DEA Metafrontier Analysis on Technical Efficiency Differences of National Universities in Thailand

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ABSTRACT

Since the national university in Thailand has a variety of academic institutes located throughout the country, resulting in technical efficiency differences among the regions. Therefore, this study aims to measure the regional differences in technical efficiency of the 77 national universities. As a metafrontier model is able to calculate the comparable technical efficiencies for firms operating under different technologies, the concept of metafrontier estimated by Data Envelopment Analysis (DEA) was adopted to be the methodology. The frontiers were divided into five regions; Bangkok, central, north, northeast, and south. Besides, this study used the cross-section data of 2011 recorded from Office of the Higher Education Commission in Thailand. Firstly, an analytical framework necessary for the definition of a metafrontier function was described. Then, the property of the metafrontier function estimated by non-parametric DEA was exclusively explained in this research. Finally, the empirical results of the DEA metafrontier were presented and discussed.

Keywords: Cross-section data, DEA metafrontier, regional differences, technical efficiency, Thai national universities.

1. INTRODUCTION

Higher education in Thailand has been initially established by king Rama V, Phra Bat Somdet Phra Poramintharamaha Chulalongkorn Phra Chunla Chom Klao Chao Yu Hua, since 1897. At that time, the fifth monach of Siam under the House of Chakri established the school of laws, the school of medicines, the school of agriculture, and the school of military, but those could not completely offer the higher education. Currently, the higher education in Thailand is definitely able to provide three levels of degree; bachelor degree, master degree, and philosophy degree, for undergraduate and graduate students. Office of the Higher Education Commission is the organization that directly regards with all universities and colleges in Thailand.

The university in Thailand is generally separated into two groups. The first group is national universities and the latter is private universities. The national universities include four academic groups. There are autonomous universities, Rajabhat universities, Rajamagala universities, and colleges and institutes. In 2012, there are approximately 140 universities, including national and private universities, established throughout the country (Ramkhamhaeng University Library, 2011). Those universities intensively offer social science and science studies to international students and local students. In general, the national universities are more difficult to gain admission than the private universities. A student who wants to study higher education in the famous national university has to hardly take some examinations or specified skills exams in order to get an entrance to the university.

An administration of national universities in Thailand has two kinds of system. The first system is called the government university, and the other is, namely, autonomous university, making both of them are definitely different. The government university is fully supported by government in terms of financial subsidies. Budget is, therefore, directly subsidized by the central government or local government. The administration system within the university is strictly controlled by government. On the other hand, the administrative system of autonomous university is independent from government. Since their administrative managements separates from the bureaucratic system, the autonomous universities still get yearly block grant from the government in the purpose of academic insurance and university's necessary. Although, the universities are independent, their staffs are no longer civil servants.

As national universities are different in administrative system and located in different regions of Thailand, making the universities face different production opportunities. Those make technically choices in university's production from different sets of possible inputs-outputs combinations. Consequently, technical efficiency of national universities in Thailand is quite different because of differences in available stocks of human and financial capital, economic infrastructure, resource and endowments, and any other characteristics of the social and economic environment in which university's production takes place.

Battese & Coelli (1988) firstly used the generalized frontier production function with panel data to predict the firm-level technical efficiency. Later, many researchers investigated the technical efficiency for different firms/units located in different areas. For example, separate frontiers have been assessed for British universities (Glass, McKillop, & Hyndman, 1995), Canadian universities (McMillan & Chan, 2006), Australian universities (Worthington & Lee, 2005). Moreover, the separate frontiers were adopted to estimate bank branches in Spain (Lovell & Pastor, 1997) and South Africa (O'Donnell & van der Westhuizen, 2002).

After using data on a group of firms/units to measure a production frontier, the relative performance of firms/units within the group are needed to measure. However, the performance of firms across groups is interested in often consideration. Unfortunately, such comparisons are only meaningful in the limiting special case where frontiers for different groups of firms are similar. For a general rule of efficiency measurement, the efficient scores assessed relative to one frontier are able to compare with efficient scores assessed relative to another frontier.

A formal theoretical framework is conducted to make efficiency comparisons across groups of firms/units. This concept can make into the practical way by measuring efficiency relative to a common metafrontier. The metafrontier is defined as the area of an unlimited production technology set. In addition, group frontiers are proposed to be the areas of limited production technology sets. Lack of economic infrastructure and other characteristics of the production environment are the restrictions. Therefore, the production efficiency in technology assessed relative to the metafrontier can be classified into two components. The first component is a distance measurement from an input-output point to the group frontier, namely, technical efficiency (TE). The second component is a distance measurement between the group frontier and the metafrontier, namely, technical gab ratios (TGRs). The latter component represents the restrictive nature of the production environment. The differences in production technology have been investigated through standard measurements of technical efficiency (TE) and technical gap ratios (TGRs) to providing regional comparisons.

The national universities established in different regions of Thailand face dissimilarity in production opportunities. Such differences have conducted the production frontier to be the fundamental for estimating the regional technology differences in national universities. As the circumstance mentioned, a metafrontier function is led to study regional differences in technical efficiency (TE) and technical gap ratios (TGRs) of those universities. The metafrontier concept is referred to the concept of the metaproduction function, proposed by Hayami & Ruttan (1971). Its function can be considered through the envelope of traditionally neoclassical production functions.

The main objective of this research is to present how metafrontier function and group frontier work efficiently based on the concept of data envelopment analysis (DEA). The DEA is the most popular non-parametric and non-stochastic approach to efficiency measurement. Therefore, this research considers DEA approach to break down the difference in efficiency performance of technical efficiency and technical gap effects. In addition, this research focuses more details on regional comparison in production technology of all national universities by using regional level data.

2. METHOD

2.1 theory background

Since this research adopts the concept of metafrontier function to study regional differences in production technology, the analytical framework necessary for the definition of the metafrontier function is introduce at this stage. Farrell (1957) originally introduced a production frontier to measure the efficiency of firms/units. They noted that using the production frontiers was a common practice for assessing the efficiency levels. Such a frontier was evaluated by using a non-parametric method to predict on various non-stochastic assumptions. Once a frontier surface was defined, the efficiency of each unit was measured by comparison with the frontier that uses radial efficiency measurement. The frontiers were normally estimated by using cross-sectional or panel data on the level of inputs used and outputs produced of firms/units.

Then, Hayami & Ruttan (1971) defined a metafrontier concept based on the metaproduction function. They presented the envelope of traditionally conceived production functions that belong to neoclassic concept. The metafrontier concept was also developed through a formal theoretical framework for making efficiency comparisons across groups of firms/units, defining as the boundary of an unrestricted technology set.

In this research, the main method that used to assess metafrontier function is data envelopment analysis (DEA) metafrontier. DEA is one kind of methods for the production frontier's estimation. Its concept does not require a non-parametric method in economic theory and operative research (Charnes, Cooper, & Roberts, 1978). Also, it is applied to assess productive efficiency for decision making units (DMUs) or firms. The non-parametric model have the high benefit of no requiring a particular functional form/shape for the frontier; however they do not provide a general relationship (equation) relating outputs produced and input used.

The concept of efficiency measurement by using DEA metafrontier framework was gradually developed by Rao, O'Donnell, & Battese (2003). The DEA metafrontier works to assess efficiencies of firms/units in different regions that operate under different technologies. This is a threshold concept for measuring the inter-regional efficiency differences. Notably, the way to measure inter-regional efficiency is the distinguished characteristic of its model. An overarching function of a given data that surrounds the elements of any frontier production function is the meaning of the metafrontier function of firms/units (Battese, Rao, & O' Donnell, 2004).

Several studies employ the metafrontier to be the main method in their research, emphasizing on the measurement of technical efficiency (TE) and technical gap ratio (TGRs). For examples, Rao, O'Donnell, & Battese (2003) used the concept of the metafrontier functions for the study of inter-regional comparison in production technologies. Battese, Rao, & O' Donnell (2004) presented a metafrontier production function to measure firms' efficiency on garment firms in the five different regions of Indonesia.

Likewise, Rao, O'Donnell, & Battese (2008) employed the concept of metafrontier frameworks to study the firm-level efficiencies and technology ratios of inter-regional productivity comparisons of agricultural efficiency. Assaf, Barros, & Josiassen (2010) measured the operative efficiency of 78 Taiwanese hotels. Huang, Chen, & Yang (2010) assessed cost efficiency of Taiwanese firms. The metafrontier concept has also involved in conducting the environmental productivity growth (Oh, 2010). Particularly, DEA metafrontier model was used to compare the efficiency of wastewater treatment technologies in Spain (Sala-Garrido, Molinos-Senante, & Hernández-Sancho, 2011).

The literature has considerably revealed a capability of metafrontier approach in the previous time. The empirical results evidently ensured that the metafrontier has an effective to assess technical efficiency and technical gab for inter-regional comparison. Moreover, it has an ability to measure the efficiency in several ways; cost efficiency, operative efficiency, and environmental productivity efficiency. Surprisingly, there are no published researches that assess specifically on technical efficiency (TE) and technical gab ratios (TGRs) of national universities. Therefore, this study needs further research on the proposed topic along the lines of metafrontier approach in the purpose of comparing the efficiency in different regions of Thailand.

According to basic analytical framework, the efficiency measurement is deeply rooted in production theory and the concept of distance functions. The metafrontier and region frontiers in terms of output sets and output distance functions are defined in this stage. The output distance function adopted to define technical efficiencies and metatechnology ratios is illustrated in the next section.

2.2 the metafrontier

Let *b* and *a* be non-negative real output and input vectors of dimension *M* x 1 and *N* x 1, respectively. Then, the metatechnology set contains all input-output combinations that are technologically feasible.

$$T = \{(a,b): a \geq 0; b \geq 0\} \quad (1)$$

Where, *a* can produce *b* that the metatechnology is associated with input and output sets. The output set is determined by any input vector, *a*, as:

$$P(a) = \{y : (a,b) \in T\} \quad (2)$$

The output metafrontier is the limited territory of this output set. The output set is assumed that it can reach the standard regularity properties listed in Färe & Primont (1995). Since the main focus of this paper is to measure efficiency, it is convenient to demonstrate the technology using the output metadistance function as written in Equation (3).

$$D(a,b) = \inf_\theta \{\theta > 0 : (b/\theta) \in P(a)\} \quad (3)$$

As given an input vector, this function can provide the maximum quantity by which a firm can extend its output vector. The distance function inherits its properties from the normal characteristics of the output set. Input-output combination (*a*, *b*) is technically efficient relative to the metafrontier production function when *D*(*a*, *b*) = 1.

2.3 regional frontiers

Regional frontiers are feasible when conceptualizing the occurrence of sub-technology productions of regions of firms. This research considers the case where the whole firms can be divided into *K* regions, more than one region. Regulatory, resources, as well as other environmental constraints are assumed that they are likely to protect firms in certain groups from selecting the full range of technologically possible input-output combinations in the metatechnology function, *T*. Perhaps, the input-output combinations available to firms/units in the k^{th} region are carried the regional specified technology set as written in Equation (4).

$$T^k = \{(a, b): a \geq 0; b \geq 0 \quad (4)$$

Where *a* can be used by firms/units in region *k* to produce *y*. The *K* regional specified technology sets is able to be showed by the following output distance functions as Equation (5), and regional specified output sets as Equation (6).

$$D^k(a,b) = \inf_\theta \{\theta > 0 : (b/\theta) \in P^k(a)\}, k = 1, 2, \ldots, K \quad (5)$$

$$P^k (a) = \{b : (a, b) \in T^k\}, k = 1, 2, \ldots , K. \quad (6)$$

The boundaries of the regional specified output sets are referred as region frontiers. If the output sets, P^k (a), k = 1, 2, ..., *K*, can reach standardized properties, the distance functions, D^k (*a*, *b*), *k* = 1, 2, ..., *K*, can also touch regularity properties. Regardless of the properties of these sets and functions, the rules explain that:

Rule 1. If (*a*, *b*) $\in T^k$ for any *k* then (*a*, *b*) $\in T$;

Rule 2. If (*a*, *b*) $\in T$ then (a, b) $\in T^k$ for some *k*;

Rule 3. $T = \{T^1 \cup T^2 \cup \ldots \cup T^K\}$; and

Rule 4. $D^k(a, b) \geq D(a, b)$ for all k = 1, 2, ... , K.

These attributes base on the fact that the regional specified output sets, $P^k(x)$, k = 1, 2, ... , K, are subsets of the unrestricted output set, $P(x)$. The production possibilities available to single-input, single-output firms from three different groups can be shown in Figure 1. The region *k* frontier is labeled as *k′* and it is assumed to be convex (*k* = 1, 2, 3). If the three regions are exhaustive, then the regional specified frontiers encompass all the input-output combinations that could be produced by any a firm/unit. This implies that the metafrontier fuction is the nonconvex piecewise frontier, 1-*B*-3′. Nevertheless, if the three regions are not exhaustive, other input–output combinations may be occurred and the metafrontier function is able to be the convex curve from *M* to *M′*.

Rule 5. Convex $P(x)$ does not necessarily imply convex group output sets, $P^k(x)$, k = 1, 2, ..., K; and vice versa.

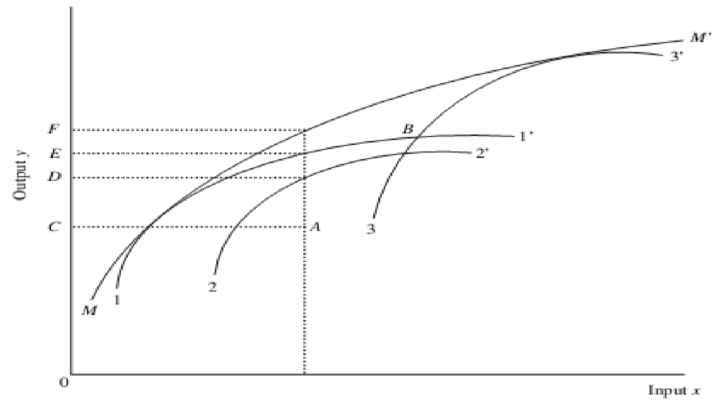

Figure 1. Technical efficiencies and metatechnology ratios

2.4 technical efficiency (TE) and technology gap ratios (TGRs)

An input-output combination (*a*, *b*) is technically efficient with respect to the metafrontier function when $D(a, b) = 1$. In general, an output-orientated measurement of the technical efficiency of an observed pair (*a*, *b*) with respect to the metatechnology function of region *k* is determined as Equation (7).

$$TE^k (a, b) = D^k (a, b) \quad (7)$$

For instance, if $D^k(a, b) = 0.7$ then the technical efficiency score indicates that the output vector, *b*, is 70 percent of the potential output which uses the same input vector.

The output-orientated technology gap ratios (*TGRs*) can be determined by the output distance functions from metatechnology, T^*, and regional technologies, T^k, as Equation (8).

$$TGRs^k(a,b) = \frac{D^*(a,b)}{D^k(a,b)} \quad (8)$$

The technology gap ratio is defined by concept of output-orientated technical efficiency as Equation (9).

$$TGRs^k(a,b) = \frac{TE^*(a,b)}{TE^k(a,b)} \quad (9)$$

As Equation 9, if the technical efficiency of (*a*, *b*) with respect to the metatechnology is 0.5, then the technology gap ratio is 0.71 (= 0.5/0.7). This number explains that, given the input vector, the potential output for region *k* is 71 percent of the matatechnology function.

2.5 DEA metafrontier

Concept of metafrontier function is enveloped by a special technique of data envelopment analysis (DEA). Originally, the DEA metafrontier based on all given data for all the firms/units in all regions. Since a total of $L = \Sigma_k L_k$ firms, the linear program (LP) is adopted to estimate the input used and output produced for all firms/units.

$$\max_{\Phi_{it},\lambda_{it}} \Phi_{it}$$

$$\text{s.t. } -\Phi_{it}b_{it} + B_{it}\lambda_{it} \geq 0,$$

$$a_{it} - A_{it}\lambda_{it} \geq 0,$$

$$\lambda_{it} \geq 0 \qquad (10)$$

where b_{it} depicts the M x 1 vector of output quantity for the i^{th} firm in the t^{th} period; a_{it} depicts the $N \times 1$ vector of input quantities for the i^{th} firm in the t^{th} period; B depicts the $M \times L$ matrix of output quantities for all L firms; A depicts the N x L matrix of input quantities for all the L firms, λ_{it} is the L x 1 vector of weights; and Φ_{it} depicts a scalar.

The maximum output shown in Equation (10) can give a technical efficiency score for a given firm relative to the metafrontier function that used all given data from all regions. Notably, the tedious work of solving a different linear program for every firm in every period is usually undertaken using purpose-built software packages such as DEAP2.1 (Coelli, 1996).

3. FINDINGS

3.1 data collection

The research obtained the secondary data from Office of the Higher Education Communication of Thailand. Cross-section data were collected from the 77 national universities in Thailand in 2011. These national universities have been established in Thailand for a long time, and they are located in five different places; Bangkok, Central, North, Northeast, and South, as shown in Table (1). The universities are not only experienced, largest, and well-known in education, but also effectively operate in academic administration. In addition, most universities have many campuses located across Thailand so that local students are able to get an admission into the universities.

Table 1: Name's lists of national universities in Thailand classified by regions

Location	University's name	Abbreviation
Bangkok (20 universities)	1. Bansomdejchaopraya Rajabhat University	BSRU
	2. Chandrakasem Rajabhat University	Chandra
	3. Chulalongkorn University	CU
	4. Dhonburi Rajabhat University	DRU
	5. Kasetsart University	KU
	6. King Mongkut's Institute of Technology Ladkrabang	KMITL
	7. King Mongkut's University of Technology North Bangkok	KMUTNB
	8. King Mongkut's University of Technology Thonburi	KMUTT
	9. Mahamakut Buddhist University	MBU
	10. Mahidol University	MU
	11. National Institute of Development Administration	NIDA
	12. Phranakhon Rajabhat University	PNRU
	13. Rajamangala University of Technology Krungthep	RMUTK
	14. Rajamangala University of Technology Phra Nakhon	RMUTP
	15. Rajamangala University of Technology Rattanakosin	RMUTR
	16. Ramkhamhaeng University	RU
	17. Silpakorn University	SU

	18. Srinakharinwirot University	SWU
	19. Suan Dusit Rajabhat University	SDPR
	20. Suan Sunandha Rajabhat University	SSRU
Central (19 universities)	1. Burapha University	BUU
	2. Kamphaengphet Rajabhat University	KPRU
	3. Kanchanaburi Rajabhat University	KRU
	4. Muban Chombueng Rajabhat University	MCRU
	5. Nakhon Pathom Rajabhat University	NPRU
	6. Nakhon Sawan Rajabhat University	NSRU
	7. Naresuan University	NU
	8. Phetchaburi Rajabhat University	PBRU
	9. Phranakhon Si Ayutthaya Rajabhat University	ARU
	10. Pibulsongkram Rajabhat University	PSRU
	11. Rajabhat Rajanagarindra University	RRU
	12. Rajamangala University of Technology Suvarnabhumi	RMUTSB
	13. Rajamangala University of Technology Tawan-ok	RMUTTO
	14. Rajamangala University of Technology Thanyaburi	RMUTT
	15. Rambhai Barni Rajabhat University	RBRU
	16. Sukhothai Thammathirat Open University	STOU
	17. Thammasat University	TU
	18. Thepsatri Rajabhat University	TRU
	19. Valaya Alongkorn Rajabhat University	VRU
North (10 universities)	1. Chiang Mai University	CMU
	2. ChiangMai Rajabhat University	CMRU
	3. Chiangrai Rajabhat University	CRU
	4. Lampang Rajabhat University	LPRU
	5. Mae Fah Luang University	MFU
	6. Maejo University	MJU
	7. Phetchabun Rajabhat University	PCRU
	8. Rajamangala University of Technology Lanna	RMUTL
	9. University of Phayao	UP
	10. Uttaradit Rajabhat University	URU
Northeast (18 universities)	1. Buriram Rajabhat University	BRU
	2. Chaiyaphum Rajabhat University	CPRU
	3. Kalasin Rajabhat University	KSU
	4. Khon Kaen University	KKU
	5. Loei Rajabhat University	LRU
	6. Mahasarakham University	MSU
	7. Nakhon Phanom University	NPU
	8. Nakhon Ratchasima Rajabhat University	NRRU
	9. Rajabhat Maha Sarakham University	RMU
	10. Rajamangala University of Technology Isan	RMUTI
	11. Roi Et Rajabhat University	RERU
	12. Sakon Nakhon Rajabhat University	SNRU
	13. Sisaket Rajabhat University	SSKRU
	14. Suranaree University of Technology	SUT
	15. Surindra Rajabhat University	SRRU
	16. Ubon Ratchathani Rajabhat University	UBRU
	17. Ubon Ratchathani University	UBU
	18. Udon Thani Rajabhat University	UDRU
South (10 universities)	1. Nakhon Si Thammarat Rajabhat University	NSTRU
	2. Phuket Rajabhat University	PKRU
	3. Prince of Songkla University	PSU
	4. Princess of Naradhiwas University	PNU
	5. Rajamangala University of Technology Srivijaya	RMUTRV
	6. Songkhla Rajabhat University	SKRU

7. Suratthani Rajabhat University	SRU
8. Thaksin University	TSU
9. Walailak University	WU
10. Yala Rajabhat University	YRU

3.2 outputs and inputs measured

The research employed four inputs and four outputs to conduct with output-oriented CCR-DEA model.
Four inputs of the model are:

Number of current teachers (*A1*): This input includes the number of lecturers, assistant professors, associated professors, and professors.

Number of current students (*A2*): This input consists of undergraduate students and graduate students.

Number of current staffs (*A3*): This input combines part-time and full-time staffs who work in main campus and affiliated campuses.

Number of educational aids' depreciation (*A4*): This input estimated the diminishing prices/values of all educational aids.

Four outputs measured in this model comprise:

Number of publications (*B1*): This output includes the manuscript that published in both international and internal academic journals.

Number of graduated students (*B2*): This output was summarized only the students who are likely to graduate and graduated in academic year 2011.

Number of research and development (*B3*): This output accounts for the number of researches and projects, occurred only internal level.

Number of research funds (*B4*): This output includes the subsidy from government and private organizations.

3.3 hypotheses

Since this study aims to measure technical efficiency (TE) and technical gap ratios (TGRs) of national universities in Thailand, the research questions try to find the solution on what differences of production technology sets among five locations. Therefore, the hypotheses are proposed as the following details.

Hypothesis 1: The national universities in five regions of Thailand are likely to differ in technical efficiency (TE) and technology gap ratios (TGRs).

Hypothesis 2: Technical efficiency (TE) and technology gap ratios (TGRs) in Bangkok are likely to differ from the TE metafrontier.

Hypothesis 3: Technical efficiency (TE) and technology gap ratios (TGRs) in the central region are likely to differ from the TE metafrontier.

Hypothesis 4: Technical efficiency (TE) and technology gap ratios (TGRs) in the north region are likely to differ from the TE metafrontier.

Hypothesis 5: Technical efficiency (TE) and technology gap ratios (TGRs) in the northeast region are likely to differ from the TE metafrontier.

Hypothesis 6: Technical efficiency (TE) and technology gap ratios (TGRs) in the southern region are likely to differ from the TE metafrontier.

3.4 empirical results

The descriptive statistics for TE-Metafrontier, TE-Regions, and TGRs are shown in Table 2. Considering TE-metafrontier, technical efficiency scores were estimated to vary from 0.114 to 1.000 in 2011. Surprisingly, only 17 out of 77 national universities were efficient. Most of efficient universities were found in the central region, while in the northern region had no efficient universities. Comparing TE-metafrontier among regions, the central regions of Thailand performed the highest technical efficiency score with an average of 0.682, followed by Northeast, Bangkok, South, and North with average scores of 0.670, 0.603, 0.564, and 0.488, respectively.

Refer to TE-region, the southern region had the highest technical efficiency with an average of 0.940, while Bangkok performed the lowest score with an average of 0.702. With technique of DEA group frontier, more than half of national universities showed efficiently. The lowest efficient score was 0.232 that was found in the central region, however, the maximum scores of 1.000 showed in all five regions.

Table 2: Technical efficiency (TE) and technical gap ratios (TGRs) estimated

	TE-Metafrontier						TE-Region						Technical Gap Ratios (TGRs)				
DMU	Bangkok	Central	North	Northeast	South	DMU	Bangkok	Central	North	Northeast	South	DMU	Bangkok	Central	North	Northeast	South
1	0.350	0.245	0.114	0.390	0.529	1	0.410	0.274	0.423	0.711	0.966	1	0.854	0.894	0.270	0.549	0.548
2	0.316	0.210	0.483	0.279	1.000	2	0.345	0.232	1.000	0.596	1.000	2	0.916	0.905	0.483	0.468	1.000
3	0.298	1.000	0.284	0.531	0.286	3	0.298	1.000	0.829	1.000	0.656	3	1.000	1.000	0.343	0.531	0.436
4	0.237	0.557	0.440	0.362	0.531	4	0.336	0.732	1.000	0.601	1.000	4	0.705	0.761	0.440	0.602	0.531
5	0.317	1.000	0.825	0.263	0.502	5	0.406	1.000	1.000	0.760	1.000	5	0.781	1.000	0.825	0.346	0.502
6	1.000	0.472	0.443	1.000	0.656	6	1.000	0.723	1.000	1.000	1.000	6	1.000	0.653	0.443	1.000	0.656
7	0.455	0.644	0.459	1.000	0.538	7	0.489	0.966	1.000	1.000	1.000	7	0.930	0.667	0.459	1.000	0.538
8	0.986	1.000	0.501	0.867	0.685	8	1.000	1.000	1.000	1.000	1.000	8	0.986	1.000	0.501	0.867	0.685
9	0.306	1.000	0.659	0.546	0.402	9	0.352	1.000	1.000	0.932	0.778	9	0.869	1.000	0.659	0.586	0.517
10	0.612	0.426	0.671	0.422	0.510	10	0.859	0.622	1.000	0.869	1.000	10	0.712	0.685	0.671	0.486	0.510
11	0.401	1.000		0.674		11	0.537	1.000		0.703		11	0.747	1.000		0.959	
12	1.000	0.354		0.818		12	1.000	0.464		1.000		12	1.000	0.763		0.818	
13	0.479	0.327		0.749		13	1.000	0.385		0.924		13	0.479	0.849		0.811	
14	1.000	1.000		0.844		14	1.000	1.000		1.000		14	1.000	1.000		0.844	
15	0.800	0.614		0.636		15	1.000	0.884		0.953		15	0.800	0.695		0.667	
16	0.627	1.000		0.684		16	0.723	1.000		0.936		16	0.867	1.000		0.731	
17	0.389	0.678		1.000		17	0.545	1.000		1.000		17	0.714	0.678		1.000	
18	0.484	0.759		1.000		18	0.744	0.960		1.000		18	0.651	0.791		1.000	
19	1.000	0.673				19	1.000	1.000				19	1.000	0.673			
20	1.000					20	1.000					20	1.000				
Mean	0.603	0.682	0.488	0.670	0.564	Mean	0.702	0.802	0.925	0.888	0.940	Mean	0.851	0.843	0.509	0.737	0.592
STD	0.295	0.288	0.201	0.257	0.190	STD	0.286	0.274	0.184	0.146	0.121	STD	0.148	0.142	0.165	0.214	0.161
Min	0.237	0.210	0.114	0.263	0.286	Min	0.298	0.232	0.423	0.596	0.656	Min	0.479	0.653	0.270	0.346	0.436
Max	1.000	1.000	0.825	1.000	1.000	Max	1.000	1.000	1.000	1.000	1.000	Max	1.000	1.000	0.825	1.000	1.000

Technical gap ratios (TGRs) were calculated by Equation (9). The highest score was found in Bangkok with an average of 0.851. Meanwhile, the lowest score was found in the northern part of Thailand (0.509), indicating that the national universities in this region performed the worst efficiency relative to the others. The minimum score at 0.270 for TGRs was found in the north as well. In conclusion, the results implied that no any regional frontier could reach the standard of metatechnology when considering an average technical efficiency score.

4. DISCUSSION AND CONCLUSIONS

The results of efficiency measurement show that national universities in Bangkok are critical because their average TE scores are lowest. Bangkok frontier firstly needs to improve efficient score, followed by Central, Northeast, North, and South, respectively. They might adjust their operative management within their system, for example increasing some potential outputs or decreasing some unnecessary inputs so that the efficient score could hugely increase. Besides, DEA metafrontier represents the overall state of knowledge, it is only partially revealed by the frontiers from different regions. Since efficiency of national universities in a region is assessed against their own frontier, it is unlikely to give an accurate assessment of the potential gains through improvements in efficiency. Moreover, the DEA metafrontier is very useful and popular in efficiency measurement literature because of two reasons. Firstly, multi-input and multi-output technology sets can be calculated by DEA approach. Secondly, the DEA approach treats all error terms as inefficiency so that they response in outliers.

This paper has developed the concept of DEA metafrontier in the purpose of studying the differences of technical efficiency (TE) and technical gap ratio (TGRs) for the 77 national universities of Thailand. TE and TGRs among five regions were definitely different. The empirical results supported the basic hypotheses that TE and TGRs in Bangkok, Central, North, Northeast, and South widely varied from TE metafrontier. Scores of TE metafrontier showed that nearly two-fourth of national universities in Thailand perform efficiently. Scores of TE region presented the high technical efficiency in the southern region that is inconsistent with the low score of TGRs. In conclusion, this research implied that no any regional frontier is able to reach the metatechnology because TGRs still be found in every region. The lower TGRs' scores a region has, the more efficiency improvements such a region needs to operate.

REFERENCES

Assaf, A., Barros, C. P., & Josiassen, A. (2010). Hotel efficiency: A bootstrapped metafrontier approach. *International Journal of Hospitality Management*, 29, 468-475.

Battese, G. E., & Coelli, T. J. (1988). Prediction of firm-level technical efficiencies with a generalised frontier production function and panel data. *Journal of Economics*, 38, 387-399.

Battese, G. E., Rao, D. S. P., & O'Donnell, C. J. (2004). A metafrontier production function for estimation of technical efficiencies and technology gaps for firms operating under different technologies. *Journal of Productivity Analysis*, 21, 91-103.

Charnes, A., Cooper, W., & Rhodes, E. (1978). Measuring the efficiency of decision-making units. *European Journal of Operational Research*, 2, 429-444.

Coelli, T. J. (1996). A guide to DEAP version 2.1: A data envelopment analysis (computer) program. CEPA Working Papers No. 8/96, Department of Econometrics, University of New England, Armidale.

Färe, R., & Primont, D. (1995). Multi-output production and duality: Theory and applications. Kluwer: Boston.

Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society*, 120, 253-281.

Glass, J. C., McKillop, D. G., & Hyndman, N. (1995). Efficiency in the provision of university teaching and research: An empirical analysis of UK universities. *Journal of Applied Econometrics*, 10, 61-72.

Hayami, Y., & Ruttan, V. W. (1971). Agricultural development: An international perspective. *Journal of Development Economics*, 26, 197-200.

Huang, Y. J., Chen, K. H., & Yang, C. H. (2010). Cost efficiency and optimal scale of electricity distribution firms in Taiwan: An application of metafrontier analysis. *Energy Economics*, 32, 15-23.

Lovell, C. A. K., & Pastor, J. T. (1997). Target setting: An application to a bank branch network. *European Journal of Operational Research,* 98, 290-299.

McMillan, M. L., & Chan, W. H. (2006, April 04). University efficiency: A comparison and consolidation of results from stochastic and non-stochastic methods. Social Science Research Network. Retrieved February 19, 2012, from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=894564

O'Donnell, C. J., & van der Westhuizen, G. (2002). Regional comparisons of banking performance in South Africa. *South Africa Journal of Economics*, 70, 485-518.

Oh, D. H. (2010). A metafrontier approach for measuring an environmentally sensitive productivity growth index. *Energy Economics*, 32, 146-157.

Ramkhamhaeng University Library. (2011, September 09). Thai universities' name lists. Retrieved February 18, 2012, from http://www.lib.ru.ac.th/university.html

Rao, D. S. P., O'Donnell, C. J., & Battese, G. E. (2003). Metafrontier functions for the study of inter-regional productivity differences. *The Journal of Productivity Analysis*, 3, 153-169.

Rao, D. S. P., O'Donnell, C. J., & Battese, G. E. (2008). Metafrontier frameworks for the study of firm-level efficiencies and technology ratios. *Empirical Economics*, 34, 231-255.

Sala, G. R., Molinos, S. M., & Hernández, S. F. (2011). Comparing the efficiency of wastewater treatment technologies through a DEA metafrontier model. *Chemical Engineering Journal*, 173, 766-772.

Worthington, A. C., & Lee, B. L. (2005). Efficiency, technology and productivity change in Australian universities, 1998-2003. Economics of Education Review, 27, 285-298.