooper et al. (2007) this decomposition is unique because it can represent the basis of inefficiency either caused by inefficient operation (pure technical efficiency) or by disadvantageous conditions within scale efficiency or from both sources. If there are differences between the estimated technical efficiency score in the CRS model compared with the estimated technical efficiency score in the VRS model, it can be concluded that the DMU has scale inefficiency. According to Coelli et al. (2005) the inefficiency in scale efficiency can be defined by Equation (5.5) below:

$$TE_{CRS} = TE_{VRs} \times SE \qquad (5.5)$$

Using Equation (5.5), the scale efficiency for each DMU in the sample can be estimated based on the estimated efficiency in the CRS and VRS model. This analysis will help to

recognise the effectiveness of the existing scale of operation in each DMU. Nevertheless the usefulness of this analysis is limited, since it only demonstrates the existence of scale efficiency but does not suggest the nature of scale economies for the DMU. Hence, in the next stage, as proposed by Coelli et al. (2005), the aim is to run the linear programming problem with the assumption of non-IRTS. This analysis is conducted by substituting the convexity constraint $N1^{'}\lambda = 1$ with $N1^{'}\lambda \leq 1$. The technical efficiency score at this stage is then compared with the technical efficiency score in the VRS model. If there is a difference between these scores, it can then be concluded that the nature of IRTScondition exists, where the DMU may be too small in its scale of operation. On the other hand, if the non-IRTS technical efficiency score is equal to the technical efficiency score in the VRS model, the DRTS condition exists, where the DMU may be too large in its scale of operation.

## 5.4 Input and Output Orientation in DEA

There are two approaches in using a DEA model: input orientation and output orientation. In an input-orientation approach the objective is to proportionally reduce the required inputs as much as possible while the output level held is held constant. Conversely, in an output-orientation method the aim is to proportionally expand the outputs as much as possible while the input level is held constant. Basically, the difference between these two approaches relates to the extent to which inputs or outputs are controllable. Both options lead to the same efficiency score under the CRS assumption, but not under the VRS assumption. Nevertheless, Coelli (1996) observes that both methods estimate a similar frontier and identify the same efficient DMUs, with a difference in efficiency scores only occurring with inefficient DMUs. The output orientation is considered more appropriate in a higher education context where universities (DMUs) may be given a fixed quantity of inputs such as student enrolments, which are controlled by the government, and asked to produce as much output as possible.

This is in line with the majority of studies that use DEA to measure the technical efficiency of higher education institutions, which use an output orientation approach; see Flegg et al. (2004), Joumandy and Ris (2005), Johnes (2006b), Agasisti and Johnes (2009), Agasisti (2009) and Bradley et al. (2010).

The output-oriented VRS model is equivalent to an input-oriented DEA model. The output-oriented VRS model is given below:

$$
\begin{aligned}
&\max_{\phi,\lambda} \phi, \\
st \quad & -\phi y_i + Y\lambda \geq 0, \\
& x_i - X\lambda \geq 0, \\
& N1'\lambda = 1 \\
& \lambda \geq 0,
\end{aligned}
\qquad (5.6)
$$

## 5.5 Malmquist Productivity Index

Measures of efficiency of DMU provided in the DEA model only are relative to the best-practice university in the sample. Nevertheless, concentrating only on efficiency estimates can provide an incomplete view of university performance over time. It is for this reason that changes in distance functions could be caused by either the movement of universities within the input-output space (efficiency changes), or the progress/regress of the boundary of the production set over time (technological changes). Caves et al. (1982) proposed the Malmquist productivity index as a theoretical index; it has since become a popular empirical tool in measuring distance functions. Since it is based on the distance function, it has several attractive properties: it readily satisfies multiple outputs as well as multiple inputs, and it requires data only on inputs/outputs quantities but not price (Färe, Grosskopf and Margatritis, 2008). This makes it suitable for productivity measurement in the higher education sector specifically, or the public sector generally, where there are multiple outputs as well as

multiple inputs and the price is not available. In literature, the Malmquist productivity index is a widely accepted tool for constructing a quantitative measure of changes in the efficiency and productivity in higher education. Johnes (2008), Worthington and Lee (2008), Agasisiti and Johnes (2009) and Bradley et al. (2010) are among the most recent studies to apply the Malmquist TFP index to this area.

In measuring change between two periods $t_1$ and $t_2$, one needs to know how firm *N* produced *q* outputs using *p* inputs over time period *T*. A generic firm in period $t_1$ employed input $x_{t_1}$ to produce output $y_{t_1}$, and in the period $t_2$, quantities of input and output are $x_{t2}$ and $y_{t_2}$, respectively. The production possibility set at time *t* is then:

$$S_t = \{(x,y) \mid x \text{ can produce } y \text{ at time } t\} \tag{5.7}$$

where *x* is an input vector, $x \in \mathbb{R}^n_+$ and *y* is an output vector and $y \in \mathbb{R}^m_+$ at time *t*. This can be described in term of its sections. For example:

$$y_{t_2}(x_{it_1}) = \left\{ y \in \mathbb{R}^m_+ \middle| (x,y) \in S_t \right\} \tag{5.8}$$

becomes the corresponding output feasibility set. Based on Shephard (1970), the output distance function for firm *i* at time $t_1$ is given by:

$$D^o_{it_1|t_2} \equiv \inf \left\{ \theta > 0 \;\middle|\; y_{it_1} / \theta \in y_{t_2}(x_{it_1}) \right\} \tag{5.9}$$

$D^0_{it_1|t_2}$ measures the distance from the $i^{th}$ firm's position in the input-output space at time $t_1$ to the boundary of the production set at time $t_2$, where inputs remain constant and $\theta$ is a scalar equal to the efficiency score. If $t_1$ and $t_2$ are equal, it is a measure of efficiency relative to

technology at the same time, and $D^0_{it|t} \leq 1$. When $t_1$ and $t_2$ are not equal, $D^0_{it_1|t_2}$ can be <, > or =1. According to Färe, Grosskopf, Lindgren and Roos (1992) the Malmquist productivity index between period $t_1$ and $t_2$ can be written as:

$$M_i^o(t_1,t_2) = \sqrt{\left(\frac{D^{oc}_{it_1|t_2}}{D^{oc}_{it_1|t_1}}\right)\left(\frac{D^{oc}_{it_2|t_2}}{D^{oc}_{it_2|t_1}}\right)} \tag{5.10}$$

Equation (5.10) shows a geometric mean of the Malmquist productivity indices for period $t_1$ and $t_2$ as defined by Caves et al. (1982). That is, if $M > 1$, total factor productivity change between period $t_1$ and $t_2$ is positive; if $M < 1$, the total factor productivity is negative; if $M = 1$ there is no change in productivity from period $t_1$ to $t_2$.

However, Simar and Wilson (1999) argued that when the production possibilities set $S_t$ is unknown, all the defined distances are therefore unobservable. Hence, there is a need for the estimation of the Malmquist productivity index and the corresponding distance functions. To do so, one should estimate the production set, $\hat{S}_t$ and the output feasibility set, $\hat{y}(x)$. Burgess and Wilson (1995) expressed the estimated production set as:

$$\widehat{S}_t = \left\{(x,y) \in \mathbb{R}_+^{m+n} \,\middle|\, y \leq Y_t\gamma,\ x \geq X_t\gamma,\ \overline{1\gamma} = 1,\ \gamma \in \mathbb{R}_+^N \right\} \tag{5.11}$$

where $Y_t = [y_{1t}, y_{2t,\dots,} y_{Nt}]$ and $y_{it}$ denote $(\mathrm{m} \times 1)$ the vector of observed output, $X_t = [x_{1t}, x_{2t,\dots,} x_{Nt}]$ and $x_{it}$ denote the $(\mathrm{n} \times 1)$ vector of observed inputs and $\vec{1}$ and $\gamma$ are a vector of one and intensity variable, respectively. Hence, corresponding output feasibility set can be expressed as:

$$\widehat{y_t^c}(x) = \left\{ y \in \mathbb{R}_+^m \middle| y \le Y_t\gamma,\ x \ge X_t\gamma,\ \gamma \in \mathbb{R}_+^N \right\}, \tag{5.12}$$

and

$$\widehat{y_t^v}(x) = \left\{ y \in \mathbb{R}_+^m \middle| y \le Y_t\gamma,\ x \ge X_t\gamma,\ \overline{1\gamma} = 1,\ \gamma \in \mathbb{R}_+^N \right\} \tag{5.13}$$

Substituting $\hat{y}_t^c(x)$ and $\hat{y}_t^v(x)$ for the $Y_t(x)$ in Equation (5.8) yields the estimated distance functions by solving the following linear programs:

$$(\widehat{D_{it_1|t_2}^{oc}})^{-1} = \max\left\{ \lambda \middle| \lambda y_{it_1} \le Y_{t_2}\gamma_i,\ x_{it_1} \ge X_{t_2}\gamma_i,\ \gamma_i \in \mathbb{R}_+^N \right\} \tag{5.14}$$

and

$$(\widehat{D_{it_1|t_2}^{ov}})^{-1} = \max\left\{ \lambda \middle| \lambda y_{it_1} \le Y_{t_2}\gamma_i,\ x_{it_1} \ge X_{t_2}\gamma_i,\ \overline{1\gamma} = 1,\ \gamma_i \in \mathbb{R}_+^N \right\} \tag{5.15}$$

where $\widehat{D_{it_1|t_2}^{oc}}$ incorporates an assumption of CRS and $\widehat{D_{it_1|t_2}^{ov}}$ allows for the VRS. Given the estimates of the distance functions, the Malmquist index can be obtained by substituting the estimated distance function values in Equation (5.10):

$$\widehat{M_i^o}(t_1, t_2) = \sqrt{\left( \frac{\widehat{D_{it_1|t_2}^{oc}}}{\widehat{D_{it_1|t_1}^{oc}}} \right) \left( \frac{\widehat{D_{it_2|t_2}^{oc}}}{\widehat{D_{it_2|t_1}^{oc}}} \right)} \tag{5.16}$$

Färe et al. (1992) decomposed this total factor productivity change into two components:

$$\widehat{M_i^o}(t_1, t_2) = \underbrace{\frac{\widehat{D_{it_2|t_2}^{oc}}}{\widehat{D_{it_1|t_1}^{oc}}}}_{\triangle Eff} \times \underbrace{\sqrt{\left( \frac{\widehat{D_{it_1|t_2}^{oc}}}{\widehat{D_{it_2|t_2}^{oc}}} \right) \left( \frac{\widehat{D_{it_1|t_1}^{oc}}}{\widehat{D_{it_2|t_1}^{oc}}} \right)}}_{\triangle Tech} \tag{5.17}$$

where the term outside the square root sign, Δ*Eff*, is an index of relative change in technical efficiency, and indicates how much closer (or farther away) a firm becomes to the best-practice frontier. The index can again be greater than, equal to or less than unity depending upon whether the evaluated firm improves, plateaus or deteriorates. The second component,

$\Delta Tech$, is the technical change component, which quantifies how much the frontier shifts, and indicates whether the best-practice firm is improving, plateauing, or deteriorating, thus permitting a comparison to the evaluated firm. Similarly it can be greater than, equal to or less than unity depending on whether the technical change is positive, zero or negative.

Färe et al. (1994) demonstrated that the technical change component can be divided into two components: pure technical and scale efficiency.

$$\widehat{M_i^o}(t_1,t_2) = \underbrace{\left(\frac{\widehat{D_{it_2|t_2}^{ov}}}{\widehat{D_{it_1|t_1}^{ov}}}\right)}_{\Delta PureEff} \times \underbrace{\left(\frac{\widehat{D_{it_2|t_2}^{oc}} / \widehat{D_{it_2|t_2}^{ov}}}{\widehat{D_{it_1|t_1}^{oc}} / \widehat{D_{it_1|t_1}^{ov}}}\right)}_{\Delta Scale} \times \underbrace{\sqrt{\left(\frac{\widehat{D_{it_1|t_2}^{oc}}}{\widehat{D_{it_2|t_2}^{oc}}}\right)\left(\frac{\widehat{D_{it_1|t_1}^{oc}}}{\widehat{D_{it_2|t_1}^{oc}}}\right)}}_{\Delta Tech} \tag{5.18}$$

where $\Delta PureEff$ and $\Delta Scale$ are proxies for pure efficiency change and change in scale efficiency, respectively, and $\Delta Eff = \Delta PureEff \times \Delta Scale$. The factor $\Delta Tech$ remains unchanged from Equation (5.17), yielding a measure of the change in technology. While $\Delta Tech$ signifies that the CRS frontier shifts over time, changes in pure efficiency and scale efficiency correspond to the VRS frontiers from two different periods.

Simar and Wilson (1998a), however, stated that if a generic firm's position in the input-output space remains fixed between time $t_1$ and $t_2$, and the only change that occurs is in the VRS estimate of technology (e.g., shift upward), then the $\Delta Tech$ presented in Equation (5.18) will be equal to unity, suggesting no change in technology. The $\Delta Tech$ in Equation (5.18) points to a change in technology if the CRS estimate of the technology changes. In this context, they concluded that the CRS estimate of the technology is statistically inconsistent. Since the VRS estimator is always consistent under the Kneip et al. (1996) assumptions, Simar and Wilson (1998a) propose an alternative decomposition of the Malmquist index to estimate changes in technology ($\Delta Tech$) by using changes in the VRS estimate:

$$\widehat{M_i^o}(t_1,t_2) = \underbrace{\left(\frac{\widehat{D_{it_2|t_2}^{ov}}}{\widehat{D_{it_1|t_1}^{ov}}}\right)}_{\triangle PureEff} \times \underbrace{\left(\frac{\widehat{D_{it_2|t_2}^{oc}} \,/\, \widehat{D_{it_2|t_2}^{ov}}}{\widehat{D_{it_1|t_1}^{oc}} \,/\, \widehat{D_{it_1|t_1}^{ov}}}\right)}_{\triangle Scale} \times$$

$$\underbrace{\sqrt{\left(\frac{\widehat{D_{it_1|t_2}^{ov}}}{\widehat{D_{it_2|t_2}^{ov}}} \times \frac{\widehat{D_{it_1|t_1}^{ov}}}{\widehat{D_{it_2|t_1}^{ov}}}\right)}}_{\triangle PureTech} \times \underbrace{\sqrt{\left(\frac{\widehat{D_{it_1|t_2}^{oc}} \,/\, \widehat{D_{it_1|t_2}^{ov}}}{\widehat{D_{it_2|t_2}^{oc}} \,/\, \widehat{D_{it_2|t_2}^{ov}}} \times \frac{\widehat{D_{it_1|t_1}^{oc}} \,/\, \widehat{D_{it_1|t_1}^{ov}}}{\widehat{D_{it_2|t_1}^{oc}} \,/\, \widehat{D_{it_2|t_1}^{ov}}}\right)}}_{\triangle ScaleTech} \qquad (5.19)$$

where $\Delta Tech$ is further decomposed into pure technical change – $\Delta PureTech$ – and change in the scale of technology – $\Delta ScaleTech$, and $\Delta Tech = \Delta PureTech \times \Delta ScaleTech$. Furthermore, $\triangle PureTech$ is the geometric mean of two ratios that measure the shift in the VRS frontier estimate relative to the firm's position at times $t_1$ and $t_2$. When $\Delta PureTech$ is greater than unity, it indicates an expansion in pure technology, or more specifically, an upward shift of the VRS estimate of the technology. $\Delta ScaleTech$ yields information concerning the shape of the technology by explaining the change in Returns to Scale of the VRS technology estimated at two fixed points, which are the firm's locations at times $t_1$ and $t_2$. When $\Delta ScaleTech$ is greater than unity, this suggests that the technology is moving farther from the CRS and the shape of technology is becoming more and more convex. Correspondingly, when this index is less than unity it suggests that the technology is moving toward the CRS; and when equal to unity suggests no change in the shape of the technology.

A similar decomposition of the Malmquist index, combining changes in the scale of efficiency and the scale of technology into a single term, was also proposed by Ray and Desli (1997). Nevertheless, Simar and Wilson (1999) contended that Ray and Desli (1997) confused changes in the shape of the technology and in the scale efficiency experienced by the production unit. Färe, Grosskopf and Norris (1997) also agreed that Ray and Desli's alternative decomposition of Malmquist incorrectly measures changes in scale efficiency. Therefore, several issues need to be considered when selecting a suitable decomposition of

the Malmquist productivity index. Färe et al. (2008) and Grosskopf (2003) argued that selection of the decomposition for the Malmquist productivity index must consider the focus and research questions develop by the researcher. In consequence, the complete decomposition of the Malmquist productivity index developed by Simar and Wilson (1998a) is applied in this study with the objective to shed some light on the efficiency and productivity changes in Malaysian public higher education institutions.[6]

When constructing Malmquist indices, the DEA models are problematic in estimating distance functions. The DEA does not allow for random errors, and thus remains without a valid statistical basis, making it inadequate for testing the statistical significance of estimated distance functions, or for undertaking sensitivity analysis to examine their asymptotic properties. For a detailed account of this issue see Simar and Wilson (1998b, 1999, 2000), Lovell (2000) and Coelli et al. (2005). With mainstream DEA analysis, an inherent problem is that distances to the frontier are underestimated if the most efficient firms within the population are excluded from the sample. This leads to biased frontier estimation, which in turn affects the measurement of distances to all other units. Uncertainty is manifested in the estimated DEA-based indices, so it is important to form the confidence intervals.

Simar and Wilson (1998b, 2000) solved this problem using the bootstrap simulation method, which determines the statistical properties of the non-parametric estimators in a multi-input and multi-output context. In this way one can express the DEA efficiency scores within confidence intervals. The bootstrap technique was subsequently applied to estimate confidence intervals for the Malmquist indices (Simar & Wilson, 1999) but its applications were in areas not related to higher education. For example, Gilbert and Wilson (1998) and

[6] The use of the Simar and Wilson (1998a) decomposition approach is well established in the context of the services sector (for example, for banking and health). Burgess and Wilson (1995), Gilbert and Wilson (1998) and Wheelock and Wilson (1999) are among the studies that have employed this technique in this area.

Wheelock and Wilson (1999), among others, employed this technique in the banking industry, and Assaf (2011), Galdeano-Gómez (2008) and Balcombe, Davidova and Latruffe (2008) used it to examine airlines, marketing and farming, respectively.

For the first time, this study employs Simar and Wilson's (1998a) approach in the context of higher education to measure the Malmquist TFP index and its components (changes in pure technical efficiency, changes in scale efficiency and pure changes in technology) and changes in the scale of technology. This approach allows a more comprehensive and robust analysis of productivity and technical changes within Malaysian universities. This study also employs the bootstrap simulation method (Simar & Wilson 1998b, 2000) to determine whether the computed changes in productivity are statistically significant; this application is the first in the case of a developing country.

## 5.6 Bootstrapping the Malmquist Productivity Index

Simar (1992) and Simar and Wilson (1998b) pioneered the use of bootstrapping in frontier models to obtain non-parametric envelopment estimators. The underlying idea of bootstrapping is to approximate a true sampling distribution by mimicking the data-generation process. This procedure is based on constructing a pseudo-sample and resolving the DEA model for each DMU with the new data. An iterative process yields an approximation of the true distribution. Simar and Wilson (1998b) demonstrate that consistent estimation of the confidence intervals depends on consistent replication of the data-generation process. In other words, the most important problem of bootstrapping in frontier models relates to the consistent replication of the data-generation process. Since the distance estimation values approach unity, re-sampling directly from the original dataset (the so-called naive bootstrap) to construct pseudo-samples will generate an inconsistent bootstrap estimation of the confidence intervals.

To overcome this problem, Simar and Wilson (1998b) proposed a smoothed bootstrap procedure. They used a univariate kernel estimator of the density of the original distance function estimates, and constructed the pseudo-data from this estimated density. To estimate the Malmquist indices, they used panel data in lieu of a single cross-section of data with the possibility of temporal correlation. Simar and Wilson (1999), in adapting the bootstrapping procedure for Malmquist indices, proposed a consistent method using a bivariate kernel density estimate via the covariance matrix of data from adjacent years. This process can be summarised in the following five steps:

1. Calculating the Malmquist index $\widehat{M_i^o}(t_1,t_2)$ for each university $(i=1,...,N)$ at time ($t_1$ and $t_2$) by solving the linear programming models in Equations (5.4 and 5.5) and their reversals.
2. Constructing the pseudo-data set $\{(x_{it}^*, y_{it}^*); i=1,...,N; t=1,2\}$ to create the reference bootstrap technology using the bivariate kernel density estimation and use of the reflection method developed by Silverman (1986).
3. Calculating the bootstrap estimate of the Malmquist index $\widehat{{}^*M_i^o}(t_1,t_2)$ for each university $(i=1,...,N)$ by applying the original estimators to the pseudo-sample from step 2.
4. Repeating Steps 2 and 3 numerous times (B times, in this study B=2,000) to facilitate B sets of estimates for each firm.
5. Constructing the confidence intervals for the Malmquist indices accordingly.

The main issue in designing the confidence intervals of the Malmquist indices pertains to the distribution of $\widehat{M_i^o}(t_1,t_2)-M_i^o(t_1,t_2)$, which is unknown and can be approximated by the distribution of $\widehat{{}^*M_i^o}(t_1,t_2)-\widehat{M_i^o}(t_1,t_2)$, where $M_i^o(t_1,t_2)$ is the true unknown index, $\widehat{M_i^o}(t_1,t_2)$ is the estimate of the Malmquist index and $\widehat{{}^*M_i^o}(t_1,t_2)$ denotes the bootstrap estimate of the index. If

the distribution of $(\widehat{M_i^o}(t_1,t_2) - M_i^o(t_1,t_2))$ were known, it would be rather easy to calculate $a_\alpha$ and $b_\alpha$ in the following interval:

$$\Pr(b_\alpha \le \widehat{M_i^o}(t_1,t_2) - M_i^o(t_1,t_2) \le a_\alpha) = 1-\alpha \tag{5.20}$$

But as the type of distribution is unknown, the bootstrap values are used to estimate $a_\alpha^*$ and $b_\alpha^*$ with high probability via Equation (5.21):

$$\Pr(b_\alpha^* \le {}^*\widehat{M_i^o}(t_1,t_2) - \widehat{M_i^o}(t_1,t_2) \le a_\alpha^*) = 1-\alpha \tag{5.21}$$

Thus, with $(1-\alpha)$ percentage confidence, one can argue that the $i^{th}$ Malmquist index lies between the following intervals:

$$\widehat{M_i^o}(t_1,t_2) + a_\alpha^* \le M_i^o(t_1,t_2) \le \widehat{M_i^o}(t_1,t_2) + b_\alpha^* \tag{5.22}$$

A Malmquist index for the $i^{th}$ firm is significantly different from unity (suggesting no productivity change) at the $\alpha$ % level, if the interval in Equation (5.22) does not include unity.

By using the calculated bootstrap value in Step 4, one can also correct for any finite-sample bias in the original estimators of the Malmquist indices with the application of the simple procedure outlined by Simar and Wilson (1999). The bootstrap bias estimate for the original estimator $\widehat{M_i^o}(t_1,t_2)$ is given by:

$$\widehat{bias_B}\left[\widehat{M_i^o}(t_1,t_2)\right] = B^{-1}\sum_{b=1}^{B} {}^*\widehat{M_i^o}(t_1,t_2)(b) - \widehat{M_i^o}(t_1,t_2) \tag{5.23}$$

Thus, a bias-corrected estimate of $M_i^o(t_1,t_2)$ can be computed as:

$$\widetilde{M_i^o}(t_1,t_2) = \widehat{M_i^o}(t_1,t_2) - \widehat{bias}_B\left[\widehat{M_i^o}(t_1,t_2)\right]$$
$$= 2\widehat{M_i^o}(t_1,t_2) - B^{-1}\sum_{b=1}^{B}{}^{*}\widehat{M_i^o}(t_1,t_2)(b) \tag{5.24}$$

This bias-corrected estimator may possess a higher mean-square error than the original estimator, and hence it will be less reliable (Simar and Wilson, 1999). The bias-corrected estimator should only be used if the sample variance ${}^{*}s_i^2$ of the bootstrap values $\left\{{}^{*}\widehat{M_i^o}(t_1,t_2)(b)\right\}_{b=1,\ldots,B}$ is not greater than one-third of the squared bootstrap bias estimate for the original estimator:

$${}^{*}s_i^2 < \frac{1}{3}\left(\widehat{bias}_B\left[\widehat{M_i^o}(t_1,t_2)\right]\right)^2 \tag{5.25}$$

This study conducted this procedure using commands *malmquist.components* and *malmquist* in the FEAR software program, which was introduced by Wilson (2006). The above methodology for Malmquist indices can easily be adapted to efficiency scores. Only the time-dependent structure of the data must be changed (by replacing $t_1$ and $t_2$ with the period considered). This procedure can be undertaken by using the command *boot.sw98* in the FEAR software program.

## 5.7 Hicks-Moorsteen TFP Index and its Decompositions

As mentioned before, the Malmquist productivity index is the most prevalent tool in measuring changes in efficiency and productivity of the universities. For instance, Johnes (2008), Worthington and Lee (2008), Agasisti and Johnes (2009) and Bradley et al. (2010) are among the most recent studies to have applied this tool to the higher education sector. Despite its evident popularity, there has also been extensive discussion of the arguments for and against the assumption to estimate the Malmquist indices. With non-CRS, the Malmquist

index does not precisely measure productivity change (Grifell-Tatje & Lovell, 1995). The bias in this way is systematic, and relies on the magnitude of scale economies. Coelli and Rao (2005) highlight the consequence of imposing the CRS upon any technology used to estimate distance functions for the calculation of a Malmquist TFP index. They conclude that without the CRS assumption the result may inaccurately measure TFP gains or losses arising from scale economies. Ray and Desli (1997) and Wheelock and Wilson (1999) also argue that the decomposition of the Malmquist index conducted by Färe et al. (1994) is problematic. When a firm's location (from one period to another) has remained unchanged, the scale efficiency change is only related to a shift in the VRS.

In order to prevent such problems, O'Donnell (2010b) proposed a new approach to decompose the multiplicatively complete TFP indices into a measure of technical change and various measures of efficiency change, without making any assumptions about the optimising behaviour of firms, the structure of markets or RTS for a multiple-input, multiple-output case. According to O'Donnell (2010b), all TFP indices that can be presented in terms of aggregate inputs and aggregate outputs are "multiplicatively complete". It should be noted that completeness is an essential requirement for an economically meaningful decomposition of the TFP change. O'Donnell (2010b) proves that the group of complete TFP indices also includes the Fisher, Konus, Törnqvist and Hicks-Moorsteen indices, but not the popular Malmquist index of Caves et al. (1982). Apart from special cases such as CRS, O'Donnell (2010b) states that the Malmquist index of Caves et al. (1982) is not complete, implying that it may be an unreliable measure of TFP change. As a result, the popular Färe et al. (1994) decomposition of the Malmquist index may also give rise to unreliable estimates of technical change and/or efficiency change (O'Donnell, 2010b).

In the context of the Malaysian higher education system, since the universities are not operating at optimal scale and face imperfect competition, the VRS assumption seems more appropriate than the CRS assumption. Therefore, in the present study the new decomposition of the Hicks-Moorsteen TFP index is used, allowing analysis of changes in the productivity of universities under the VRS assumption.[7] Moreover, according to Epure, Kerstens and Diego (2011) another issue with the use of the Malmquist index is that there is a possibility of infeasible results. Gilbert and Wilson (1998), Glass and McKillop (2000) and Arjomandi, Valadkhani and Harvie (2011) experienced this difficulty in their studies of the Korean banks, UK building societies and Iranian banks, respectively. Epure et al. (2011) suggest that one can turn to the Hicks-Moorsteen TFP index to address these problems.

Considering a firm that uses multiple inputs and outputs[8], O'Donnell (2008) used the usual definition of total factor productivity following Jorgenson and Griliches (1967) and Good, Nadiri and Sickle (1997): $TFP_{nt} = Y_{nt} / X_{nt}$, where $TFP_{nt}$ indicates the TFP of the $n^{\text{th}}$ firm in period $t$, $Y_{nt} \equiv Y(y_{nt})$ and $X_{nt} \equiv X(x_{nt})$, where $Y_{nt}$ and $X_{nt}$ are the aggregate output and aggregate input of the firm, respectively. According to this definition, one can specify TFP changes as the ratio of an output quantity index to an input quantity index (the ratio of output growth to input growth). O'Donnell (2010b) refers to such index numbers as multiplicatively complete.

The Hicks-Moorsteen TFP index is the only multiplicatively complete index that is estimated without requiring price data. This index is a ratio of Malmquist output and input quantity

[7] Using a similar dataset to that of Coelli et al. (2005), O'Donnell (2008) showed that the estimated Malmquist index numbers differed from the estimated Hicks-Moorsteen index numbers, even though both were computed under the assumption of CRS. Estimated components of TFP changes were also found to differ under other approaches. Hence, this study was not able to provide a comparison between the results of the Malmquist index and the Hicks-Moorsteen index. See Färe et al. (1996) & Färe,Grosskopf and Roos (1998) for the necessary and sufficient conditions for the Malmquist index to be equal to the Hicks-Moorsteen index.

[8] For a comprehensive review of the literature on the TFP index and its decomposition, see O'Donnell (2008).

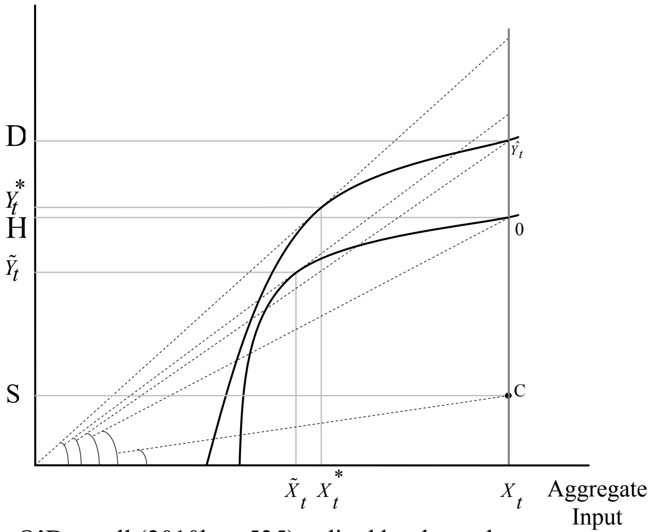
indices, so named because Diewert (1992, p.240) related its origins to Hicks (1961) and Moorsteen (1961). The Hicks-Moorsteen TFP index operates as follows:

$$TFP_{HM}^{t,t+1} = \left( \frac{D_o^{t+1}(x^{t+1}, y^{t+1}) D_o^t(x^t, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^t) D_o^t(x^t, y^t)} \frac{D_I^{t+1}(x^t, y^{t+1}) D_I^t(x^t, y^t)}{D_I^{t+1}(x^{t+1}, y^{t+1}) D_I^t(x^{t+1}, y^t)} \right)^{1/2} \tag{5.26}$$

where $D_o(x,y)$ and $D_I(x,y)$ are output and input distance functions, respectively, defined by Shephard (1953) as $D_O^T(x,y) = \min\left\{\delta > 0 : (x, y/\delta) \in P^T\right\}$, and $D_I^T(x,y) = \max\left\{\rho > 0 : (x/\rho, y) \in P^T\right\}$, where $P^T$ denotes the period-*T* production possibilities set. Using DEA, one can calculate these distance functions. O'Donnell (2010b) developed a DEA methodology for computing and decomposing the Hicks-Moorsteen TFP index. All DEA problems necessary for computing and decomposing the Hicks-Moorsteen TFP indices are detailed in O'Donnell (2010b). As in Hoang (2011) and O'Donnell (2010b), DEA is also used in this thesis as a nonparametric method that does not make any assumption about the behaviour of firms, the functional form of the technology or efficiency distribution. It should be mentioned that as DEA makes no allowance for statistical inferences, its results should be interpreted with caution.[9]

[9] One possible solution for quantifying the magnitude of these possible errors would be to estimate the technology using an econometric methodology that allows for statistical noise (e.g., SFA). However, not only does this type of analysis require a larger sample size than one is used here, it also goes beyond the scope of this thesis.

**Figure 5.1: Output-Oriented Decompositions of TFP Efficiency**




**Source:** O’Donnell (2010b, p.535), edited by the author.

Figure 5.1 shows O’Donnell’s (2010b) mapping of multiple-input and multiple-output production points into aggregate quantity space. The curve through points *D* and *C* denotes a mix-restricted frontier, as it represents the boundary of the set of all technically feasible aggregate input-output combinations that hold the same input and output mix as the firm operating at point A. Firm A can raise its TFP by expanding outputs until it achieves point *C*. The vertical distance from point *A* to point *C* shows the measure of output-oriented technical efficiency (OTE), and can be defined as:

$$OTE_t = \frac{Y_t}{\bar{Y}_t} = \frac{\tan a}{\tan c} \tag{5.27}$$

where $\bar{Y}_t$ is the maximum aggregate output that is technically feasible when using $x_t$ to generate a scalar multiple of $y_t$. Accordingly, the TFP of firm A, and the maximum possible TFP at point *C* (holding the input vector and output mix fixed) can be defined as $Y_t / X_t = \tan a$ and $\bar{Y}_t / X_t = \tan c$, respectively.

However, the TFP of Firm A is not maximised by moving to the technically efficient point *C*. Firm A can maximise its TFP by shifting to a point where a line through the origin is

tangential to the restricted production possibilities frontier. This point, labelled point *D* in Figure 1, is named as the point of MIOS by O'Donnell (2010b). Subsequently, pure scale efficiency can be a measure of the difference between the TFP at *C*, which is the technically efficient point, and the TFP at *D*, the point of MIOS. The term "pure" is used because input and output mixes are being held fixed, meaning that the change in TFP is a pure scale effect. The vertical distance from point *C* to point *S* denotes the measure of output-oriented scale efficiency (OSE), and can be defined as:

$$OSE = \frac{\bar{Y}_t / X_t}{\tilde{Y}_t / \tilde{X}_t} = \frac{\tan c}{\tan d} \tag{5.28}$$

where $\tilde{X}_t$ and $\tilde{Y}_t$ represent the aggregate input and output quantities at the MIOS point.

The curve passing through point *V* is the unrestricted production frontier that forms the limit of the production possibility set when all mix restrictions are relaxed. Now Firm A can expand aggregate output compared with point *C* and move vertically to point *V* in Figure 5.1. In this situation, O'Donnell (2010b) defined the mix efficiency measure as the difference between the TFP at a technically efficient point on the mix-restricted frontier and the TFP at a technically efficient point on the unrestricted frontier. Hence, the pure output-oriented mix efficiency (OME) is written as:

$$OME_t = \frac{\bar{Y}_t}{\hat{Y}_t} = \frac{\bar{Y}_t / X_t}{\hat{Y}_t / X_t} = \frac{\tan c}{\tan v} \tag{5.29}$$

where $\hat{Y}_t$ is the maximum aggregate output feasible when a firm uses $x_t$ to produce a vector of output.

However, the TFP of Firm A can be maximised only by moving to point E, where a straight line through the origin is tangential to the unrestricted production possibilities frontier. Point E is named as the point of maximum productivity. The residual scale efficiency measure is

defined by O'Donnell (2010b) as the difference between the TFP at point V and the TFP at point E. The residual output-oriented scale efficiency (ROSE) denotes a measure of the vertical distance from point V to point H:

$$ROSE_t = \frac{\hat{Y}_t / X_t}{Y^*_t / X^*_t} = \frac{\tan v}{\tan e} \tag{5.30}$$

According to the definitions provided above, it can be then concluded that:

$$\text{TFP Efficiency } = TFPE_t = \frac{TFP_t}{TFP_t^*} = \frac{\tan a}{\tan e} = \frac{\tan a}{\tan c}\frac{\tan c}{\tan v}\frac{\tan v}{\tan e}. \tag{5.31}$$

Equation (5.31) is a measure of TFP efficiency, which calculates the proportionate increase in TFP as the firm moves from point *A* to point *E*. Figure 5.1 shows that there are many pathways from point *A* to point *E*. Thus, there are many ways to decompose TFP efficiency in Equation (5.31). Pathway ACVE is employed for $TFPE_t$; another possible way is ACDE, which shows that TFP efficiency can also be written as:

$$TFPE_t = \frac{\tan a}{\tan e} = \frac{\tan a}{\tan c}\frac{\tan c}{\tan d}\frac{\tan d}{\tan e}. \tag{5.32}$$

In relation to the efficiency measures defined in this section (Equations 5.27 to 5.30), the following output-oriented decomposition can thus be defined:

$$TFPE_t = \frac{TFP_{nt}}{TFP_t^*} = OTE_{nt} \times OME_{nt} \times ROSE_{nt} \tag{5.33}$$

This decomposition can be used as a foundation for an output-oriented decomposition of a multiplicatively complete TFP index, and can be rewritten as:

$$TFP_{nt} = TFP_t^* \times (OTE_{nt} \times OME_{nt} \times ROSE_{nt}) \tag{5.34}$$

A similar equation can be defined for any other firm that is like *m* in period *s*. Accordingly, the index number that compares the TFP of firm *n* in period *t* with the TFP of firm *m* in period *s* will be given by:

$$TFP_{ms,nt} = \frac{TFP_{nt}}{TFP_{ms}} = \underbrace{\left(\frac{TFP_t^*}{TFP_s^*}\right)}_{Technical\ changes} \times \underbrace{\left(\frac{OTE_{nt}}{OTE_{ms}} \times \frac{OME_{nt}}{OME_{ms}} \times \frac{ROSE_{nt}}{ROSE_{ms}}\right)}_{Efficiency\ changes}. \tag{5.35}$$

The term included in the first parentheses on the right-hand side of this equation represents technical changes, measuring the difference between the maximum TFP possible using the technology feasible in periods *t* and *s*. Thus, the sector experiences technical improvement or decline depending on whether $TFP_t^* / TFP_s^*$ is greater or less than 1. In Figure 5.1, $TFP_t^* / TFP_s^*$ measures the change in the slope of the line that passes through point *E*. In contrast to the decomposition of the Malmquist TFP index, Färe et al. (1994) calculate the change in the slope of the line passing through point *D*. Hence, O'Donnell (2010b) presents that this technical change contains a mixed effect, and characteristically differs from firm to firm. The three other ratios on the extreme right-hand side of Equation (5.35) are referred to as measures of technical efficiency change, mix efficiency change and (residual) scaleefficiency change. Equation (5.35) is used to examine different components of technical efficiency changes. This method has also been employed by Hoang (2011) and O'Donnell (2010b) to investigate changes in the agricultural productivity of OECD countries and Australia, respectively. The DPIN software developed by O'Donnell (2010a) is used to estimate different measures of efficiency and TFP components.

## 5.8 Specification of Inputs and Outputs

The crucial factor in the use of the DEA approach relates to the appropriate selection of inputs and outputs. However, there is no consensus in the literature as to how to specify them (Johnes & Johnes, 1993; 1995; Avkiran, 2001). According to Lindsay (1982, p.176) some characteristics of higher education institutions, such as lack of profit motivation, goal diversity and uncertainty, diffuse decision-making and poorly understood production technology, differentiate this sector from other industries and complicate the specification of

the variables. Carrington et al. (2005) also state that it is difficult to accurately define the university inputs and outputs, as they are diverse and multi-faceted.

The inputs and outputs used in this study are based on the production approach: universities combine labour and non-labour factors of production to produce outputs in the form of teaching, research and other educational services. This method is most consistent with Worthington and Lee (2008), but also has a conceptualisation of university performance in common with Beasley (1990; 1995), Johnes and Johnes (1993; 1995), Madden and Savage (1997), Athanassapoulos and Shale (1997) and Glass et al. (2006).

The four inputs included in the analysis, are as follows: 1) undergraduate enrolments; 2) postgraduate enrolments; 3) the number of full-time equivalent academic staff members; and 4) the allocated government research funding. Instead of the more commonly used full-time equivalent student loads, the total student enrolment is used due to the unavailability of FTE data. This difficulty was also experienced by Agasisti and Johnes (2009). Our three outputs are defined as follows: 1) the number of undergraduate qualifications awarded; 2) the number of postgraduate qualifications awarded; 3) and the number of refereed articles as a proxy for research output. Some reported descriptive statistics are reported in Table 5.1.

Three observations are noteworthy at this point. First, inputs are considered homogenous and there is no direct allowance for quality. This is consistent with DEA models of previous studies (e.g. Athanassapoulos & Shale, 1997; Flegg & Allen, 2007; Johnes, 2008; Worthington & Lee, 2008). Second, some studies have taken into account the quality of undergraduate output by using the number of graduates receiving a first-class degree (see Flegg et al., 2004; Flegg & Allen, 2007). However, our study has not adopted this approach because of the unavailability and/or inaccuracy of data. Third, this study mainly focuses on

**Table 5.1: Descriptive Statistics**

| Year | University | Des. Statistics | X1 | X2 | X3 | X4 | Y1 | Y2 | Y3 |
|---|---|---|---|---|---|---|---|---|---|
| 2006 | Research University | min | 16418.0 | 3146.0 | 1589.0 | 19869969.0 | 4512.0 | 479.0 | 76.1 |
| | | max | 23123.0 | 9543.0 | 1922.0 | 41572260.0 | 5896.0 | 1493.0 | 349.6 |
| | | mean | 19055.2 | 5869.6 | 1795.2 | 27991788.8 | 5200.2 | 1034.6 | 269.5 |
| | | SD | 2503.3 | 2601.4 | 133.0 | 8098824.7 | 556.2 | 382.6 | 113.9 |
| | Comprehensive University | min | 5972.0 | 774.0 | 570.0 | 809077.0 | 1144.0 | 100.0 | 24.1 |
| | | max | 38061.0 | 2398.0 | 4966.0 | 7305560.0 | 9403.0 | 608.0 | 55.5 |
| | | mean | 18199.5 | 1584.8 | 1936.5 | 4221105.8 | 4295.3 | 313.8 | 36.8 |
| | | SD | 13849.9 | 913.4 | 2072.1 | 2950408.6 | 3558.2 | 239.2 | 13.8 |
| | Focused University | min | 2413.0 | 37.0 | 292.0 | 100000.0 | 84.0 | 1.0 | 0.2 |
| | | max | 20403.0 | 1674.0 | 1145.0 | 9655178.0 | 4874.0 | 616.0 | 6.7 |
| | | mean | 6941.5 | 426.5 | 507.1 | 2236459.3 | 1501.4 | 121.9 | 2.2 |
| | | SD | 6567.5 | 554.1 | 294.1 | 3251598.6 | 1723.6 | 212.2 | 2.2 |
| | The Industry | min | 2413.0 | 37.0 | 292.0 | 100000.0 | 84.0 | 1.0 | 0.2 |
| | | max | 38061.0 | 9543.0 | 4966.0 | 41572260.0 | 9403.0 | 1493.0 | 349.6 |
| | | mean | 13153.3 | 2299.9 | 1222.3 | 10278531.8 | 3246.6 | 435.5 | 88.9 |
| | | SD | 9640.9 | 2801.3 | 1154.6 | 12736402.8 | 2596.4 | 481.7 | 133.9 |
| 2007 | Research University | min | 18798.0 | 3400.0 | 1668.0 | 34732109.0 | 4988.0 | 1072.0 | 91.7 |
| | | max | 24051.0 | 7635.0 | 2136.0 | 95902406.0 | 6102.0 | 1555.0 | 417.1 |
| | | mean | 20984.2 | 5582.0 | 1920.2 | 50698333.0 | 5582.2 | 1283.2 | 315.7 |
| | | SD | 2003.0 | 1546.4 | 179.9 | 25792387.9 | 539.2 | 237.6 | 130.9 |
| | Comprehensive University | min | 4914.0 | 641.0 | 625.0 | 3438177.0 | 1430.0 | 134.0 | 25.2 |
| | | max | 47746.0 | 2885.0 | 6001.0 | 13422398.0 | 10741.0 | 797.0 | 76.3 |
| | | mean | 20104.3 | 1790.0 | 2094.3 | 7311893.0 | 4837.8 | 400.3 | 46.2 |
| | | SD | 18908.7 | 1003.4 | 2614.6 | 4370554.0 | 4075.2 | 302.1 | 21.7 |
| | Focused University | min | 1858.0 | 1.0 | 354.0 | 175480.0 | 428.0 | 3.0 | 0.2 |
| | | max | 24298.0 | 3191.0 | 1706.0 | 7940316.0 | 4834.0 | 655.0 | 21.2 |
| | | mean | 7538.0 | 772.3 | 641.3 | 3182497.5 | 1953.6 | 148.0 | 7.7 |
| | | SD | 7747.2 | 1071.8 | 455.9 | 2670016.0 | 1752.1 | 229.1 | 8.1 |

| Year | University | Des. Statistics | X1 | X2 | X3 | X4 | Y1 | Y2 | Y3 |
|---|---|---|---|---|---|---|---|---|---|
| | The Industry | min | 1858.0 | 1.0 | 354.0 | 175480.0 | 428.0 | 3.0 | 0.2 |
| | | max | 47746.0 | 7635.0 | 6001.0 | 95902406.0 | 10741.0 | 1555.0 | 417.1 |
| | | mean | 14449.5 | 2426.4 | 1359.3 | 18129365.7 | 3699.5 | 541.2 | 107.4 |
| | | SD | 11812.0 | 2422.9 | 1368.2 | 25405741.5 | 2735.9 | 555.4 | 154.5 |
| 2008 | Research University | min | 17317.0 | 5339.0 | 1780.0 | 19876858.0 | 4708.0 | 1066.0 | 124.4 |
| | | max | 27288.0 | 8768.0 | 2247.0 | 33835625.0 | 6351.0 | 1479.0 | 632.4 |
| | | mean | 21202.2 | 6636.0 | 1989.4 | 27557276.0 | 5641.0 | 1285.0 | 469.7 |
| | | SD | 3666.4 | 1446.8 | 178.6 | 6515536.8 | 657.4 | 179.2 | 199.4 |
| | Comprehensive University | min | 6054.0 | 633.0 | 634.0 | 2405062.0 | 1470.0 | 52.0 | 30.4 |
| | | max | 38061.0 | 2682.0 | 6354.0 | 11919631.0 | 9403.0 | 608.0 | 85.2 |
| | | mean | 18875.3 | 1708.8 | 2347.8 | 5606347.5 | 4380.5 | 327.0 | 55.4 |
| | | SD | 13573.6 | 987.2 | 2718.8 | 4381551.3 | 3461.0 | 280.1 | 26.0 |
| | Focused University | min | 4241.0 | 111.0 | 412.0 | 616400.0 | 214.0 | 1.0 | 0.3 |
| | | max | 30152.0 | 4434.0 | 1200.0 | 4602035.0 | 3215.0 | 871.0 | 26.9 |
| | | mean | 8947.5 | 820.9 | 640.0 | 1957890.4 | 1421.1 | 267.1 | 10.9 |
| | | SD | 8979.3 | 1469.6 | 269.6 | 1632639.7 | 1084.8 | 382.0 | 10.2 |
| | The Industry | min | 4241.0 | 111.0 | 412.0 | 616400.0 | 214.0 | 1.0 | 0.3 |
| | | max | 38061.0 | 8768.0 | 6354.0 | 33835625.0 | 9403.0 | 1479.0 | 632.4 |
| | | mean | 14887.8 | 2740.1 | 1438.7 | 10345581.9 | 3358.6 | 580.6 | 156.3 |
| | | SD | 10356.6 | 2915.8 | 1430.4 | 12196161.9 | 2575.8 | 553.9 | 232.2 |
| 2009 | Research University | min | 16505.0 | 7002.0 | 1866.0 | 5296664.0 | 4531.0 | 1125.0 | 215.1 |
| | | max | 21983.0 | 8532.0 | 2273.0 | 22623647.0 | 5950.0 | 1461.0 | 1029.2 |
| | | mean | 18784.2 | 7978.0 | 2043.6 | 11945324.2 | 5312.0 | 1207.8 | 712.3 |
| | | SD | 2051.8 | 654.2 | 169.7 | 7749288.3 | 686.3 | 142.4 | 304.2 |
| | Comprehensive University | min | 6664.0 | 720.0 | 637.0 | 1522520.0 | 1421.0 | 106.0 | 31.5 |
| | | max | 57486.0 | 4662.0 | 7270.0 | 6598928.0 | 14361.0 | 836.0 | 137.6 |
| | | mean | 24941.5 | 2677.5 | 2582.3 | 3626881.5 | 5483.0 | 488.5 | 90.5 |
| | | SD | 22379.5 | 1678.5 | 3165.2 | 2235744.5 | 5993.7 | 395.8 | 49.4 |

| Year | University | Des. Statistics | X1 | X2 | X3 | X4 | Y1 | Y2 | Y3 |
|---|---|---|---|---|---|---|---|---|---|
| | Focused University | min | 4504.0 | 174.0 | 476.0 | 162700.0 | 592.0 | 3.0 | 2.4 |
| | | max | 30155.0 | 5158.0 | 1216.0 | 3804342.0 | 6754.0 | 1048.0 | 73.6 |
| | | mean | 9190.0 | 1067.1 | 686.0 | 1133523.5 | 2143.4 | 189.8 | 25.4 |
| | | SD | 8784.7 | 1706.4 | 260.9 | 1201157.1 | 2176.5 | 355.2 | 23.3 |
| | The Industry | min | 4504.0 | 174.0 | 476.0 | 162700.0 | 592.0 | 3.0 | 2.4 |
| | | max | 57486.0 | 8532.0 | 7270.0 | 22623647.0 | 14361.0 | 1461.0 | 1029.2 |
| | | mean | 15718.1 | 3478.6 | 1531.5 | 4900137.4 | 3861.1 | 559.5 | 242.7 |
| | | SD | 13199.9 | 3362.1 | 1622.0 | 6292148.1 | 3423.0 | 539.1 | 349.5 |

x1= undergraduate enrolments;
x2= postgraduate enrolments;
x3= the number of full-time equivalent academic staff members; and
x4= the allocated government research funding.

y1= the number of undergraduate qualifications awarded;
y2= the number of postgraduate qualifications awarded;
y3= the number of refereed articles as a proxy for research output.

teaching and research as the most important outcomes, rather than community services. The reason for this is that there is no accepted or easy way to evaluate community and consultation services university-wide (see Ahn et al., 1988; Ahn et al., 1989; Carrington et al., 2005; Johnes, 2008; Worthington & Lee 2008).

There are many ways of measuring university research outputs (e.g. Sarafoglou & Haynes, 1996; Carrington et al., 2005; Glass et al., 2006; McMillan & Chan, 2006). Abbott and Doucouliagos (2003) argued that one should consider both quantity and quality of research outputs. As a proxy for research output, a number of studies have used research income (e.g. Abbott & Doucouliagos, 2003; Flegg et al., 2004; Flegg & Allen, 2007; Johnes, 2008; Worthington & Lee, 2008).

Malaysian universities do not usually provide consistent reports of their research outputs. Different categories are used, and they frequently change over time. Some universities do not report their research outcomes accurately. Against this backdrop, this study employs an alternative proxy for research-output data, known as the pure bibliometric approach, using the number of published research papers in refereed journals. Similar approaches have been adopted by Abbott and Doucouliagos (2003) and Worthington and Lee (2008) for the Australian higher education system, and by Athanassapoulos and Shale (1997) and Flegg et al. (2004) for UK universities, as well as by Abramo, D'Angelo and Pugini (2008) and Abramo, Cicero, and D'Angelo (2011) for Italian universities.

The bibliometric approach possesses a considerable advantage over other alternatives such as the peer-review approach[10]. For instance, it costs less, is non-invasive and easy to implement

[10] Peer-review approach is a process for evaluating research output that involves a qualified individual within the relevant areas; it has commonly been used by several studies such as Johnes and Johnes (1993, 1995), Johnes (1995) and Meng, Zhang, Qi, and Liu (2008).

and ensures rapid updates. Application of the bibliometric approach is usually based on data extracted from the Thomson Reuters WoS, a practice common to previous studies (see Bonaccorsi & Daraio, 2006; Abramo et al., 2008; Abramo & D'Angelo 2011; Abramo et al., 2011). However, it is believed that the Scopus database is a better choice, as it covers more refereed journals and conference proceedings than WoS (Meho & Rogers, 2008), and provides the best coverage of social-science literature (Norris & Openheim, 2007). It is noteworthy that the WoS database coverage focuses mainly on North American, Western European and English-language titles (Meho & Yang, 2007). Thus, the Scopus database is deemed more appropriate in the case of Malaysian higher education institutions.

In the process of counting the number of refereed articles by each university, care was taken to ensure the accuracy of the data. For example, issues of affiliation were treated cautiously when some authors used their faculty as their affiliation rather than their university. Additionally, the issue of double-counting was given due consideration when co-authors were from the same institution. To overcome this problem, a weight was assigned to each university based on the total number of authors. For instance, for an article with three authors – two from University A and one from University B – University A was weighted 2/3 and University B is weighted 1/3. If all three universities had been given equal weights, the results would have been overestimated.

## 5.9 Summary

This chapter has provided the theoretical foundations of efficiency and productivity measurements using DEA models. It has shown that DEA, despite its inherent limitations, possesses several desirable properties that make it appropriate to fulfil the objective of this study. The chapter has discussed a basic DEA model with both CRS and VRS technologies,

as well as its orientation (output-oriented or input-oriented). It has also shown that both the CRS and VRS models can be used to measure technical and scale efficiencies and facilitate the identification of the nature of the scale efficiencies, which is a characteristic that parametric approaches fail to address. The chapter has also presented the specification of inputs and outputs employed in the measurement of efficiency and productivity in Malaysian higher education institutions in this study.

The chapter has also discussed the bootstrap procedure method developed by Simar and Wilson (1998b, 2000), which attempts to provide a statistical foundation for DEA. This procedure helps develop statistical properties for DEA including standard errors and confidence intervals, and offers a more robust efficiency score. In addition, the chapter reviewed the major determinants of inefficiency identified in the literature in the context of the higher education sector, as they help explain efficiency differences and help the development of policy recommendations to design better higher education policies.

The overview of the conceptual framework for measuring productivity change also has been discussed here, with a focus on the popular index for productivity change: the Malmquist approach. The weaknesses in the process of decomposing the Malmquist index, an alternative decomposition and the bootstrap procedure for the Malmquist approach have also been provided in this chapter. The application of the bootstrap procedure in measuring productivity changes using the Malmquist approach identifies changes in productivity, efficiency and technology that are significant in a statistical sense.

Finally, the chapter reviews a new decomposition of the Hicks-Moorsteen TFP index, introduced by O'Donnell (2008). This index has been classified by O'Donnell (2008) as a member of the class of multiplicatively complete TFP index numbers. This allows the

decomposition of the TFP index into a simple measure consisting of technical change components and various measures of efficiency change. Compelling features of this approach, such as it being free from any assumptions concerning firms' optimising behaviour, as well as the degree of competition in product markets and the RTS properties, make it more applicable than the popular Malmquist productivity index in measuring higher education productivity change. Having explained how DEA is executed in measuring efficiency and productivity indices, the following chapter employs this technique to examine the efficiency and productivity of Malaysian public higher education institutions. This process involves running the data on DEA software and obtaining the computed indices. The result will be further explored and presented in the next chapter.

# Chapter Six
# Empirical Results and Analysis

## 6.1 Introduction

The previous chapter presented bootstrapped DEA efficiency scores, as well as the bootstrapped Malmquist index and its decomposition, developed by Simar and Wilson (1998a), and discussed a new decomposition of the Hicks-Moorsteen TFP index, introduced by O'Donnell (2010b). This chapter presents the empirical findings on the issues outlined in Chapter Five. Using this information, two primary issues related to the performance analysis of Malaysian public higher education institutions have been addressed in Sections 6.2 and 6.3: technical efficiency and Malmquist indices of productivity growth. Unlike the popular decomposition of the Färe et al. (1994) Malmquist productivity index, the alternative decomposition by Simar and Wilson (1998a) can further decompose technological changes into the changes in pure technology and changes in the scale of technology (which shows the changes in the shape of the technology). The bootstrap procedure developed by Simar and Wilson (1998b; 1999) has also been employed to provide more robust estimates.

In addition, to corroborate the findings of the bootstrapped Malmquist indices and decompose the efficiency changes into changes of pure technical efficiency, scale efficiency and mix efficiency, Section 6.4 and 6.5 present efficiency estimates and different components of the Hicks-Moorsteen TFP index. This study uses a four-year panel dataset (2006–2009) for analysing the performance of 17 Malaysian public universities before and after the implementation of the NHESP. This research considers all 20 public universities operating in Malaysia except *Universiti Malaysia Kelantan*, *Universiti Pertahanan Nasional Malaysia* and *Universiti Sultan Zainal Abidin*, due to the unavailability of the data. The 17 universities

are divided into three main sub-groups: 1) research universities; 2) comprehensive universities; and 3) focused universities. The empirical results obtained in this chapter help to address the four research questions stated in Chapter One of this thesis:

I. What is the mean efficiency score of Malaysian public higher education institutions?

II. What is the *TFP* change for public higher education institutions in Malaysia?

III. Has the implementation of the NHESP led to improvement in efficiency and productivity of the Malaysian public higher education sector?

IV. What are the main sources of efficiency or inefficiency in Malaysian public universities?

The remaining sections of this chapter are organised as follows. Section 6.2 discusses the bootstrapped efficiency of Malaysian public higher education institutions. Section 6.3 examines how the bootstrapped Malmquist productivity index is employed to measure productivity growth of Malaysian public higher education institutions. Section 6.4 and 6.5, following O'Donnell's (2008) new decomposition of the Hicks-Moorsteen index; discuss efficiency estimates and different components of the Hicks-Moorsteen TFP index for Malaysian public higher education institutions. Finally, Section 6.6 presents some concluding remarks on the major findings of this chapter.

## 6.2 Bootstrapped Output-Oriented Technical Efficiency Scores of the Malaysian Public Higher Education Institutions

This section presents the empirical findings and discussions of the institutions' efficiency analysis using the bootstrap output-oriented DEA models under the VRS assumption. To obtain these estimates, the linear programming problems in Equation (5.4) of Chapter Five must be solved for each institution in each period. An efficiency estimate equal to unity

indicates that the university lies on the boundary of the production possibility set of that specific period, and thus is (relatively) efficient. A value below unity indicates that the university is positioned under the frontier and is (relatively) inefficient.

Before delving into individual university results, it is useful to provide an overall picture of their efficiency and productivity performance. Table 6.1 summarises the annual mean efficiency estimates of the Malaysian public higher education sector. The second, third and fourth columns of this table provide the means of efficiency, bias-corrected efficiency and bias estimates of the entire sector, respectively. The fifth and sixth columns present the lower and upper bounds of the 95% confidence intervals for the annual mean efficiency scores.

In general, the estimates of technical efficiency using the standard DEA models (presented in the second column) are greater than the bias-corrected estimates. Also, in all cases, the estimated means of bias-corrected efficiency lie toward the upper bound of the estimated confidence intervals. These results are consistent with the theory behind the construction of the confidence intervals presented by Simar and Wilson (1998b) provided in Section 5.5.

**Table 6.1: Annual Mean Efficiency Score for the Whole Public Higher Education Sector Based on the Bootstrap Method (2006–2009)**

| Year | Estimated Efficiency | Bias-Corrected | Bias | Lower Bound | Upper Bound |
|---|---|---|---|---|---|
| 2006 | 0.9817 | 0.9542 | 0.0276 | 0.8531 | 0.9810 |
| 2007 | 0.9507 | 0.8635 | 0.0872 | 0.7127 | 0.9487 |
| 2008 | 0.9990 | 0.9974 | 0.0016 | 0.9837 | 0.9990 |
| 2009 | 0.9813 | 0.9439 | 0.0374 | 0.8632 | 0.9904 |
| Mean | 0.9782 | 0.9397 | 0.0385 | 0.8544 | 0.9798 |

**Source**: Author's calculations.

In addition, as theoretically expected, Table 6.1 indicates that the bias estimates for all periods are positive. It is noteworthy that in most periods the bias mean is quite small, indicating the stability of the results obtained from the models. For instance, the bias is about

0.028 and 0.002 in the years 2006 and 2008, respectively. Overall, the results presented in Table 6.1 reveal that the sector bias-corrected efficiency level declined over 2006–2007, significantly improved between 2007–2008 and slightly declined again over 2008–2009. Table 6.1 indicates that the sector's technical efficiency reached its peak in 2008, with a bias-corrected estimate of 0.9974. Nevertheless, these results do not provide much information about the performance of individual universities. To provide more informative results, the bootstrapped efficiency estimates of individual universities for each year are presented in Tables 6.2 to 6.5. Each table provides the three major sub-groups of universities: research, comprehensive and focused. The universities are reported in descending order of the year of university establishment.

Tables 6.2 to 6.5 provide the estimated technical efficiency levels, the bias-corrected estimates, the bias estimates, the 95% confidence interval bounds and the confidence interval ranges for the individual universities in the period 2006–2009. The results suggest that despite the sample size being small and higher education being multi-dimensional in nature, the sector's confidence intervals are of moderate length for most of the reported periods. The average width of the confidence intervals for the sector's technical efficiency estimates were found to be less than 0.15 in all periods except 2007, in which the average bound width was about 0.24. The mean bias for industry was very small in 2008 (0.0016); hence, the bias-corrected efficiency scores were very close to the original estimates in this year. But the mean bias was relatively high in 2007 (0.0872), suggesting large differences. These tables also show that the bias estimates are relatively higher for the most efficient universities (with an estimated efficiency of 1.0) in all years.

**Table 6.2: Individual Efficiency Scores Based on the Bootstrap Method (2006)**

| University | Estimated Efficiency | Bias-Corrected | Bias | Lower Bound | Upper Bound | Bound Width |
|---|---|---|---|---|---|---|
| **Research Universities** | | | | | | |
| *Universiti Malaya* | 1.0000 | 0.9687 | 0.0313 | 0.8377 | 0.9994 | 0.1617 |
| *Universiti Sains Malaysia* | 1.0000 | 0.9691 | 0.0309 | 0.8380 | 0.9991 | 0.1612 |
| *Universiti Kebangsaan Malaysia* | 0.9356 | 0.9237 | 0.0119 | 0.8988 | 0.9351 | 0.0363 |
| *Universiti Putra Malaysia* | 1.0000 | 0.9656 | 0.0344 | 0.8334 | 0.9992 | 0.1658 |
| *Universiti Teknologi Malaysia* | 0.9556 | 0.9440 | 0.0116 | 0.9177 | 0.9550 | 0.0373 |
| **Comprehensive Universities** | | | | | | |
| *Universiti Islam Antarabangsa Malaysia* | 0.7984 | 0.7890 | 0.0094 | 0.7751 | 0.7977 | 0.0226 |
| *Universiti Malaysia Sarawak* | 1.0000 | 0.9675 | 0.0325 | 0.8358 | 0.9992 | 0.1634 |
| *Universiti Malaysia Sabah* | 1.0000 | 0.9677 | 0.0323 | 0.8455 | 0.9994 | 0.1539 |
| *Universiti Teknologi MARA* | 1.0000 | 0.9671 | 0.0329 | 0.8364 | 0.9992 | 0.1628 |
| **Focused Universities** | | | | | | |
| *Universiti Utara Malaysia* | 1.0000 | 0.9686 | 0.0314 | 0.8376 | 0.9993 | 0.1617 |
| *Universiti Pendidikan Sultan Idris* | 1.0000 | 0.9674 | 0.0326 | 0.8352 | 0.9993 | 0.1641 |
| *Universiti Malaysia Terengganu* | 1.0000 | 0.9676 | 0.0324 | 0.8374 | 0.9992 | 0.1619 |
| *Universiti Sains Islam Malaysia* | 1.0000 | 0.9671 | 0.0329 | 0.8349 | 0.9993 | 0.1645 |
| *Universiti Tun Hussein Onn* | 1.0000 | 0.9753 | 0.0247 | 0.9217 | 0.9992 | 0.0774 |
| *Universiti Teknikal Melaka Malaysia* | 1.0000 | 0.9799 | 0.0201 | 0.9471 | 0.9923 | 0.0522 |
| *Universiti Malaysia Pahang* | 1.0000 | 0.9653 | 0.0347 | 0.8345 | 0.9991 | 0.1647 |
| *Universiti Malaysia Perlis* | 1.0000 | 0.9673 | 0.0327 | 0.8364 | 0.9992 | 0.1627 |
| **Mean** | **0.9817** | **0.9542** | **0.0276** | **0.8532** | **0.9810** | **0.1279** |

**Source:** Author's calculations.

Tables 6.2 to 6.5 show that, based on the estimation of the standard DEA models, 10 of the universities (*Universiti Malaya*, *Universiti Sains Malaysia*, *Universiti Putra Malaysia*, *Universiti Teknologi MARA*, *Universiti Pendidikan Sultan Idris*, *Universiti Malaysia Terengganu*, *Universiti Sains Islam Malaysia*, *Universiti Tun Hussein Onn*, *Universiti Malaysia Pahang* and *Universiti Malaysia Perlis*) were found to be efficient across all four periods. However, the bias-corrected efficiency scores reveal that, although these universities are still among the most efficient, none of them scored a technical efficiency of unity over the reported periods. These differences highlight the importance of bootstrapping in any studies of this kind.

**Table 6.3: Individual Efficiency Scores Based on the Bootstrap Method (2007)**

| University | Estimated Efficiency | Bias-Corrected | Bias | Lower Bound | Upper Bound | Bound Width |
|---|---|---|---|---|---|---|
| **Research Universities** | | | | | | |
| *Universiti Malaya* | 1.0000 | 0.9282 | 0.0718 | 0.8158 | 0.9976 | 0.1818 |
| *Universiti Sains Malaysia* | 1.0000 | 0.9185 | 0.0815 | 0.7440 | 0.9977 | 0.2537 |
| *Universiti Kebangsaan Malaysia* | 1.0000 | 0.9236 | 0.0764 | 0.7832 | 0.9982 | 0.2150 |
| *Universiti Putra Malaysia* | 1.0000 | 0.9518 | 0.0482 | 0.8959 | 0.8975 | 0.1015 |
| *Universiti Teknologi Malaysia* | 1.0000 | 0.9356 | 0.0644 | 0.8447 | 0.9979 | 0.1532 |
| **Comprehensive Universities** | | | | | | |
| *Universiti Islam Antarabangsa Malaysia* | 1.0000 | 0.9217 | 0.0783 | 0.7846 | 0.9982 | 0.2137 |
| *Universiti Malaysia Sarawak* | 0.9053 | 0.8706 | 0.0347 | 0.8213 | 0.9033 | 0.0820 |
| *Universiti Malaysia Sabah* | 0.8432 | 0.8122 | 0.0310 | 0.7696 | 0.8416 | 0.0719 |
| *Universiti Teknologi MARA* | 1.0000 | 0.8798 | 0.1202 | 0.6480 | 0.9981 | 0.3501 |
| **Focused Universities** | | | | | | |
| *Universiti Utara Malaysia* | 1.0000 | 0.8715 | 0.1285 | 0.6310 | 0.9982 | 0.3672 |
| *Universiti Pendidikan Sultan Idris* | 1.0000 | 0.8683 | 0.1317 | 0.6524 | 0.9976 | 0.3453 |
| *Universiti Malaysia Terengganu* | 1.0000 | 0.8612 | 0.1388 | 0.6308 | 0.9969 | 0.3660 |
| *Universiti Sains Islam Malaysia* | 1.0000 | 0.8711 | 0.1289 | 0.6307 | 0.9982 | 0.3675 |
| *Universiti Tun Hussein Onn* | 1.0000 | 0.9335 | 0.0665 | 0.8292 | 0.9982 | 0.1690 |
| *Universiti Teknikal Melaka Malaysia* | 0.4139 | 0.3982 | 0.0157 | 0.3730 | 0.4132 | 0.0402 |
| *Universiti Malaysia Pahang* | 1.0000 | 0.8732 | 0.1268 | 0.6310 | 0.9982 | 0.3672 |
| *Universiti Malaysia Perlis* | 1.0000 | 0.8606 | 0.1394 | 0.6306 | 0.9976 | 0.3670 |
| **Mean** | **0.9507** | **0.8635** | **0.0872** | **0.7127** | **0.9487** | **0.2360** |

**Source:** Author's calculations.

It should be noted that, as stated by Simar and Wilson (1998b), relative comparisons of the performance among firms based on the estimated efficiency scores should be made with caution. Of special note, in 2008 four universities were observed to be the most efficient, having the highest level of bias-corrected technical efficiency estimates, 0.9984 (*Universiti Malaya*, *Universiti Sains Malaysia*, *Universiti Malaysia Sabah* and *Universiti Sains Islam Malaysia*). However, *Universiti Malaya* had the narrowest estimated confidence interval. Hence, *Universiti Malaya* can be considered as the most efficient university in 2008. Therefore, the bias-corrected efficiency scores can be very helpful in distinguishing between decision units.

**Table 6.4: Individual Efficiency Scores Based on the Bootstrap Method (2008)**

| University | Estimated Efficiency | Bias-Corrected | Bias | Lower Bound | Upper Bound | Bound Width |
|---|---|---|---|---|---|---|
| **Research Universities** | | | | | | |
| *Universiti Malaya* | 1.0000 | 0.9984 | 0.0016 | 0.9839 | 1.0000 | 0.0160 |
| *Universiti Sains Malaysia* | 1.0000 | 0.9984 | 0.0016 | 0.9838 | 1.0000 | 0.0162 |
| *Universiti Kebangsaan Malaysia* | 1.0000 | 0.9983 | 0.0017 | 0.9837 | 1.0000 | 0.0162 |
| *Universiti Putra Malaysia* | 1.0000 | 0.9982 | 0.0018 | 0.9835 | 1.0000 | 0.0164 |
| *Universiti Teknologi Malaysia* | 1.0000 | 0.9983 | 0.0017 | 0.9837 | 1.0000 | 0.0163 |
| **Comprehensive Universities** | | | | | | |
| *Universiti Islam Antarabangsa Malaysia* | 1.0000 | 0.9982 | 0.0018 | 0.9835 | 1.0000 | 0.0165 |
| *Universiti Malaysia Sarawak* | 1.0000 | 0.9984 | 0.0016 | 0.9836 | 1.0000 | 0.0164 |
| *Universiti Malaysia Sabah* | 1.0000 | 0.9982 | 0.0018 | 0.9834 | 1.0000 | 0.0166 |
| *Universiti Teknologi MARA* | 1.0000 | 0.9983 | 0.0017 | 0.9836 | 1.0000 | 0.0163 |
| **Focused Universities** | | | | | | |
| *Universiti Utara Malaysia* | 0.9831 | 0.9825 | 0.0006 | 0.9815 | 0.9831 | 0.0016 |
| *Universiti Pendidikan Sultan Idris* | 1.0000 | 0.9983 | 0.0017 | 0.9836 | 1.0000 | 0.0163 |
| *Universiti Malaysia Terengganu* | 1.0000 | 0.9983 | 0.0017 | 0.9834 | 1.0000 | 0.0166 |
| *Universiti Sains Islam Malaysia* | 1.0000 | 0.9984 | 0.0017 | 0.9837 | 1.0000 | 0.0162 |
| *Universiti Tun Hussein Onn* | 1.0000 | 0.9983 | 0.0017 | 0.9846 | 1.0000 | 0.0164 |
| *Universiti Teknikal Melaka Malaysia* | 1.0000 | 0.9983 | 0.0017 | 0.9837 | 1.0000 | 0.0163 |
| *Universiti Malaysia Pahang* | 1.0000 | 0.9983 | 0.0017 | 0.9838 | 1.0000 | 0.0162 |
| *Universiti Malaysia Perlis* | 1.0000 | 0.9983 | 0.0017 | 0.9836 | 1.0000 | 0.0164 |
| **Mean** | **0.9990** | **0.9974** | **0.0016** | **0.9837** | **0.9990** | **0.0152** |

**Source:** Author's calculations.

Given this information, a comparison of the bias-corrected efficiency estimates presented in Tables 6.2 to 6.5 reveal that although there are no consistent results with regard to the most and least efficient universities, *Universiti Teknikal Melaka Malaysia*, *Universiti Putra Malaysia*, *Universiti Malaya* and *Universiti Tun Hussein Onn* were the most efficient universities in 2006, 2007, 2008 and 2009, respectively. On the other hand, *Universiti Islam Antarabangsa Malaysia*, *Universiti Teknikal Melaka Malaysia*, *Universiti Utara Malaysia* and *Universiti Malaysia Sarawak* can be considered as the most inefficient universities respectively, in these periods. In Table 6.4 there is only one inefficient university. One explanation of this issue could be the number of inputs/outputs used in comparison with the number of DMUs. However, one should not be concerned about this issue in this study as the

utilized bootstrap technique provides us the bias corrected efficiency values (presented in the fourth column of Tables 6.2-6.5).

However, these findings only present a general guide to identify the most and least technically efficient universities in the industry. A comprehensive investigation of why some universities are more efficient than others will require an in-depth analysis of changes in government or universities' policies within an historical context.

**Table 6.5: Individual Efficiency Scores Based on the Bootstrap Method (2009)**

| University | Estimated Efficiency | Bias-Corrected | Bias | Lower Bound | Upper Bound | Bound Width |
|---|---|---|---|---|---|---|
| **Research Universities** | | | | | | |
| *Universiti Malaya* | 1.0000 | 0.9593 | 0.0407 | 0.8676 | 0.9988 | 0.1312 |
| *Universiti Sains Malaysia* | 1.0000 | 0.9584 | 0.0416 | 0.8668 | 0.9987 | 0.1319 |
| *Universiti Kebangsaan Malaysia* | 0.9587 | 0.9384 | 0.0203 | 0.9083 | 0.9576 | 0.0493 |
| *Universiti Putra Malaysia* | 1.0000 | 0.9578 | 0.0422 | 0.8644 | 0.9987 | 0.1343 |
| *Universiti Teknologi Malaysia* | 0.9004 | 0.8799 | 0.0205 | 0.8491 | 0.8993 | 0.0503 |
| **Comprehensive Universities** | | | | | | |
| *Universiti Islam Antarabangsa Malaysia* | 1.0000 | 0.9586 | 0.0414 | 0.8671 | 0.9988 | 0.1318 |
| *Universiti Malaysia Sarawak* | 0.8229 | 0.8049 | 0.0180 | 0.7806 | 0.8220 | 0.0415 |
| *Universiti Malaysia Sabah* | 1.0000 | 0.9593 | 0.0407 | 0.8651 | 0.9987 | 0.1336 |
| *Universiti Teknologi MARA* | 1.0000 | 0.9598 | 0.0402 | 0.8672 | 0.9987 | 0.1315 |
| **Focused Universities** | | | | | | |
| *Universiti Utara Malaysia* | 1.0000 | 0.9598 | 0.0402 | 0.8691 | 0.9987 | 0.1296 |
| *Universiti Pendidikan Sultan Idris* | 1.0000 | 0.9574 | 0.0426 | 0.8635 | 0.9988 | 0.1353 |
| *Universiti Malaysia Terengganu* | 1.0000 | 0.9578 | 0.0422 | 0.8631 | 0.9986 | 0.1355 |
| *Universiti Sains Islam Malaysia* | 1.0000 | 0.9579 | 0.0421 | 0.8645 | 0.9984 | 0.1339 |
| *Universiti Tun Hussein Onn* | 1.0000 | 0.9602 | 0.0398 | 0.8706 | 0.9988 | 0.1282 |
| *Universiti Teknikal Melaka Malaysia* | 1.0000 | 0.9575 | 0.0425 | 0.8694 | 0.9986 | 0.1292 |
| *Universiti Malaysia Pahang* | 1.0000 | 0.9590 | 0.0410 | 0.8695 | 0.9988 | 0.1293 |
| *Universiti Malaysia Perlis* | 1.0000 | 0.9597 | 0.0403 | 0.8688 | 0.9987 | 0.1299 |
| **Mean** | **0.9813** | **0.9439** | **0.0374** | **0.8632** | **0.9800** | **0.1168** |

**Source:** Author's calculations.

## 6.3 The Decomposition of the Bootstrapped Malmquist TFP Index

As mentioned in Section 6.2 of this chapter, the estimation of technical efficiency in the literature does not fully determine the changes in performance of the university over time. Using the measurement of productivity growth over time, one will be able to distinguish

between the movement in the input-output space (technical efficiency changes) and the efficient frontier's shift over time (technological changes). By employing the alternative decomposition of the Malmquist productivity index, as explained in Section 5.8, it is possible to achieve a comprehensive analysis of changes in the universities' productivity, pure efficiency, scale efficiency, pure technology and scale of technology. Table 6.6 presents the summary results for the estimated $\Delta TFP$ index and its components for the three sub-groups of universities[11]. Then, Tables 6.7 to 6.11 provide these indices for each of the individual universities. The interpretation of the results is straightforward. An estimated value of greater than unity indicates improvements in corresponding measure, and a value below unity indicates deterioration.

Table 6.6 shows that the higher education sector as whole experienced improvements in productivity changes in 2006–2007, 2007–2008 and 2008–2009 of 10.33%, 11.39% and 36.59%, respectively. Table 6.6 shows that the major significant components of the sectoral TFP changes were technology changes ($\Delta Tech$), not efficiency changes ($\Delta Eff$), in all periods. The TFP changes were attributable to the positive changes in $\Delta Tech$ by 2.59%, 30.58% and 38.88%, respectively, in 2006–2007, 2007–2008 and 2008–2009. One may attribute these increases in $\Delta Tech$ in 2007–2008 and 2008–2009 to the implementation NHESP in 2007, which fostered more usage and absorption of ICT and promoted the international image of Malaysian universities. This plan allowed the universities to improve their technological capabilities, which helped expand the frontier, and at the same time the boosted productivity changes in the sector. For instance, almost all the research universities and comprehensive

[11] It should also be noted that Table 6.6 shows TFP changes and its decompositions based on the bootstrap values which evidently different from the original efficiency values. Therefore, in some cases such as research universities in 2007 and 2008, although they are all originally efficient (see the original values in Tables 6.3 and 6.4), Table 6.6 reports that overall efficiency regresses by 0.9960.

universities showed very large positive changes in pure technology (Δ*PureTech*) after 2007. For a detailed account of changes in individual universities see Tables 6.7 to 6.11.

Table 6.6 also shows that in the pre-NHESP period (2006–2007), the improvement in productivity growth of the sector was attributable to the focused (Δ*TFP*=1.203) and research (Δ*TFP*=1.0943) universities, while the comprehensive universities showed productivity regress over this period, deteriorating by 8.47% (Δ*TFP*=0.9153). However, in the post-NHESP period, all the sub-groups – research, comprehensive and focused universities – showed positive changes in their TFP indices of by.79%, 11.32% and 1.80%, respectively in 2007–2008, and 64.88%, 6.07% and 34.18%, respectively in 2008–2009.

**Table 6.6: Estimates of Malmquist Indices (Changes in Productivity) for Different University Sub-Groups (2006–2009)**

| University | Period | Δ*TFP* | Δ*Eff* | Δ*Tech* | Δ*Pure Eff* | Δ*Scale* | Δ*Pure Tech* | Δ*Scale Tech* |
|---|---|---|---|---|---|---|---|---|
| Research Universities | 2006–2007 | 1.0943 | 1.0063 | 1.0791 | 1.0231 | 1.0480 | 1.0480 | 1.0297 |
| | 2007–2008 | 1.2679 | 0.9960 | 1.2725 | 1.0000 | 1.2412 | 1.2412 | 1.0253 |
| | 2008–2009 | 1.6488 | 0.9915 | 1.6510 | 0.9718 | 1.6681 | 1.6681 | 0.9898 |
| Comprehensive Universities | 2006–2007 | 0.9153 | 0.9934 | 0.9198 | 1.00031 | 0.9932 | 0.9069 | 1.0143 |
| | 2007–2008 | 1.1132 | 1.0731 | 1.0689 | 1.0726 | 10005 | 1.0140 | 1.0542 |
| | 2008–2009 | 1.0607 | 0.9108 | 1.1728 | 0.9557 | 0.9530 | 1.2074 | 0.9713 |
| Focused Universities | 2006–2007 | 1.2030 | 1.1480 | 1.1275 | 0.9267 | 1.2387 | INF | INF |
| | 2007–2008 | 1.0180 | 1.0459 | 1.6018 | 1.1749 | 0.8902 | INF | INF |
| | 2008–2009 | 1.3418 | 1.1984 | 0.9584 | 1.0021 | 1.1958 | INF | INF |
| The Sector | 2006–2007 | 1.1033 | 1.0754 | 1.0259 | 0.9724 | 1.1059 | INF | INF |
| | 2007–2008 | 1.1139 | 1.0414 | 1.3058 | 1.0994 | 0.9473 | INF | INF |
| | 2008–2009 | 1.3659 | 1.0678 | 1.3888 | 0.9823 | 1.0871 | INF | INF |

Note: *ΔTFP = ΔEff × ΔTech, ΔEff = ΔPureEff × ΔScale, and ΔTech= ΔPureTech× ΔScaleTech*
INF: Because of the infeasibility of some of the values it was not possible to provide these means in the table.
**Source**: Author's calculations.

Although the technological changes were the main reason for the TFP changes in the sector, the results also show considerable improvements of the efficiency changes (Δ*Eff*) in the sector over 2006–2007 (7.54%), 2007–2008 (4.14%) and 2008–2009 (6.78%). The main

reasons for these positive changes were pure efficiency and scale efficiency improvements in 2007–2008 and 2008–2009. The result of the bootstrap procedure presented in Tables 6.7 to 6.11 allows the testing of the null hypothesis of no efficiency changes, no technology changes and no productivity changes. In other words the corresponding measures are not statistically different from unity. The results at the 10%, 5% and 1% level of significance are provided. The explanation is straightforward: for instance, if the 95% confidence interval contains unity, then the corresponding estimate is not significantly different from unity at the 5% significance level. In contrast, if the interval does not contain unity, it can be concluded that the corresponding measure is significantly different from unity at the 5% significant level. The same interpretative approach is appropriate for the 90% and 99% levels.

**Table 6.7: Estimates of Malmquist Indices (Changes in Productivity) for Individual Universities (2006–2009)**

| University | 2006–2007 | 2007–2008 | 2008–2009 |
|---|---|---|---|
| **Research Universities** | | | |
| *Universiti Malaya* | 0.9450** | 1.3460** | 1.9908** |
| *Universiti Sains Malaysia* | 0.9510** | 1.4496** | 2.1712** |
| *Universiti Kebangsaan Malaysia* | 1.2241** | 1.4153** | 1.0587* |
| *Universiti Putra Malaysia* | 0.9416** | 1.2106** | 2.1294** |
| *Universiti Teknologi Malaysia* | 1.4098** | 0.9177* | 0.8930** |
| **Comprehensive Universities** | | | |
| *Universiti Islam Antarabangsa Malaysia* | 1.2168** | 1.5914** | 1.1943** |
| *Universiti Malaysia Sarawak* | 0.6800** | 0.9780** | 0.9092** |
| *Universiti Malaysia Sabah* | 0.8263** | 0.8467** | 1.1373* |
| *Universiti Teknologi MARA* | 0.9379** | 1.0566** | 1.0018** |
| **Focused Universities** | | | |
| *Universiti Utara Malaysia* | 0.5052** | 0.9868** | 1.5674** |
| *Universiti Pendidikan Sultan Idris* | 0.4328** | 2.1295** | 0.7392** |
| *Universiti Malaysia Terengganu* | 2.5271** | 0.4464** | 1.0652** |
| *Universiti Sains Islam Malaysia* | 0.7091** | 0.2395** | 2.4367** |
| *Universiti Tun Hussein Onn* | 0.9605** | 2.1403** | 0.9422** |
| *Universiti Teknikal Melaka Malaysia* | 0.6381** | 1.0941* | 1.3116** |
| *Universiti Malaysia Pahang* | 1.1378** | 0.1515** | 1.4250** |
| *Universiti Malaysia Perlis* | 2.7131** | 0.9560** | 1.2472** |
| **Mean** | **1.1033** | **1.1139** | **1.3659** |

Note: Numbers greater than unity indicates improvement and those less than unity indicate declines.
(*), (**): significant differences from unity at 10% and 5%, respectively.
**Source:** Author's calculations.

Table 6.7 provides the estimates of productivity changes for the individual universities in the three sub-groups over the three periods (2006–2007, 2007–2008, and 2008–2009). As shown in the table, all the estimates are significantly different from unity at the 10% or 5% significance levels. Overall, the table shows that the means of TFP changes for research universities and focused universities were above unity in all periods. It also shows that two universities (*Universiti Kebangsaan Malaysia* and *Universiti Islam Antarabangsa Malaysia*) showed productivity improvements across all three periods. It should be emphasised that over the period 2006–2007, only six universities showed productivity gains. However, the number of productive universities in 2007–2008 and 2008–2009 significantly increased to nine and 13 universities, respectively.

**Table 6.8: Estimated Changes in Pure Efficiency for Individual Universities (2006–2009)**

| University | 2006–2007 | 2007–2008 | 2008–2009 |
|---|---|---|---|
| **Research Universities** | | | |
| *Universiti Malaya* | 1.0000** | 1.0000** | 1.0000** |
| *Universiti Sains Malaysia* | 1.0000** | 1.0000** | 1.0000** |
| *Universiti Kebangsaan Malaysia* | 1.0688** | 1.0000** | 0.9587** |
| *Universiti Putra Malaysia* | 1.0000** | 1.0000** | 1.0000** |
| *Universiti Teknologi Malaysia* | 1.0465** | 1.0000** | 0.9004* |
| **Comprehensive Universities** | | | |
| *International Islamic University Malaysia* | 1.2525** | 1.0000** | 1.0000** |
| *Universiti Malaysia Sarawak* | 0.9053** | 1.1046** | 0.8229** |
| *Universiti Malaysia Sabah* | 0.8432** | 1.1860* | 1.0000** |
| *Universiti Teknologi MARA* | 1.0000** | 1.0000** | 1.0000** |
| **Focused Universities** | | | |
| *Universiti Utara Malaysia* | 1.0000** | 0.9831** | 1.0172** |
| *Universiti Pendidikan Sultan Idris* | 1.0000** | 1.0000** | 1.0000** |
| *Universiti Malaysia Terengganu* | 1.0000** | 1.0000** | 1.0000** |
| *Universiti Sains Islam Malaysia* | 1.0000** | 1.0000** | 1.0000** |
| *Universiti Tun Hussein Onn* | 1.0000* | 1.0000** | 1.0000** |
| *Universiti Teknikal Melaka Malaysia* | 0.4139** | 2.4160** | 1.0000** |
| *Universiti Malaysia Pahang* | 1.0000** | 1.0000** | 1.0000** |
| *Universiti Malaysia Perlis* | 1.0000** | 1.0000** | 1.0000* |
| **Mean** | **0.9724** | **1.0994** | **0.9823** |

Note: Numbers greater than unity indicates improvement and those less than unity indicate declines.
(*), (**): significant differences from unity at 10% and 5%, respectively.
**Source:** Author's calculations.

**Table 6.9: Estimated Changes in Scale Efficiency for Individual Universities (2006–2009)**

| University | 2006–2007 | 2007–2008 | 2008–2009 |
|---|---|---|---|
| **Research Universities** | | | |
| *Universiti Malaya* | 1.0000* | 1.0000** | 1.0000* |
| *Universiti Sains Malaysia* | 1.0000* | 1.0000** | 1.0000* |
| *Universiti Kebangsaan Malaysia* | 1.0006** | 1.0000** | 0.9938** |
| *Universiti Putra Malaysia* | 0.9114** | 1.0972** | 1.0000* |
| *Universiti Teknologi Malaysia* | 1.0059** | 0.8831** | 1.1076** |
| **Comprehensive Universities** | | | |
| *Universiti Islam Antarabangsa Malaysia* | 1.0001** | 1.0000*** | 1.0000* |
| *Universiti Malaysia Sarawak* | 0.9611** | 0.9850** | 0.9390** |
| *Universiti Malaysia Sabah* | 0.9809** | 1.0195** | 1.0000* |
| *Universiti Teknologi MARA* | 1.0306** | 0.9974** | 0.8729** |
| **Focused Universities** | | | |
| *Universiti Utara Malaysia* | 1.0000*** | 0.6220** | 1.6078** |
| *Universiti Pendidikan Sultan Idris* | 1.0000* | 1.0000*** | 1.0000*** |
| *Universiti Malaysia Terengganu* | 1.0260** | 1.0000* | 1.0000* |
| *Universiti Sains Islam Malaysia* | 1.0000* | 0.4307** | 1.9936** |
| *Universiti Tun Hussein Onn* | 0.9587** | 0.9902** | 1.0690** |
| *Universiti Teknikal Melaka Malaysia* | 1.0130** | 1.0785** | 1.0000** |
| *Universiti Malaysia Pahang* | 1.0000*** | 1.0000*** | 1.0000*** |
| *Universiti Malaysia Perlis* | 2.9122** | 1.0000*** | 0.8965** |
| **Mean** | **1.1059** | **0.9473** | **1.0871** |

Note: Numbers greater than unity indicates improvement and those less than unity indicate declines.
(*), (**), (***): significant differences from unity at 10%, 5% and 1%, respectively.
**Source:** Author's calculations.

Table 6.8 shows the estimated changes in pure efficiency over the three reported periods. All the estimates were significantly different from unity at the 5% level of significance. Out of 51 estimates of changes in pure efficiency, only 14 differed from unity (either > or <) across the three reported periods. Ten universities (*Universiti Malaya*, *Universiti Sains Malaysia*, *Universiti Putra Malaysia*, *Universiti Teknologi MARA*, *Universiti Pendidikan Sultan Idris*, *Universiti Malaysia Terengganu*, *Universiti Sains Islam Malaysia*, *Universiti Tun Hussein Onn*, *Universiti Malaysia Pahang* and *Universiti Malaysia Perlis*) showed no changes in pure efficiency for all years in the study period. These findings generally show that pure efficiency change was not an effective component of TFP change. Hence, one may argue that there has

been a stable management of inputs and outputs in the sector over 2006–2009 in terms of pure efficiency.

Table 6.9 presents the estimated changes in scale efficiency; while all the estimated changes were statistically significant, the results were mixed. Table 6.9 shows that although there are a few universities in each period showing some changes in scale efficiency, four universities (*Universiti Malaya*, *Universiti Sains Malaysia*, *Universiti Pendidikan Sultan Idris* and *Universiti Malaysia Pahang*) did not experience any scale efficiency changes over these three periods. This result, in conjunction with those concerning the changes in pure efficiency (from Table 6.8), indicate that neither pure efficiency changes nor scale efficiency changes can account for the considerable TFP changes in the sector over 2006–2009. Instead, the results can be explained by technological change components, which will be explained using Tables 6.10 and 6.11.

Tables 6.10 and 6.11 present the estimated changes in pure technology and the scale of technology, respectively. Most of the estimates were found to be significant at 5%. In both tables, changes in some cases could not be computed; these are indicated by "INF". This problem arose due to the infeasibility of constraints in the linear programming. The same computational impossibilities were encountered by Gilbert and Wilson (1998, p.149). The estimated pure-technology changes in Table 6.10 show an inward shift of the frontier in 2006–2007 for all universities except three (*Universiti Kebangsaan Malaysia*, *Universiti Teknologi Malaysia*, *Universiti Teknikal Melaka Malaysia*). In contrast, in 2007–2008 and 2008–2009 the results indicate an outward shift in either 2007–2008 or 2008–2009 for all universities except *Universiti Teknologi Malaysia*, suggesting that there was an overall technological increase in the sector during these two periods. As mentioned before, this is most probably due to the increased use of ICT and e-learning facilities. Johnes (2008) found

the same result in UK universities, and pointed out that the advancements in technology increase the accessibility of ICT, and bring about positive changes in teaching methods and an increase in their efficiency.

**Table 6.10: Estimated Changes in Pure Technology (2006–2009)**

| University | 2006–2007 | 2007–2008 | 2008–2009 |
|---|---|---|---|
| **Research Universities** | | | |
| *Universiti Malaya* | 0.9608** | 1.3110** | 1.9947** |
| *Universiti Sains Malaysia* | 0.9443** | 1.4248** | 2.0140** |
| *Universiti Kebangsaan Malaysia* | 1.1182** | 1.3607** | 1.1320 |
| *Universiti Putra Malaysia* | 0.9969** | 1.1480** | 1.9886** |
| *Universiti Teknologi Malaysia* | 1.0480** | 0.9613 | 0.9787** |
| **Comprehensive Universities** | | | |
| *Universiti Islam Antarabangsa Malaysia* | 0.9721** | 1.6010** | 1.1528** |
| *Universiti Malaysia Sarawak* | 0.7188** | 0.7856** | 1.1101 |
| *Universiti Malaysia Sabah* | 0.9911** | 0.7083 | 1.1901** |
| *Universiti Teknologi MARA* | 0.9454** | 0.9609** | 1.3767** |
| **Focused Universities** | | | |
| *Universiti Utara Malaysia* | 0.5344** | 1.2310** | 1.4716** |
| *Universiti Pendidikan Sultan Idris* | 0.1587** | 2.1108** | INF |
| *Universiti Malaysia Terengganu* | INF | INF | INF |
| *Universiti Sains Islam Malaysia* | INF | INF | INF |
| *Universiti Tun Hussein Onn* | 0.9363** | 1.7395** | INF |
| *Universiti Teknikal Melaka Malaysia* | 1.5062** | 0.3682 | INF |
| *Universiti Malaysia Pahang* | INF | INF | INF |
| *Universiti Malaysia Perlis* | INF | INF | INF |
| **Mean** | **0.9233** | **1.2086** | **1.4642** |

Note: Numbers greater than unity indicates improvement and those less than unity indicate declines.
(**): significant differences from unity at 5% level of significance.
**Source**: Author’s calculations.

Table 6.11 shows that estimated changes in the scale of the technology are significantly more than unity in most cases reported in the three periods. This indicates that the shape of the frontier is moving toward the VRS to become more convex and variable. Overall, Tables 6.10 to 6.11 not only reinforce the results of Table 6.6 that technological changes were the most important reasons for the industry TFP changes, but also demonstrate that changes in pure technology are the major component of these changes. In general, the results from Tables 6.6 to 6.11 indicate that the implementation of the NHESP might have resulted in a large increase

in technological changes for all the university sub-groups after 2007. This is consistent with the findings of similar higher education studies (Johnes, 2008; Flegg et al., 2004; Worthington & Lee, 2008).

**Table 6.11: Estimated Changes in Scale Technology (2006–2009)**

| University | 2006–2007 | 2007–2008 | 2008–2009 |
|---|---|---|---|
| **Research Universities** | | | |
| *Universiti Malaya* | 0.9836** | 1.0267** | 1.0011** |
| *Universiti Sains Malaysia* | 1.0071** | 1.0174 | 1.0008** |
| *Universiti Kebangsaan Malaysia* | 1.0237** | 1.0401** | 1.0290** |
| *Universiti Putra Malaysia* | 1.0363** | 0.9612** | 1.0029 |
| *Universiti Teknologi Malaysia* | 1.0978** | 1.0810** | 0.9898** |
| **Comprehensive Universities** | | | |
| *Universiti Islam Antarabangsa Malaysia* | 0.9992** | 0.9815** | 1.0360** |
| *Universiti Malaysia Sarawak* | 1.0872** | 1.1442 | 1.0599** |
| *Universiti Malaysia Sabah* | 1.0081** | 0.9888** | 0.9556** |
| *Universiti Teknologi MARA* | 0.9626** | 1.1024** | 0.8337** |
| **Focused Universities** | | | |
| *Universiti Utara Malaysia* | 0.9454** | 1.3111** | 0.6513** |
| *Universiti Pendidikan Sultan Idris* | 2.7275** | 1.0089** | INF |
| *Universiti Malaysia Terengganu* | INF | INF | INF |
| *Universiti Sains Islam Malaysia* | INF | INF | INF |
| *Universiti Tun Hussein Onn* | 1.0701** | 1.2426** | INF |
| *Universiti Teknikal Melaka Malaysia* | 1.0104** | 1.1403** | INF |
| *Universiti Malaysia Pahang* | INF | INF | INF |
| *Universiti Malaysia Perlis* | INF | INF | INF |
| **Mean** | **1.1507** | **1.0805** | **0.9485** |

Note: Numbers greater than unity indicates improvement and those less than unity indicate declines.
(**): significant differences from unity at 5% level of significance.
**Source:** Author's calculations.

## 6.4 Output-Oriented Technical Efficiency, Scale Efficiency and Mix Efficiency of Malaysian Public Higher Education Institutions under the Hicks-Moorsteen Method

This section presents the empirical findings and discussion of the analysis of the estimated output-oriented technical, scale and mix efficiency of Malaysian public higher education institutions using the Hicks-Moorsteen TFP index. As shown in the previous chapter, this

technique is a distance function based index and among the class of multiplicatively complete indices.

The DEA approach developed by O'Donnell (2010b) is used to compute these estimates; this allows for the VRS and technical regression (O'Donnell, 2008). Estimates of output-oriented technical, scale and mix efficiency over four years (2006–2009) are presented in Tables 6.12 and 6.13. The measurements of technical and scale efficiency have been established in the efficiency and productivity literature for decades. In contrast, measurement of mix efficiency is new in the literature (O'Donnell, 2010b). The explanation of the results is straightforward: efficiency estimates vary between zero and unity, where efficient universities have technical efficiency levels equal to unity and inefficient universities have technical efficiency estimates below zero. A university that has technical efficiency estimates equal to unity and mix efficiency less than unity is still on the frontier, but at a relatively unproductive point.

Tables 6.12 and 6.13 show that a number of universities were fully efficient (technically efficient, as well as scale- and mix-efficient) in certain years. For instance, Table 6.12 shows that in the pre-NHESP periods there were eight fully efficient universities in 2006 (*Universiti Malaya*, *Universiti Sains Malaysia*, *Universiti Utara Malaysia*, *Universiti Putra Malaysia*, *Universiti Malaysia Sabah*, *Universiti Pendidikan Sultan Idris*, *Universiti Sains Islam Malaysia* and *Universiti Malaysia Pahang*). The same pattern occurred in 2007, with eight fully efficient universities (*Universiti Sains Malaysia*, *Universiti Teknologi MARA*, *Universiti Utara Malaysia*, *Universiti Pendidikan Sultan Idris*, *Universiti Malaysia Terengganu*, *Universiti Sains Islam Malaysia*, *Universiti Malaysia Pahang* and *Universiti Malaysia Perlis*). Table 6.12 shows that five universities – *Universiti Sains Malaysia*, *Universiti Utara Malaysia*, *Universiti Pendidikan Sultan Idris*, *Universiti Sains Islam Malaysia* and *Universiti Malaysia Pahang* – were fully efficient in both periods.

**Table 6.12: Estimates of Output-Oriented Technical, Scale and Mix Efficiency for the Individual University under the Hicks-Moorsteen Method (2006–2007)**

| | 2006 | | | 2007 | | |
|---|---|---|---|---|---|---|
| **University** | **OTE** | **OSE** | **OME** | **OTE** | **OSE** | **OME** |
| **Research Universities** | | | | | | |
| *Universiti Malaya* | 1 | 1 | 1 | 1 | 1 | 0.9529 |
| *Universiti Sains Malaysia* | 1 | 1 | 1 | 1 | 1 | 1 |
| *Universiti Kebangsaan Malaysia* | 0.9357 | 0.9994 | 0.9651 | 1 | 1 | 0.9305 |
| *Universiti Putra Malaysia* | 1 | 1 | 1 | 1 | 0.9114 | 1 |
| *Universiti Teknologi Malaysia* | 0.9565 | 0.9938 | 0.9267 | 1 | 1 | 0.9561 |
| **Comprehensive Universities** | | | | | | |
| *Universiti Islam Antarabangsa Malaysia* | 0.7984 | 0.9998 | 0.9902 | 1 | 1 | 0.6646 |
| *Universiti Malaysia Sarawak* | 1 | 1 | 0.8042 | 0.9127 | 0.9533 | 0.4053 |
| *Universiti Malaysia Sabah* | 1 | 1 | 1 | 0.8432 | 0.9809 | 0.9384 |
| *Universiti Teknologi MARA* | 1 | 0.9703 | 1 | 1 | 1 | 1 |
| **Focused Universities** | | | | | | |
| *Universiti Utara Malaysia* | 1 | 1 | 1 | 1 | 1 | 1 |
| *Universiti Pendidikan Sultan Idris* | 1 | 1 | 1 | 1 | 1 | 1 |
| *Universiti Malaysia Terengganu* | 1 | 0.9747 | 1 | 1 | 1 | 1 |
| *Universiti Sains Islam Malaysia* | 1 | 1 | 1 | 1 | 1 | 1 |
| *Universiti Tun Hussein Onn* | 1 | 0.9854 | 1 | 1 | 0.9448 | 0.2609 |
| *Universiti Teknikal Melaka Malaysia* | 1 | 0.8914 | 0.9689 | 0.4335 | 0.9667 | 0.9921 |
| *Universiti Malaysia Pahang* | 1 | 1 | 1 | 1 | 1 | 1 |
| *Universiti Malaysia Perlis* | 1 | 0.3408 | 0.1823 | 1 | 1 | 1 |

**Source:** Author's calculations.

Table 6.13 indicates that the number of fully efficient universities in the post-NHESP period (2008–2009) remained at eight in 2009, and increased to nine in 2008, staying at that level in 2009. Overall, three universities (*Universiti Sains Malaysia*, *Universiti Pendidikan Sultan Idris* and *Universiti Malaysia Pahang*) were classified as fully efficient across all the years from 2006 to 2009. This finding shows that these universities produced more output per input unit than the other universities, and might be considered as the best-practice benchmarks in the Malaysian public higher education sector during the corresponding years.

In relation to output-oriented technical efficiency (OTE), the results in Tables 6.12 and 6.13 for the years 2006–2009 indicate that the technical efficiency scores of almost all the institutions were very high: the sector mean of technical efficiency varied from 0.9561 to

0.9993. This finding is generally consistent with our finding of the industry-wide technical efficiency based on the bootstrapped efficiency (presented in previous sections), and with results of some earlier international studies in the literature, such as Athanassapoulos and Shale (1997), Avkiran (2001) and Abbott and Doucouliagos (2003). However, since the public higher education sector is without profit motivation, the high level of technical efficiency obtained in this and a similar study deserves further clarification.[12]

**Table 6.13: Estimates of Output-Oriented Technical, Scale and Mix Efficiency for the Individual University under the Hicks-Moorsteen Method (2008–2009)**

| | 2008 | | | 2009 | | |
|---|---|---|---|---|---|---|
| **University** | **OTE** | **OSE** | **OME** | **OTE** | **OSE** | **OME** |
| **Research Universities** | | | | | | |
| *Universiti Malaya* | 1 | 1 | 1 | 1 | 1 | 0.9310 |
| *Universiti Sains Malaysia* | 1 | 1 | 1 | 1 | 1 | 1 |
| *Universiti Kebangsaan Malaysia* | 1 | 1 | 0.9678 | 0.9587 | 0.9938 | 0.9537 |
| *Universiti Putra Malaysia* | 1 | 1 | 1 | 1 | 1 | 1 |
| *Universiti Teknologi Malaysia* | 1 | 0.8831 | 1 | 0.9004 | 0.9780 | 0.8214 |
| **Comprehensive Universities** | | | | | | |
| *Universiti Islam Antarabangsa Malaysia* | 1 | 1 | 0.8671 | 1 | 1 | 0.5831 |
| *Universiti Malaysia Sarawak* | 1 | 0.9479 | 0.9483 | 0.8230 | 0.8889 | 0.9713 |
| *Universiti Malaysia Sabah* | 1 | 1 | 0.8732 | 1 | 1 | 1 |
| *Universiti Teknologi MARA* | 1 | 0.9974 | 1 | 1 | 0.8706 | 1 |
| **Focused Universities** | | | | | | |
| *Universiti Utara Malaysia* | 0.9832 | 0.6219 | 0.9769 | 1 | 1 | 1 |
| *Universiti Pendidikan Sultan Idris* | 1 | 1 | 1 | 1 | 1 | 1 |
| *Universiti Malaysia Terengganu* | 1 | 1 | 1 | 1 | 1 | 1 |
| *Universiti Sains Islam Malaysia* | 1 | 0.4307 | 1 | 1 | 0.8587 | 1 |
| *Universiti Tun Hussein Onn* | 1 | 0.9355 | 1 | 1 | 1 | 1 |
| *Universiti Teknikal Melaka Malaysia* | 1 | 1 | 1 | 1 | 1 | 1 |
| *Universiti Malaysia Pahang* | 1 | 1 | 1 | 1 | 1 | 1 |
| *Universiti Malaysia Perlis* | 1 | 1 | 1 | 1 | 0.8965 | 1 |

**Source:** Author's calculations.

[12] One of the possible reasons for this finding may be that frontier approaches offer only *relative* technical efficiency measures, not absolute efficiency. The technical efficiency measure is a measure of the distance between an observed data point and a point on the production frontier, which may differ from the true technology (production frontier) in an efficient higher education sector. Therefore comparisons between the universities are still likely to be reliable (Johnes, 2006a; 2008).

In term of the universities' scale efficiency (OSE), Table 6.12 shows that some of universities from the focused-universities sub-group were found to be inefficient in 2006 and 2007 (e.g. *Universiti Malaysia Terengganu* and *Universiti Malaysia Perlis*). However, Table 6.13 shows that all of these universities became scale efficient (OSE=1.00) after 2007, which coincided with their being upgraded from university colleges to universities. This structural improvement could be due to the 2007 introduction of the NHESP, which enabled these institutions to optimise their size and economies of scale. However, Table 6.13 shows that some of the universities (e.g. *Universiti Utara Malaysia* and *Universiti Sains Islam Malaysia*) became considerably scale inefficient after 2007, suggesting that there is significant room for their improvement toward scale optimisation to achieve the optimisation level for higher education services. In terms of mix efficiency (OME), Tables 6.12 and 6.13 show that three of the universities (*Universiti Kebangsaan Malaysia*, *Universiti Islam Antarabangsa Malaysia* and *Universiti Malaysia Sarawak*) were found to be mix inefficient during all the reported years, indicating they have not used the best mix of resources to optimise their services.

Table 6.14 summarises the estimated means of output-oriented technical efficiency (OTE), output-oriented scale efficiency (OSE) and output-oriented mix efficiency (OME) in three sub-groups of the universities (i.e. research universities, comprehensive universities, focused universities) and in the sector as a whole for the period 2006–2009. Columns 3 to 5 of Table 6.14 list the means of OTE, OSE and OME for each year.

This table reveals that the technical efficiency and mix efficiency for the sector as a whole decreased between 2006 and 2007 then rose notably after 2007. More specifically, OTE increased from 0.9561 in 2007 to 0.9993 in 2008, and OME improved greatly, from 0.8755 in 2007 to 0.9709 in 2008. It should be noted that although the mean values for OTE and OME

fell in 2009, these values were still higher than those observed prior to 2008, suggesting an overall improvement in the sector after the implementation of policy reforms embedded in the 2007 NHESP. One may argue that the positive changes occurring after 2007 were mainly related to the implementation of the NHESP, which helped the public universities to enhance their staff and resource usage efficiency.

**Table 6.14: Estimates of Output-Oriented Technical, Scale and Mix Efficiency under the Hicks-Moorsteen Method (2006–2009)**

| University | Year | OTE | OSE | OME |
|---|---|---|---|---|
| *Research Universities* | 2006 | 0.9784 | 0.9986 | 0.9784 |
| | 2007 | 1.0000 | 0.9823 | 0.9679 |
| | 2008 | 1.0000 | 0.9766 | 0.9936 |
| | 2009 | 0.9718 | 0.9944 | 0.9412 |
| *Comprehensive Universities* | 2006 | 0.9496 | 0.9925 | 0.9486 |
| | 2007 | 0.9390 | 0.9836 | 0.7521 |
| | 2008 | 1.0000 | 0.9863 | 0.9222 |
| | 2009 | 0.9558 | 0.9399 | 0.8886 |
| *Focused Universities* | 2006 | 1.0000 | 0.8990 | 0.8939 |
| | 2007 | 0.9292 | 0.9889 | 0.9066 |
| | 2008 | 0.9979 | 0.8735 | 0.9971 |
| | 2009 | 1.0000 | 0.9649 | 1.0000 |
| *The Industry* | 2006 | 0.9759 | 0.9634 | 0.9403 |
| | 2007 | 0.9561 | 0.9849 | 0.8755 |
| | 2008 | 0.9993 | 0.9455 | 0.9709 |
| | 2009 | 0.9760 | 0.9679 | 0.9433 |

Note: OTE is output-oriented technical efficiency; OSE is output-oriented scale efficiency; OME is output-oriented mix efficiency.
**Source:** Author's calculations.

In terms of scale efficiency, the results are quite mixed. For instance, the focused-universities sub-group showed low levels of scale efficiency in 2006 and 2008 and high levels in 2007 and 2009. This may be due to the fact that most of these universities had been upgraded from colleges to universities, and were not operating on an optimal scale. However, the public universities do not necessarily need to be scale efficient. For example, one possible reason for scale inefficiency could be that these universities have had to follow government prescribed

policies such as the opening of additional branches in rural areas, as well as encouraging employment of additional staff in such areas.

## 6.5 Decomposition of the Hicks-Moorsteen TFP Index

Table 6.15 presents the summary results of the industry estimated changes in total factor productivity indices ($\Delta TFP$) and their components; these results have been used to analyse the main reasons for the TFP changes in the sector. Next, focusing on the performance of the individual universities, Tables 6.16, 6.17 and 6.18 present the values for the TFP changes of the institutions and their components during the periods 2006–2007, 2007–2008 and 2008–2009. The three components of the efficiency changes ($\Delta Eff$) – changes in output-oriented pure technical efficiency ($\Delta OTE$), in output-oriented residual scale efficiency ($\Delta ROSE$) and in output-oriented mix efficiency ($\Delta OME$) – are shown in columns 6, 7 and 8, respectively. The interpretation of the findings in these tables is straightforward. Estimated values greater than unity indicate improvement in the corresponding changes, and estimated values less than unity show deterioration in the corresponding measures.

A cursory look at Table 6.15 shows that mix efficiency change ($\Delta OME$) is the major component of the changes in efficiency ($\Delta Eff$) in all periods. For instance, in 2006–2007, the sector experienced a significant deterioration in $\Delta Eff$ by 56.83% ($\Delta Eff$=0.4317), which was attributable to the 59.4% negative change of $\Delta OME$ ($\Delta OME$=0.406). However, the sector's efficiency change improved markedly by 302.31% ($\Delta Eff$=4.0231) in 2007–2008 and 45% ($\Delta Eff$=1.452) in 2008–2009 because of large mix efficiency improvements of 1.9695% ($\Delta OME$=2.9695) in 2007–2008 and 53.23% ($\Delta OME$=1.5323) in 2008–2009. This reflects an overall improvement in the way the universities' resources were allocated in the post-NHESP era.

**Table 6.15: TFP Changes and Their Components for Different University Sub-Groups between 2006 and 2009 under the Hicks-Moorsteen Method**

| University | Period | ΔTFP | ΔTech | ΔEff | ΔOTE | ΔROSE | ΔOME |
|---|---|---|---|---|---|---|---|
| *Research Universities* | 2006–2007 | 0.9793 | 3.2118 | 0.3049 | 1.0228 | 0.9897 | 0.3012 |
| | 2007–2008 | 1.2026 | 0.3188 | 3.7723 | 1.0000 | 1.0271 | 3.6729 |
| | 2008–2009 | 1.7212 | 1.1167 | 1.5413 | 0.9718 | 0.9476 | 1.6738 |
| *Comprehensive Universities* | 2006–2007 | 0.9817 | 3.2118 | 0.3057 | 1.0021 | 0.7784 | 0.3919 |
| | 2007–2008 | 1.2177 | 0.3188 | 3.8198 | 1.0704 | 1.3938. | 2.5603 |
| | 2008–2009 | 1.2050 | 1.1167 | 1.0790 | 0.9558 | 0.9605. | 1.1755 |
| *Focused Universities* | 2006–2007 | 2.3048 | 3.2118 | 0.7176 | 0.9292 | 1.4715 | 0.5249 |
| | 2007–2008 | 1.3392 | 0.3188 | 4.2009 | 1.1613 | 1.3522 | 2.6754 |
| | 2008–2009 | 1.9617 | 1.1167 | 1.7567 | 1.0021 | 1.0030 | 1.7478 |
| *The Industry* | 2006–2007 | 1.3865 | 3.2118 | 0.4317 | 0.9847 | 1.0799 | 0.4060 |
| | 2007–2008 | 1.2826 | 0.3188 | 4.0231 | 1.0772 | 1.2577 | 2.9695 |
| | 2008–2009 | 1.6215 | 1.1167 | 1.4520 | 0.9766 | 0.9703 | 1.5323 |

Note: $\Delta TFP = \Delta Tech \times \Delta Eff$ and $\Delta Eff = \Delta OTE \times \Delta ROSE \times \Delta OME$.
**Source**: Author's calculations.

Table 6.15 shows that Δ*OME* is also the most important component of the TFP changes in 2007–2008 and 2008–2009. As a result of large mix efficiency changes in these periods, the sector experienced TFP growth of 28.3% and 62.15% in 2007–2008 and 2008–2009, respectively. Δ*Tech* was found to be the second important component of TFP changes. Table 6.15 shows that Δ*Tech* appears to be the same for each university in all periods, suggesting that all institutions had the same access to the same production possibility set. As a result, any shifts in the production possibility set resulting from changes in external factors and–or government intervention can affect all universities equally, either in terms of improvement or worsening of the production frontier. This is entirely consistent with the theory behind technical changes explained by O'Donnell (2010a).

Table 6.15 shows that although the sector experienced negative changes in Δ*Tech* during 2007–2008, it showed a remarkable growth in Δ*Tech* in 2006–2007 and 2008–2009. Hence, one may conclude that the sector's Δ*Tech* largely improved during 2006–2009. One possible

explanation for this positive achievement can be related to the widespread use of information technology and e-learning initiatives launched within the Malaysian universities in this period. As highlighted by Johnes (2008), an increased use of technology and e-learning activities can facilitate the accessibility of information for students, diversify teaching methods and boost administrative efficiency. In addition, Johnes (2008) states that the technological improvements can also strengthen universities' research capability to undertake further collaborative research.

A general comparison of TFP changes of different sub-groups, shown in Table 6.15, reveals that research and comprehensive universities that had been experiencing productivity regress before 2007 showed considerable productivity growth after the implementation of the NHESP. Table 6.15 also reveals that the focused universities recorded better performance than the other two sub-groups in all of the periods. In sum, this study's results provided convincing evidence that the sector as a whole enjoyed significant productivity progress during the sample period (2006–2009), particularly over the post-NHESP era (2008–2009). Tables 6.16 to 6.18 show the performance of the individual universities. These tables show that in 2006–2007 more than half of the institutions (10 universities) experienced TFP regress. However, this number decreased to six and four in the periods 2007–2008 and 2008–2009, respectively.

A comparison of Tables 6.16 to 6.18 reveals that in the post-NHESP period (after 2007), research and comprehensive universities recorded better performance than focused universities. Almost all institutions of these two sub-groups showed TFP progress in this period. Tables 6.16 to 6.18 also show that one of the research universities (*Universiti Kebangsaan Malaysia*) and one of the comprehensive universities (U*niversiti Islam Antarabangsa Malaysia*) showed positive changes in the TFP index over all periods. It should

be added that the findings reveal that the focused universities were affected by technological changes (Δ*Tech*) more than the institutions of the other sub-groups. It becomes very obvious by comparing these universities' TFP changes in the period 2007–2008 reveals where technology regress of the sector offsets the improvements in efficiency (Δ*Eff*) of these universities and leads to the TFP regression of four of them.

**Table 6.16: TFP Change and its Components for Individual Universities in 2006–2007 under the Hicks-Moorsteen Method**

| University | ΔTFP | ΔTech | ΔEff | ΔOTE | ΔROSE | ΔOME |
|---|---|---|---|---|---|---|
| *Research Universities* | | | | | | |
| Universiti Malaya | 0.8813 | 3.2118 | 0.2744 | 1.0000 | 0.2880 | 0.9529 |
| Universiti Sains Malaysia | 0.9052 | 3.2118 | 0.2818 | 1.0000 | 0.2818 | 1.0000 |
| Universiti Kebangsaan Malaysia | 1.0600 | 3.2118 | 0.3300 | 1.0687 | 0.3203 | 0.9641 |
| Universiti Putra Malaysia | 0.9996 | 3.2118 | 0.3112 | 1.0000 | 0.3112 | 1.0000 |
| Universiti Teknologi Malaysia | 1.0551 | 3.2118 | 0.3285 | 1.0455 | 0.3046 | 1.0317 |
| *Comprehensive Universities* | | | | | | |
| Universiti Islam Antarabangsa Malaysia | 1.1838 | 3.2118 | 0.3686 | 1.2524 | 0.4385 | 0.6711 |
| Universiti Malaysia Sarawak | 0.7623 | 3.2118 | 0.2373 | 0.9127 | 0.5160 | 0.5040 |
| Universiti Malaysia Sabah | 0.9195 | 3.2118 | 0.2863 | 0.8432 | 0.3618 | 0.9384 |
| Universiti Teknologi MARA | 0.8067 | 3.2118 | 0.2512 | 1.0000 | 0.2512 | 1.0000 |
| *Focused Universities* | | | | | | |
| Universiti Utara Malaysia | 0.5617 | 3.2118 | 0.1749 | 1.0000 | 1.0000 | 1.0000 |
| Universiti Pendidikan Sultan Idris | 0.4686 | 3.2118 | 0.1459 | 1.0000 | 1.0000 | 1.0000 |
| Universiti Malaysia Terengganu | 2.0902 | 3.2118 | 0.6508 | 1.0000 | 1.0000 | 1.0260 |
| Universiti Sains Islam Malaysia | 0.5971 | 3.2118 | 0.1859 | 1.0000 | 1.0000 | 1.0000 |
| Universiti Tun Hussein Onn | 1.2975 | 3.2118 | 0.4040 | 1.0000 | 0.2609 | 0.9587 |
| Universiti Teknikal Melaka Malaysia | 0.7573 | 3.2118 | 0.2358 | 0.4335 | 1.0239 | 1.0845 |
| Universiti Malaysia Pahang | 1.5151 | 3.2118 | 0.4717 | 1.0000 | 0.4717 | 1.0000 |
| Universiti Malaysia Perlis | 2.1490 | 3.2118 | 0.6690 | 1.0000 | 0.2280 | 2.9341 |

**Note:** Δ*TFP* = Δ*Tech* × Δ*Eff* and Δ*Eff*= Δ*OTE* × Δ*ROSE*× Δ*OME*.
**Source**: Author's calculations.

As expected theoretically, Tables 6.16 to 6.18 show that Δ*Tech* is the same for each university in all periods, suggesting that all the universities had the same access to the same production possibility set. As a result, any changes in the production possibility set that can be caused by changes in the environment and/or government intervention will affect all

universities equally, in terms of either improvement or deterioration of the production frontier. This is entirely consistent with the theory behind technical changes explained by O'Donnell (2008)[13]. In 2006–2007 (Table 6.16) and 2008–2009 (Table 6.18) the Δ*Tech* in all universities is greater than unity.

**Table 6.17: TFP Change and its Components for Individual Universities in 2007–2008 under the Hicks-Moorsteen Method**

| University | ΔTFP | ΔTech | ΔEff | ΔOTE | ΔROSE | ΔOME |
|---|---|---|---|---|---|---|
| *Research Universities* | | | | | | |
| Universiti Malaya | 1.2653 | 0.3188 | 3.9691 | 1.0000 | 3.7821 | 1.0494 |
| Universiti Sains Malaysia | 1.3696 | 0.3188 | 4.2961 | 1.0000 | 4.2961 | 1.0000 |
| Universiti Kebangsaan Malaysia | 1.4516 | 0.3188 | 4.5533 | 1.0000 | 4.3781 | 1.0400 |
| Universiti Putra Malaysia | 1.0611 | 0.3188 | 3.3285 | 1.0000 | 3.3285 | 1.0000 |
| Universiti Teknologi Malaysia | 0.8602 | 0.3188 | 2.6982 | 1.0000 | 2.5798 | 1.0459 |
| *Comprehensive Universities* | | | | | | |
| Universiti Islam Antarabangsa Malaysia | 1.5770 | 0.3188 | 4.9468 | 1.0000 | 3.7913 | 1.3048 |
| Universiti Malaysia Sarawak | 1.0041 | 0.3188 | 3.1496 | 1.0957 | 1.2284 | 2.3399 |
| Universiti Malaysia Sabah | 0.7738 | 0.3188 | 2.4272 | 1.1860 | 2.1994 | 0.9305 |
| Universiti Teknologi MARA | 1.0015 | 0.3188 | 3.1464 | 1.0000 | 3.1464 | 1.0000 |
| *Focused Universities* | | | | | | |
| Universiti Utara Malaysia | 1.0145 | 0.3188 | 3.1822 | 0.9832 | 3.3130 | 0.9769 |
| Universiti Pendidikan Sultan Idris | 2.3614 | 0.3188 | 7.4073 | 1.0000 | 7.4073 | 1.0000 |
| Universiti Malaysia Terengganu | 0.5698 | 0.3188 | 1.7873 | 1.0000 | 1.7873 | 1.0000 |
| Universiti Sains Islam Malaysia | 0.3449 | 0.3188 | 1.0818 | 1.0000 | 1.0818 | 1.0000 |
| Universiti Tun Hussein Onn | 1.9466 | 0.3188 | 6.1061 | 1.0000 | 1.5932 | 3.8326 |
| Universiti Teknikal Melaka Malaysia | 1.0755 | 0.3188 | 3.3736 | 2.3068 | 1.4509 | 1.0079 |
| Universiti Malaysia Pahang | 0.6377 | 0.3188 | 2.0002 | 1.0000 | 2.0002 | 1.0000 |
| Universiti Malaysia Perlis | 0.8828 | 0.3188 | 2.7691 | 1.0000 | 2.7691 | 1.0000 |

**Note:** Δ*TFP* = Δ*Tech* × Δ*Eff* and Δ*Eff*= Δ*OTE* × Δ*ROSE*× Δ*OME.*
**Source**: Author's calculations.

13 According to O'Donnell (2010a; 2010c), Δ*Tech* measures the difference between the maximum TFP possible using the period-*t* technology and the maximum TFP possible using the period-*s* technology. This can be seen in Figure 5.1, where in term of angles, $TFP_t^* / TFP_s^* = \tan a / \tan e$. Based on Table 6.16, 6.17 and 6.18, the measure of technical changes is identical for every university in any period, indicating that every university faces the same production technology. Thus, any expansion or contraction in the production possibilities set will generate equal impact toward all universities. O'Donnell (2008) and Arjomandi et. al. (2012) have also found the same result highlighted that changes in the production possibilities set (Δ*Tech*) can be attributable to any changes in the environment, where it will capture any changes in the environment and-or government policies.

**Table 6.18: TFP Change and its Components for Individual Universities in 2008–2009 under the Hicks-Moorsteen Method**

| University | ΔTFP | ΔTech | ΔEff | ΔOTE | ΔROSE | ΔOME |
|---|---|---|---|---|---|---|
| *Research Universities* | | | | | | |
| Universiti Malaya | 2.3623 | 1.1167 | 2.1155 | 1.0000 | 2.2724 | 0.9310 |
| Universiti Sains Malaysia | 2.1618 | 1.1167 | 1.9360 | 1.0000 | 1.9360 | 1.0000 |
| Universiti Kebangsaan Malaysia | 1.0279 | 1.1167 | 0.9205 | 0.9587 | 0.9743 | 0.9855 |
| Universiti Putra Malaysia | 2.4105 | 1.1167 | 2.1586 | 1.0000 | 2.1586 | 1.0000 |
| Universiti Teknologi Malaysia | 0.8486 | 1.1167 | 0.7600 | 0.9004 | 1.0276 | 0.8214 |
| *Comprehensive Universities* | | | | | | |
| Universiti Islam Antarabangsa Malaysia | 1.1470 | 1.1167 | 1.0272 | 1.0000 | 1.5276 | 0.6724 |
| Universiti Malaysia Sarawak | 0.9388 | 1.1167 | 0.8407 | 0.8230 | 0.9973 | 1.0243 |
| Universiti Malaysia Sabah | 1.1307 | 1.1167 | 1.0125 | 1.0000 | 0.8841 | 1.1452 |
| Universiti Teknologi MARA | 1.4436 | 1.1167 | 1.2928 | 1.0000 | 1.2928 | 1.0000 |
| *Focused Universities* | | | | | | |
| Universiti Utara Malaysia | 1.4881 | 1.1167 | 1.3326 | 1.0171 | 1.2799 | 1.0236 |
| Universiti Pendidikan Sultan Idris | 0.6066 | 1.1167 | 0.5432 | 1.0000 | 0.5432 | 1.0000 |
| Universiti Malaysia Terengganu | 1.4661 | 1.1167 | 1.3129 | 1.0000 | 1.3129 | 1.0000 |
| Universiti Sains Islam Malaysia | 6.9934 | 1.1167 | 6.2627 | 1.0000 | 6.2627 | 1.0000 |
| Universiti Tun Hussein Onn | 0.9130 | 1.1167 | 0.8176 | 1.0000 | 0.8176 | 1.0000 |
| Universiti Teknikal Melaka Malaysia | 1.6497 | 1.1167 | 1.4773 | 1.0000 | 1.4773 | 1.0000 |
| Universiti Malaysia Pahang | 1.0272 | 1.1167 | 0.9198 | 1.0000 | 0.9198 | 1.0000 |
| Universiti Malaysia Perlis | 1.5284 | 1.1167 | 1.3687 | 1.0000 | 1.3687 | 1.0000 |

Note: $\Delta TFP = \Delta Tech \times \Delta Eff$ and $\Delta Eff = \Delta OTE \times \Delta ROSE \times \Delta OME$.
**Source**: Author's calculations.

One possible explanation is the development of information technology and e-learning in Malaysian universities. As highlighted by Johnes (2008), the increased use of technology has increased the accessibility of information for students, causing improvement in teaching methods and raised administrative efficiency. In addition, the improved communication caused by technology also strengthens the universities' research capability in areas in which collaborative research can be undertaken. As a result, the university's activities overall are influenced by the increased implementation of information technology.

## 6.6 Summary

The results of empirical analysis of Malaysian public higher education institutions have been presented in this chapter using two different DEA-based approaches (the bootstrapped Malmquist TFP index and the Hicks-Moorsteen TFP index), covering the period 2006 to 2009. Sections 6.2 and 6.3 presented the empirical results for efficiency scores that were generated from bootstrapped DEA models and empirical results of the bootstrapped Malmquist indices. The bootstrap procedure ensures that the majority of our estimates are statistically significant. The empirical results for the Hicks-Moorsteen TFP indices and efficiency scores have been presented in Sections 6.4 and 6.5.

Based on our findings, under both methods, the sector's efficiency level decreased during 2006–2007, then significantly improved soon after the implementation of the NHESP in 2007–2008 and again slightly declined during 2008–2009. However, the overall efficiency gained during the entire sample showed a significant improvement. One can thus argue that the NHESP has improved the absolute efficiency of the universities by shifting the production possibility frontiers outwards, and has ultimately increased universities' TFP growth. The NHESP was aimed at strengthening the principles of good governance in the university delivery system, improving accessibility and equity of resources in the public higher education sector, enhancing the universities' innovation capabilities and the quality of teaching and learning. Thus, it may be stated that the NHESP has positively affected the efficiency of various groups of Malaysian universities.

Overall mean efficiency score results under the two approaches across all Malaysian public universities suggest that these universities are operating at a reasonably high level of efficiency relative to each other, even though there is room for improvement in a number of universities. These results are broadly consistent with the finding of other similar higher

education efficiency studies (e.g. Athanassopoulos & Shale, 1997; Johnes, 2006a; Avkiran, 20001; Abbott & Doucouliagos, 2003). This is likely due the fact that, although Malaysian public universities have no profit motivation, global forces are exerting increasing influence to give more focus on efficiency to attract the best students and research funding.

Regardless of the techniques used in this study, three of the universities (*Universiti Sains Malaysia*, *Universiti Pendidikan Sultan Idris* and *Universiti Malaysia Pahang*) were found to be the most efficient institutions across all the periods, producing more output per input unit than the other universities. Specifically, these universities were the most technically efficient universities in most years. This result shows that these universities might be considered the best-practice benchmarks in the Malaysian public higher education sector during the period of study.

In terms of TFP changes, both approaches found that the sector as a whole experienced positive improvements in productivity during the period 2006–2009, particularly during the post-NHESP era (2008–20090. Under the bootstrapped Malmquist TFP index approach, the major component of the sectoral TFP changes in all periods was technology changes (Δ*Tech),* and not efficiency changes (Δ*Eff*). Under the Hicks-Moorsteen TFP index approach the key components of ΔTFP in the sector were changes in mix efficiency in addition to technical changes (Δ*Tech*). These findings are useful because under both approaches technical change (Δ*Tech*) is a major reason behind TFP improvement in this sector.

One may argue that such achievements are the result of advancements in information, communication and technology as well as the increased use of e-learning facilities in the public higher education sector. Moreover, the implementation of the NHESP in 2007 fostered more usage and absorption of ICT and promoted the universities' international image. This

plan allowed the universities to improve their technological capabilities, which helped the expansion of the frontier and at the same time boosted productivity changes in the sector. This result is aligned with previous international higher education productivity studies, which found that technological changes were a significant factor in university productivity growth (e.g., Flegg et al., 2004; Johnes, 2008; Worthington & Lee, 2008).

The result also reveals that in the pre-NHESP period, TFP improvements were achieved mainly within the focused universities, whereas in the post-NHESP period all three university sub-groupings (research, comprehensive and focused universities) benefitted from significant TFP rises. Therefore, one may conclude that the government higher education policies in the post-NHESP period have indiscriminately improved the productivity and efficiency of the Malaysian public universities.

# Chapter Seven
# Policy Implication of the Study

## 7.1 Introduction

The previous chapter empirically investigated the technical efficiency and productivity changes of 17 Malaysian public universities using two different DEA-based techniques (the bootstrapped Malmquist TFP index and the Hicks-Moorsteen TFP index) for the period 2006–2009. The empirical findings indicate that no matter which techniques are taken into consideration, the *Universiti Sains Malaysia*, *Universiti Pendidikan Sultan Idris* and *Universiti Malaysia Pahang* were consistently found to be the most efficient institutions across all the periods. The overall mean efficiency scores under the two approaches across all public universities also suggest that these universities are operating at a reasonably high level of efficiency relative to each other, even though there is room for improvement in a number of universities.

Over time, the sector's efficiency level decreased during 2006–2007, and then significantly improved soon after the implementation of the NHESP in 2007–2008 and again slightly declined again during 2008–2009. However, the overall efficiency gained during the entire sample showed a significant improvement. These results suggest that the current policies, particularly the NHESP, have played important roles in improving efficiency levels in this sector. Thus, policy makers in the Ministry of Higher Education should give greater priority to initiating innovative policy and redesigning current policy to further improve and sustain high overall economic efficiency levels in the higher education sector.

In terms of productivity analysis the results indicate that under both approaches, the sector as whole experienced positive improvements in productivity during the period 2006–2009, particularly over the post-NHESP era (2008–2009). Under the bootstrapped Malmquist TFP index approach, the major significant component of the sectoral TFP changes in all periods was technology change (Δ*Tech),* not efficiency change (Δ*Eff*). Under the Hicks-Moorsteen TFP index approach the key components of Δ*TFP* in the sector were changes in mix efficiency and technical changes (Δ*Tech*). These findings are useful because under both approaches a technical change (Δ*Tech*) appears to have played a major role in TFP improvements in the sector; this shows the positive effect of environmental changes (e.g. government policies) on the sector's performance.

A general comparison of TFP changes in different sub-groups of universities reveals that in the pre-NHESP era (2006–2007) under both approaches, TFP improvements were achieved mainly within the focused universities, whereas in the post-NHESP period (2008–2009) all three university sub-groups (research, comprehensive and focused universities) benefitted from significant TFP rises. Therefore, one may conclude that the government's higher education policies in the post-NHESP period have indiscriminately improved the productivity and efficiency of the Malaysian public universities.

Overall, public universities in Malaysia have recorded a large improvement in productivity growth, especially after the implementation of the NHESP. Moreover the DEA results also show improvement in technical efficiency. If these trends continue, the public universities may move closer to the best practice exemplified by frontier universities. Nevertheless, the sector as a whole cannot attain its full potential if inefficiencies continue to exist. One may argue that the implementation of the NHESP beginning in 2007 has probably been the main driving force for enhanced efficiency and productivity growth. Thus, there are a number of

important policy consequences arising from the empirical results of the present study that could lead to sustainability in efficiency and productivity growth of the higher education sector in Malaysia.

## 7.2 Implications of the Results

Several implications arise from the high efficiency and positive productivity change in the Malaysian public higher education sector during the period of study, particularly following the implementation of the NHESP. First, although the universities have achieved a high level of efficiency, this does not mean there is no scope for improvement. For example, one may consider the situation where fairly static conditions remain in the education production frontier. The universities may manage to catch up with best-practice universities only if there is innovation and expansion in the education production frontier.

Second, from a policy perspective, improved productivity in public universities could result in a stronger accountability mechanism, better learning conditions, improved research capabilities and reduced inefficiency; these in turn can improve the universities' quality and expand the sector's performance as a whole. The challenge for policy makers is therefore to establish the environment in which higher education institutions have the capability to sustain their high efficiency and productivity growth. A number of relevant policy implications flow from this thesis. Generally, five main approaches could be considered:

1) Quality assurance mechanisms;
2) High quality teaching and innovative methods of delivery;
3) Technological innovation;

4) Input-output management in terms of universities' consistently reporting well-defined key performance indicators; and
5) Governance reform.

### 7.2.1 Quality Assurance Mechanisms

The empirical analysis under both approaches, which examined the mean efficiency of the public universities, suggests that they are operating at a reasonably high level of efficiency. This result is broadly consistent with findings generated applying DEA to universities in other countries, such as the UK (see Athanassopoulus & Shale, 1997; Johnes, 2006a) and Australia (see Avkiran, 2001; Abbot & Doucouliagos, 2003). Nevertheless, there is still scope for improvement that can sustain this efficiency. One possible action is to enhance Malaysian universities' transparency and quality assurance mechanisms. According to the World Bank (2000), appropriate and reliable accreditation and evaluation processes are needed to assure the public that course programmes and degrees offered by the universities meet acceptable academic and professional standards. The World Bank (2007) recommends that Malaysia:

- ensure that academic standards are respected and maintained across all public universities and programs;
- make sure that new programs are approved only if the demand exists and appropriate resources are available;
- simplify the process of reviewing academic standards;
- establish simpler and more transparent university entry standards and acceptance criteria;
- apply those standards and criteria to match the most academically qualified students to the best programs, whilst recognising the value of diversity; and

- ensure the autonomy of the MQA, with a mandate to apply the same standards to both private and public universities; ensure appropriate technical capacity; engage international peer reviewers; and produce transparent reports available to the public.

### 7.2.2 High Quality Teaching and Innovative Delivery Methods

DEA is a very powerful benchmarking approach that can be used to identify the most efficient or the best-practice units, as well as the inefficient units in which there is potential for real improvement. The findings of this study, under both approaches, identified three universities that can be classified as the most efficient units, namely the *Universiti Sains Malaysia*, *Universiti Pendidikan Sultan Idris*, and *Universiti Malaysia Pahang*. When specific changes are identified in the inefficient units, management can implement appropriate actions to achieve potential savings located within DEA. These changes would have the potential to make the inefficient unit performance approach the performance of the best-practice unit. Management receives information about the performance of units that can be used to help transfer the systems and managerial expertise from the better managed and relatively efficient units to the inefficient unit. One of the specific changes that could be implemented by inefficient universities is the adoption of high quality teaching and innovative delivery methods. The World Bank (2007) suggests faculty management reforms in Malaysia's inefficient universities to ensure that:

- the academic staff are not burdened with teaching loads; this allows opportunities to plan and initiate innovative teaching methods;
- senior researchers and academics are more involved in the teaching of undergraduate students; this promotes better integration of research and undergraduate education;
- student course evaluations are fed back into the organisation to influence academic staff tenure and staff promotion;

- the academic performance of the faculty staff is measured by the impact of teaching, scholarship and research, based on an agreed specific set of criteria, judged as appropriate by external and international peers; and
- the faculty shortage can be addressed by creating flexible conditions to retain qualified academics beyond the current retirement age of 58, as well as systematically releasing junior academics to fast-track the completion of the requirements for their doctorates.

### 7.2.3 Technological Innovation

The accelerated pace of new technological development has made access to knowledge a crucial requirement for participation in global economies (World Bank 2002). To sustain high efficiency and productivity growth, public universities can take advantage of the opportunities offered by new technology, which can significantly change the speed of knowledge production, use and distribution. The results under both the approaches in this study indicate that the positive productivity change between 2006 and 2009 is found to have been caused largely by technological changes (i.e., an outwardly shifting production frontier). This finding aligns with previous international higher education productivity studies, which found that technological changes were a significant factor in university productivity growth (see Flegg et al., 2004; Johnes, 2008; Worthington & Lee, 2008). An important factor driving this finding might be the result of advancements in information, communication and technology, as well as the increased use of e-learning facilities in the public higher education sector.

Therefore, the combination of increased computing power, lower hardware and software prices and improvements in wireless and satellite technologies would result in lower

telecommunication costs and the removal of space and time barriers to information access and exchange in the public universities. This will cause improvement in pedagogy and teaching methods as well as increase academics' efficiency. In addition to investing in technology for teaching, universities also need to focus on the adaptation of new technologies in the area of R&D. The convergence of increased computing power and reduced communication cost means that there are few logistical barriers to information exchange and communication, and thus collaboration, between researchers in local and international universities. Johnes (2008) argued that increasing the use and application of new technology improves all aspects of university activities. Thus, universities will gain benefits from new information and communication technologies and deliver the best services to their clients as well as sustain productivity growth in the long term.

The World Bank (2001) argues the critical importance of making appropriate, well-functioning, information and communication technologies available to the higher education sector, as they:

- simplify and reduce administrative tasks, permitting greater management efficiency and productivity;
- expand access to, and improve the quality of, instruction and learning at all levels; and
- vastly broaden access to information and data across the campus and across the globe.

### 7.2.4 Input-Output Management

According to the present study's results, under the Hicks-Moorsteen TFP index approach the key components of $\Delta TFP$ in the sector before the implementation of the NHESP were attributed to mix inefficiency. This can be attributed to the government giving these universities insufficient autonomy to manage their inputs and outputs, particularly the

capacity to enrol the most qualified students and the capacity to recruit the most competent academic staff and researchers. To improve this situation, the government need to redesign and rethink their policy measures with the objective of increasing university autonomy. Ideally, public universities would be given the power to:

- Enrol students based on institution-specific criteria.

Currently, students are centrally allocated to universities notwithstanding that universities may independently determine their minimum cumulative grade point average requirement for entry to specific programs. Students may rank up to eight programs and universities of their choice, but the Ministry of Higher Education has the final say in allocating students.

- Offer competitive remuneration and employment conditions to retain and engage the best academics relative to their needs.

In Malaysia academics are classified as civil servants, and their remuneration scale is fixed. Public universities are only able to offer remuneration according to the scale, and may not offer additional incentives to attract academicians of their choice. It is also recommended that all public universities adhere to the principles of accountability and facilitate future productivity by reporting well-defined key performance indicators to the Ministry of Higher Education. An efficiency study makes such reporting more accurate.

### 7.2.5 Reforms in Governance, Resources and Financing

The NHESP has positively affected the Malaysian public higher education sector. The analysis of efficiency and productivity change in this study shows that the Malaysian public universities can capitalise on the opportunity created by the NHESP to gain high levels of efficiency and productivity. According to the findings of this thesis, there has been an overall improvement in the sector's efficiency since the implementation of the NHESP. In addition, a general comparison of TFP changes in different university sub-groups reveals that in the

post-NHESP period (2008–2009) all three university sub-groups benefitted from this plan, showing significant TFP improvements. Nevertheless, despite many positive outcomes from the implementation of the NHESP, it is necessary that the nation's universities continue to modify the governance structure to move closer to optimum management functionality. The World Bank (2000) has identified a number of areas where immediate, practical reforms are required for the higher education systems in developing countries, including governance, resource allocation and financial reforms. The following detailed suggestions provide an indication of the reforms proposed:

a) Governance reform

Malaysian higher education policy makers should consider the implementation of longer-term governance reforms in Malaysian public universities that include:

- Ensuring that their mission, priorities and academic orientation complement each other at the national and regional levels;
- Encouraging the pursuit of diverse missions to enable them to respond to the needs of their constituencies;
- Increasing their autonomy in return for full accountability;
- Empowering their independence to make decisions about mission, governance, hiring of academic leaders, hiring of academic and non-academic staff, selecting students and introducing new programs and courses; and
- Ensuring that the academic context and governance structures create a climate conducive to upholding academic values of autonomy, freedom of expression, collegiality and integrity.

b) Resource-allocation mechanism reform

Malaysia relies on a traditional negotiated-allocation approach for distribution of budget funding amongst public universities. Each university submits an annual budget proposal based on intake numbers specified by the Ministry of Higher Education. The Ministry of Finance makes the final allocation based on the previous year's allocation plus a small increase dependent on the overall availability of public resources. In 1997, to improve accountability and transparency, the Government introduced the Modified Budgeting System (MBS) to operate as an output-oriented budget-allocation mechanism, bringing the universities in line with all other statutory bodies in Malaysia. In practice, however, the final budget allocation has continued to be determined through negotiation without reliance on output measures. Funds are distributed on the basis of an incremental cost approach linked to inputs. The main drawback of the present system is that in negotiated budgets the amount of resources allocated does not reflect the cost structure or performance of the recipient universities. The system provides no incentives for universities to manage their resources efficiently and improve their labour-market results.

In 2004, in an attempt to adopt an allocation mechanism that would stimulate more effective use of public resources, the Ministry of Higher Education implemented a funding formula to align the budget-allocation process with the Government's policy goals for the university sector. However, formula funding is not the only method to encourage universities to more effectively improve quality and relevance. Over the past decade in various parts of the world, a number of innovative allocation mechanisms that link funding directly to some measure of outputs or outcomes have been implemented. These performance-based funding approaches differed from most other allocation approaches: 1) they attempted to reward institutions for actual rather than promised performance; 2) they tended to use performance indicators that

reflected public-policy objectives rather than institutional needs; and 3) they included incentives for institutional improvement, not just maintaining the status quo.

The World Bank (2007) suggested the following four types of innovative allocation mechanisms for consideration as performance-based funding in the Malaysian public higher education sector:

- performance contracts, where the government enters into regulatory agreements with institutions to set mutual performance-based objectives;
- performance allocations, where a portion of public funding for a university is allocated for payment upon the achievement of pre-determined performance measures;
- competitive funds, sought through peer-reviewed proposals and designed to achieve institutional improvement or national policy objectives;
- payments for results, where output, or outcome, measures are used to determine all or some of the funding; for example, payment for the number of graduating students, with higher amounts available for graduates in certain fields of study or with specific skills.

c) Funding reform

Universities by nature require financial stability to develop in an orderly way. A major challenge for the Malaysian government is to further increase access to higher education to meet growing social demands and satisfy the increasing need for a skilled workforce. Thus, financial reform is required to establish a sustainable finance system that encourages responsiveness and flexibility. Rapid growth in public-university enrolments cannot be achieved using the traditional model of building and funding universities with government budgetary resources. Given the prevailing constraints on further expansion of the higher education budget, the World Bank (2007) suggested two strategies for financial reform in Malaysian public universities:

- Increased resource diversification

Public funding remains the main source of support for higher education in most countries in the world. However, public universities have attempted to complement their revenues in many ways, such as generating business income from institutional assets, seeking donations and sponsorships from commercial organisations and philanthropists and mobilising additional resources from students and their families. The Ministry of Higher Education could provide financial incentives to encourage public universities to generate additional resources through continuing-education programs, consultancies and research contracts in the commercial sector and other income-generating mechanisms.

- Balanced growth of the university and non-university sub-sectors, with clear quantitative targets

Instead of expanding the university sector, an enrolment strategy can be implemented in a more financially manageable way from a public-resources perspective. Whilst protecting the resource base of the public universities by absorbing a significant proportion of secondary-school graduates, the non-university institutions could offer vocational-training opportunities that respond more flexibly to labour-market demands. As part of its overall tertiary education strategy, the Malaysian government has promoted the expansion of a network of polytechnics and community colleges, as well as other types of tertiary institutions such as the Open University. Setting indicative growth targets for each sub-sector of the tertiary education system could lead to a more balanced growth of public investment in the entire tertiary education system.

Table 7.1 summarises the challenges and obstacles to Malaysian public higher education efficiency and productivity, along with policy recommendations.

**Table 7.1: Summary of Recommendations**

| Challenges and Obstacles | Recommendations |
|---|---|
| Overall mean efficiency score results under two approaches across all Malaysian public universities suggest that these universities are operating at a reasonably high level of efficiency relative to each other, even though there is room for improvement in a number of universities. | ***Establish quality assurance mechanisms***<br>- Ensure academic standards are maintained and respected across all public universities and programs;<br>- Approve new programs only if the demand exists and appropriate resources are available;<br>- Simplify the process of reviewing academic standards;<br>- Make entry standards and acceptance criteria for university simpler and more transparent;<br>- Match the most academically qualified students to the most appropriate programs;<br>- Ensure the autonomy of quality assurance bodies (MQA), with a mandate to apply the same standards to both private and public universities. These bodies should have technical capacity, involve international peer reviewers and produce transparent reports that are available to the public. |
| Three universities (*Universiti Sains Malaysia*, *Universiti Pendidikan Sultan Idris* and *Universiti Malaysia Pahang*) under both approaches were fully technically efficient universities across all the periods. | ***Develop high quality teaching and innovative methods of delivery***<br>- The academic staff is not overburdened with teaching workload and there is opportunity to initiate innovative teaching methods;<br>- Senior researchers and academics are more involved in the teaching of undergraduate students to promote a better integration of research and undergraduate education;<br>- Student course evaluations have an impact on academic staff tenure and promotion;<br>- The performance of academic staff is measured by the impact of teaching, scholarship and research, based on agreed criteria, judged as appropriate by external and international peers;<br>- The faculty shortage can be addressed by creating flexible conditions to retain qualified academics beyond the current retirement age of 58, as well as systematically releasing junior academics to fast-track the completion of the degree requirements for their doctorate. |
| Under both approaches technological changes ($\Delta Tech$) have been identified as a major reason behind TFP improvement in the sector. | ***Exploiting technological innovation***<br>- Simplify and reduce administrative tasks, making possible greater efficiency and productivity in the management of the higher education system and institutions;<br>- Expand access and improve the quality of instruction and learning at all levels;<br>- Vastly broaden access to information and data across the campus and across the globe. |

**Table 7.1: Summary of Recommendations**

| Challenges and Obstacles | Recommendations |
|---|---|
| Under the Hicks-Moorsteen TFP index approach the key components of $\Delta TFP$ in the sector during pre–NHESP were changes in mix efficiency. | ***Input-output management***<br>- Capability to choose students based on specific criteria;<br>- Opportunity to offer competitive remuneration to keep the best academics and to engage the best internationally. |
| Although, as this study has found, the implementation of the NHESP has served the public higher education sector well, the nation's universities should continue to modify the governance structure to move closer to optimum management functionality. | ***Governance, resource and financing reform***<br>- Ensure that Malaysian public universities complement each other in their mission, priorities and academic orientation at the national and regional levels;<br>- Encourage universities to pursue diverse missions so that they can respond to the needs of their constituencies; increase the autonomy of public universities and expect full accountability in return;<br>- Empower universities to make independent decisions about their mission; governance; hiring of their academic leaders, academic and non-academic staff; selecting students; and introducing new programs and courses;<br>- Ensure the academic context and governance structure creates a climate that upholds academic values including autonomy, freedom of expression, collegiality and integrity;<br>- Implement innovative allocation mechanisms (e.g. performance contracts, competitive funds, payment for results);<br>- Increase resource diversification in public universities;<br>- Ensure balanced growth of the university and non-university sub-sectors with clear quantitative targets. |

# Chapter Eight
# Summary and Conclusions

## 8.1 Introduction

The Malaysian public higher education sector consists of 20 public universities, categorised into three sub-groups: research universities, comprehensive universities and focused universities. The Malaysian government aims to boost productivity in the public higher education sector, which has been an engine for promoting the development of quality human capital in the last decade. This sector has faced new challenges and undergone fundamental changes that have led to its rapid expansion. In particular, the implementation of the NHESP in 2007 was the most important policy change in this area. Kaur and Sirat (2010) argue that the NHESP can be considered Malaysia's key policy initiative toward revolutionising and transforming the higher education sector. An important policy focus in the government agenda is to turn Malaysia into a major regional hub for higher education.

The NHESP was formulated to achieve several key factors, such as information development, communication and technology improvement, growth of internationalisation and the reinforcement of the delivery system of Malaysian universities. For this purpose, the government was determined to raise the share of research and development in GDP from 1.5% to 4.9% during this Plan (Ministry of Higher Education, 2007). The public universities were the main recipients of these national research and development funds. Therefore, it is of paramount importance to investigate how the NHESP has influenced the performance of the Malaysian public universities during 2006–2009.

The main aim of this study has been to conduct an empirical investigation of Malaysian public higher education institutions, with the focus on measuring their technical efficiency and productivity changes. By examining and analysing trends in technical efficiency and productivity changes during a four-year period from 2006 to 2009, the current thesis has systematically addressed the following four questions: a) What is the mean efficiency score of public universities in Malaysia? b) What is the TFP change in Malaysia's public higher education institutions? c) Has the implementation of the NHESP led to an improvement in the efficiency and productivity growth of the public higher education sector? and d) What are the major determinants of efficiency or inefficiency in Malaysian public universities?

This chapter summarises the key findings for each of these research questions and draws conclusions, as follows: Section 8.2 summarises the study and the main findings from the previous chapters; Section 8.3 discusses policy implications from the empirical findings; Section 8.4 highlights the specific contributions of this study; Section 8.5 outlines some of this study's limitations; and Section 8.6 suggests further research.

## 8.2 Summary of Major Empirical Findings

DEA, a non-parametric approach, was employed in this thesis to empirically analyse the technical efficiency and productivity changes in Malaysian higher education institutions. To the best of my knowledge, no previous study of higher education institutions in developing countries has employed a bootstrapped Malmquist method under the assumption of VRS, as proposed by Simar and Wilson (1999), in the measurement of efficiency and productivity changes. The bootstrap approach demonstrates that the majority of estimates obtained in this study are statistically significant. In addition, a comprehensive decomposition of the Hicks-Moorsteen TFP index, developed by O'Donnell (2010b), has been applied in this thesis. This is the first study to use the new decomposition of the Hicks-Moorsteen TFP index to analyse

efficiency and productivity changes in a higher education context. Unlike the popular Malmquist productivity index, it makes no assumption concerning a firm's optimising behaviour, the structure of markets, or the type of RTS. In this study the production technology exhibits VRS, which is plausible as universities usually operate at sub-optimal levels.

Based on the empirical findings of this study the major outcomes of this chapter can be summarised as follows:

- The mean efficiency score of Malaysian public universities under both the bootstrapped-DEA and Hicks-Moorsteen, is reasonably high. This result is consistent with other international studies of efficiency in the higher education sector (see Athanassopoulus and Shale, 1997; Johnes, 2006a; Avkiran, 2001; Abbot and Doucouliagos, 2003).
- Under both approaches, the sector's efficiency showed decreasing levels during 2006–2007, then significant improvement after the implementation of the NHESP in 2007–2008, but again slightly declined during 2008–2009. Nevertheless, the overall efficiency gained during the entire sample period showed a significant improvement.
- In terms of productivity change analysis, under both approaches, the higher education sector as a whole experienced positive productivity growth at the frontier during the post-NHESP period.
- Under both bootstrapped Malmquist and Hicks-Moorsteen approaches, the positive improvement during post-NHESP in productivity growth was mostly associated with technological improvement. This aligns with other studies on higher education productivity change, which also found that technological improvement was an important factor in university productivity growth (see Flegg et al., 2004; Johnes, 2008; Worthington & Lee, 2008).

- During the pre-NHESP period, under the Hicks-Moorsteen approach, the mix efficiency change component played an important role in TFP deterioration in the sector.
- The empirical results indicate that irrespective of the approach, during the post-NHESP period all the university sub-groups showed significant TFP progress. This finding highlights the role of the NHESP in the improvement of the overall performance of the public higher education sector.

## 8.3 Policy Implications

A number of significant policy implications have become apparent from the findings of this thesis. First, the estimated high efficiency is an important matter, as the higher education sector is a critical pillar of human development in Malaysia's economy. If this overall high efficiency is to be maintained, policy makers must revisit their higher education policies and reform measures. Several strategies could accomplish this, including establishing a transparent quality assurance mechanism; developing high quality and innovative methods of teaching delivery; and exploiting technological innovation in teaching and research. The first strategy could be achieved by ensuring that academic standards are maintained and respected across all public universities and programs; simplifying the process of reviewing academic standards; ensuring that enrolment standards and acceptance criteria for university entry are simpler and more transparent; and ensuring the autonomy of quality assurance bodies (Malaysian Qualification Agency). The second strategy would involve ensuring that academic staff are not disproportionately overburdened with teaching workloads; providing the academic staff with opportunities to plan and initiate innovative teaching methods; engaging senior researchers and academics in the teaching of undergraduate students; developing student course evaluations that may potentially influence academic staff tenure and promotion; ensuring that the academic performance of academic staff is measured in

terms of the impact of their teaching, scholarship and research; creating flexible employment conditions to retain qualified academics beyond the current retirement age of 58 years; and releasing junior academics to fast-track the completion of degree requirements for their doctorates. The third strategy could be achieved by taking advantage of new opportunities presented by the knowledge economy and the ICT revolution; simplifying administrative tasks in the management of the higher education system by using the latest technologies; expanding access and improving the quality of instruction and learning at all levels; and broadening access to information and data across campuses, and across the globe.

Second, despite the many positive impacts on the productivity growth of Malaysian public universities through the implementation of the NHESP, it is necessary for the government to continue the process of improvement by redesigning and rethinking the governance structure of the higher education sector. This is vital to ensure that the sector's structure is robust and flexible in confronting likely critical changes, including the convergent impact of globalisation, the increasing importance of knowledge as the main driver of economic growth and the information and communication revolution. This would involve reform in the areas of governance, resource allocation, accountability and financial funding. These reforms could be achieved by ensuring that the Malaysian public universities complement each other; encouraging public universities to pursue diverse missions; increasing their autonomy and expecting full accountability in return; empowering public universities to make independent decisions in several critical decision-making areas (mission, governance, hiring of their academic leaders, academic and non-academic staff, selecting students and introducing new programs and courses); and ensuring that the general academic context and governance structures uphold academic values. The reform in resource allocation would involve the development of innovative allocation mechanisms, including performance contracts, performance allocation, competitive funds and payment for results. Whilst ensuring

sustainable funding in the higher education sector, the government could consider reform in this area involving strategies of increased resource diversification in public universities, and balancing the growth of the university and non-university subsectors with clear quantitative aims.

## 8.4 Contributions of the Study

This thesis makes four significant contributions to the literature of efficiency and productivity changes in higher education institutions. First, this study is the first attempt to examine the issue of efficiency and productivity change by employing DEA and TFP indices on the multiple inputs and outputs of obtained from 17 Malaysian public universities during the period from 2006 to 2009. Second, this is the first study to measure the university efficiency and productivity growth in response to significant policy changes in the Malaysian higher education sector during 2007. The effect of the NHESP on the performance of Malaysian higher education institutions over the period of 2006–2009 in particular is investigated. Third, no previous study in developing countries has employed a bootstrapped Malmquist method under the assumption of VRS (Simar & Wilson, 1999) to measure efficiency and productivity changes in higher education institutions. Lastly, to the best of my knowledge, this is the first study to use a new decomposition of the Hicks-Moorsteen TFP index in to analyse efficiency and productivity change.

## 8.5 Limitations of the Study

Despite the relevance and urgency of this study and its theoretical and empirical merit, like any other study it has limitations; however, these offer an opportunity for further research to deepen the understanding of Malaysian public higher education institutions' efficiency and productivity. First, the current study uses the DEA methodology to compute and decompose the Hicks-Moorsteen TFP index. A problem with DEA is that it makes no allowances for the

presence of measurement and specification errors. Therefore, any measurement or specification errors in the data will be reflected in both efficiency and TFP estimates. One possible solution is to apply the bootstrapped procedure in the DEA methodology, which allows for statistical noise. Nevertheless, due to the unavailability of an appropriate software program, the programming of which was beyond the scope of this study, it was not possible to apply the bootstrapped procedure to this index. Second, data availability is also somewhat limited in this study, because it was not possible to incorporate the contextual or non-discretionary factors into the empirical analysis. As a result, the present analysis did not examine the impact of environmental factors that could influence the efficiency and productivity of Malaysian public higher education institutions.

## 8.6 Areas for Future Research

The findings and limitations of the current research suggest that this study can be extended and further investigated in several areas related to issues of efficiency and productivity. This study has measured the efficiency and productivity of the higher education sector by computing and decomposing the Hicks-Moorsteen TFP index, which is a DEA-based method. One possibility for further research is to develop new computer programming that can perform the bootstrapped procedure to the Hicks-Moorsteen TFP index.

It is also suggested that the same method of analysis can be carried out for different disciplines within public higher education institutions, instead of aggregating them as universities. Furthermore, it would be useful to add entrepreneurial universities as an additional category to the present sub-group of research, comprehensive and focused universities. This analysis would emphasise the relative trends of efficiency and productivity changes in such related groups of institutions. In addition, when data for a longer period

period (say, 2010–2012) become available, it will be possible to evaluate the full extent of the ongoing effects of the 2007 NHESP on individual universities.

Another possibility for future studies would be an empirical comparison between the public and private universities in terms of changes in efficiency and productivity overtime. An inter-sectoral analysis of efficiency and productivity change may provide an in-depth analysis of the impact of the NHESP on the higher education sector, leading to an accurate evaluation of higher educational policies. Hence, this study suggests the need to perform an inter-sectoral empirical comparison study to investigate the overall impact of such government intervention on the operational performance of the higher education sector in totality.

Future extensions of the present study could include the benchmarking of higher education performance with those of other developing economies at a similar stage of economic development. The primary focus of this benchmarking exercise would be to recognise the areas in which the higher education sector performance could be improved and determine what policies should implemented to accomplish improvements in this sector.

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## List of Candidate's Publications

### Refereed Journal Articles

Salleh, M.I., Arjomandi, A. & Valadkhani, A. 2012, 'Productivity Analysis in the Malaysian Public Universities Using a Bootstrapped Malmquist Approach', *Applied Economics*, **under review**.

Valadkhani, A., Arjomandi, A. & Salleh, M.I. 2012, 'Productivity Changes in the Malaysian Public Higher Education Sector Using the Hicks-Moorsteen TFP Index', *Asian Economic Journal*, **under review**.

### Refereed Conference Papers

Salleh, M.I., Arjomandi, A. & Valadkhani, A. 2012, 'A Use of the Hicks-Moorsteen TFP Index to Estimate Productivity Change in the Public Higher Education Sector: A Case Study of Malaysia', presented and published at the 8th Asia-Pacific Productivity Conference, 25–27 July, King Mongkut Institute of Technology Ladkrabang (KMITL), Bangkok, Thailand.