Performance of Vietnamese Higher Education Institutions: Evidence Using Data Envelopment Analysis

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ABSTRACT

The main objective of this thesis is to evaluate the performance of Vietnamese higher education institutions (HEIs), namely, universities and colleges. In doing so, nonparametric data envelopment analysis (DEA) approaches are used to: (i) estimate the operational efficiencies of HEIs; (ii) examine the impacts of contextual variables on input usages and compute the environmentally-adjusted efficiencies of HEIs; (iii) investigate and identify sources of input mix inefficiencies in HEIs; (iv) evaluate the technological heterogeneity and efficiencies of universities and colleges using metafrontier technology; and (v) analyse the contribution of the financial efficiencies to the academic efficiencies and overall efficiencies of public universities and colleges under a network structure.

Balanced panel data for 112 universities and 141 colleges for the years 2011–2013 were collected from the Viet Nam Ministry of Education and Training (MOET). The number of HEIs in the sample involved accounts for 60 per cent of the total number of HEIs in Viet Nam. All of these institutions have complied with the regulations to submit their annual reports to MOET during the period considered in the analysis.

The thesis is organised in a paper-based format and presented in three main parts. Part I provides the contextual background of the study, characteristics and challenges of the Vietnamese higher education sector and the role of the productive efficiency analysis in higher education. Part II presents the empirical analyses of the performance of Vietnamese HEIs with respect to specific objectives and methods. Part III presents an integrating discussion of core findings, managerial implications, directions for future research, and contributions of the thesis.

Using the standard and bootstrapped DEA models, the results reveal that the efficiencies of universities and colleges in both models are less than the full efficiency of one. The second-stage regression models indicate that some contextual variables are influential in the efficiencies of HEIs. After the process of adjusting the impacts of determinants on input usages, the average efficiencies of universities and colleges significantly increase but are still less than the frontier full efficiency. The Färe-Primont productivity index is calculated and decomposed into measures of technology, technical efficiency, scale efficiency and mix efficiency for an input orientation to gain a better understanding of the sources and levels of the inefficiencies. Results indicate that there is significant evidence of input mix inefficiency and these are substantially affected by contextual variables. Using the metafrontier framework, the metafrontier efficiencies of universities and colleges are

measured relative to their individual teaching technologies. The results indicate that universities are significantly more efficient than colleges in a common context. The metatechnology gaps between their individual frontiers and the metafrontier are mainly driven by policy, environmental, and institutional constraints. Finally, the dynamic network DEA approach is used to assess the financial and academic efficiencies of public HEIs in the organisational structure. The results indicate that the average estimated efficiencies of financial and academic divisions are less than the fully technical efficiency, for both universities and colleges. The correlation between the financial and academic efficiencies is weak. The overall efficiencies of public universities are more strongly related to academic efficiencies than to financial efficiencies. By contrast, the financial efficiencies contribute more to the overall efficiencies of public colleges.

Some important implications are found in this thesis. First, HEIs in Viet Nam are inefficient in their operations in the years involved. The average of the mean efficiencies of universities and colleges obtained from different models are 0.806 and 0.768, respectively. This implies that there is much room for them to improve their performance. Among the possible solutions, more flexibility in the governance system may be helpful for HEIs to improve their mix efficiencies in using input mix to diversify the production outputs. Second, the proportion of postgraduate staff contributes significantly to the efficiencies of universities; thus, the human resource strategy of the government concerning higher degrees should keep being enhanced. Third, universities and colleges are operating comparatively well with respect to their own teaching technology under a general scenario. This suggests that it may not be necessary to upgrade colleges to university status on the basis of efficiency issues. Finally, although the financial efficiencies occupy a crucial role in the operations of public HEIs, their contribution to the academic operations is not substantial.

This research has made the following significant contributions: (i) introducing a new research context to the efficiency literature by constructing a profile of the performance of Vietnamese HEIs; (ii) providing empirical results by applying advanced DEA methods with extensions that are applicable and can be used to compare the findings of other studies in the higher education sector; and (iii) offering managerial suggestions in the reform process of higher education in Viet Nam, where the role of the government dominates in the educational market and the complicated governance system affects the flexibility of the operations of HEIs.

DECLARATION

I certify that the substance of this thesis has not already been submitted for any other degree and is not currently being submitted for any degree.

I certify that, to the best of my knowledge, any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

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LIST OF ABBREVIATIONS

ASEAN	Association of Southeast Asian Nations
CRS	Constant-returns-to-scale
DEA	Data envelopment analysis
DGP	Data-generating process
DMU	Decision making units
GDP	Gross domestic product
HEIs	Higher education institutions
HERA	Higher Education Reform Agenda
IME	Input mix efficiency
ISE	Input scale efficiency
ITE	Input technical efficiency
MOET	Ministry of Education and Training
MTR	Metatechnology ratios
ND–CP	Nghi Dinh Chinh Phu (*Decree of Government*)
NEE	National entrance examination
NQ–CP	Nghi Quyet Chinh Phu (*Resolution of Government*)
NQ–QH11	Nghi Quyet Quoc Hoi 11 (*Resolution of Parliament 11*)
OLS	Ordinary Least Squares
QD–TTg	Quyet Dinh Thu Tuong Chinh Phu (*Decision of Prime Minister*)
QD–BGDDT	Quyet Dinh Bo Giao Duc va Dao Tao (*Decision of MOET*)
SFA	Stochastic frontier analysis
TE	Technical efficiency
TT–BGDDT	Thong tu Bo Giao Duc va Dao Tao (*Circular of MOET*)
TTg–KGVX	Cong van Thu Tuong Chinh Phu (*Document of Prime Minister*)
TTLT–BTC–BGDDT–BLDTBXH	Thong tu lien tich Bo Tai Chinh, Bo Giao Duc va Dao Tao, va Bo Lao Dong Thuong Binh va Xa Hoi (*Joint Circular of Ministry of Finance, MOET and Ministry of Labour, Invalids and Social Affairs*)
VND	Viet Nam dong
VRS	Variable-returns-to-scale

PART 1: CONTEXTUAL BACKGROUND OF THE STUDY

Chapter 1: Introduction

1. Research context

Since 1997 when educational reform was introduced, the higher education sector in Viet Nam has witnessed remarkable growth in numbers of higher education institutions (HEIs) including universities and colleges (119 per cent) and in numbers of students (127 per cent) (MOET, 2013). The Vietnamese higher education sector has contributed significantly to the workforce of the national economy and producing knowledge outputs for the social development of the nation. Also, the higher education sector plays a vital role in fostering foreign direct investment and promoting economic growth by providing its highly-qualified labour force to the economy (Anwara and Nguyen, 2010).

The government has made massive efforts through financial investment in the educational sector and issuing several policies favouring the operating environment of HEIs. However, there are indications that, so far, these have not been sufficient to improve the performance of HEIs relative to the world education system. In the recent global competitiveness report for 2013/14 of the World Economic Forum (Schwab, 2013), the Vietnamese higher education sector was only ranked 95th, a quite low position among the 148 nations involved. It is clear that the Vietnamese higher education sector has not demonstrated its full capacity to improve its competitiveness. This has inevitably led to great concern from educational leaders and policymakers about the nation's low ranking in the higher education index, together with a decrease in the trust of the community about efficiencies of HEIs in the national education system. Some questions that arise include: What are the real indicators of performance of Vietnamese HEIs in the current operating environment? What are the factors affecting this performance? What are the measures of efficiency and sources of mix inefficiencies of HEIs? Do financial efficiencies contribute to academic operations and the overall performance of HEIs? It is imperative that these questions be empirically examined to respond to social concerns and provide sufficient information for policymakers and educational leaders to make better strategies for the development of Vietnamese higher education.

Studies in recent years have given more explicit attention to the efficiencies of HEIs in the process of international integration. Research on efficiency using data envelopment analysis (DEA) in the higher education sector has been conducted in many countries. For example, studies have been conducted in Western countries including the UK, the US, Australia, Canada and Italy. These studies include those of Abbott and Doucouliagos (2003; 2009), Agasisti and Pohl (2012), Carrington, Coelli and Rao (2005), Johnes and Johnes (2009), McMillan and Datta (1998) and Sav (2012, 2013). Studies in Asian nations include those from China, Taiwan, the Philippines and Malaysia, for example, Cai, Zhang and Guo (2014), Castano and Cabanda (2007a; 2007b), Johnes and Yu (2008), Munisamy and Talib (2007; 2008), and Kuah and Wong (2013). These studies have provided insights about the efficiencies and productivities of HEIs over time, including the effects of external factors on their performance, and managerial implications for further improvement. As for Viet Nam, very little empirical work has been implemented to measure the performance of HEIs in Viet Nam. The lack of empirical work in the area of efficiency analysis of HEIs in Viet Nam provides an important basis for this thesis that aims to comprehensively analyse and examine the performance of HEIs at the institutional level.

2. Rationale and research problems

As in most developing nations, improving the educational standards is one of the important strategies to attain competitiveness in Viet Nam. The remarkable growth in the student and HEI numbers is evidence for the progress of the higher education sector. However, whether such growth is sustainable and HEIs are performing efficiently is not clear. In the vote about trust recently held by the Vietnamese national assembly, 36 per cent of all voters did not think that they should put their trust in educational leaders (Vnexpress, 2013) because they felt the governance system is too complicated and the performance of HEIs had not been acknowledged as efficient. This has accelerated social concern on the real efficiencies of HEIs.

Vietnamese HEIs are currently facing more challenges resulting from swift changes of the world's higher education standards and internal pressures such as inflexibility of governance, insufficient financial support for institutional autonomy, and lack of transparent accountability of institutions (Dao, 2014; Nguyen and Tran, 2013; Tran, 2014).

First, Viet Nam is lacking a single HEI of internationally-recognised quality in teaching and research (Vallely and Wilkinson, 2008). It is widely claimed that the pace of development of knowledge-based economies has increased the needs for education quality. Gamage (2012) argued that Asian nations are facing the dilemma of the internationalisation of public HEIs while trying to ensure that these institutions meet local needs and play an important role in national development.

Vietnamese higher education is not an exceptional case. Based on Document 1269/2004/CP–KG, enacted in 2004, and the recent approvals of the government, two Vietnamese national universities, located in Ho Chi Minh City and Ha Noi City, three regional universities and 12 other universities are designated as key public universities. They are given priorities and more autonomy in operations such as financing, staff recruitment, and curricula development. Although they are expected to become leading HEIs in implementing the reform policy of the sector and building research skills in HEIs, one discerns that, with the holistic challenges of the higher education system, they may find it difficult to make significant breakthroughs because of the lack of flexibility of regulations (Brooks, 2010; Hayden and Lam, 2007; Hayden, 2012; Pham, 2012). It is evident that among the top 400 universities of the world, there are 11 universities in the Asian region, but none in Viet Nam (Thanh, 2012). In 2013, the government issued Decision 37/2013/QD–TTg with the ultimate aim that at least one Vietnamese university be ranked in the top 200 universities of the world by 2020. If this objective is to be achieved, performance evaluation of Vietnamese HEIs is imperative so that a relevant strategy for enhancing their rankings nationally and internationally can be developed.

Second, Vietnamese HEIs face challenges of inflexibility of using input resources to produce outputs as enforced by policy constraints. The curricula framework of HEIs mainly relies on the standardised guidelines issued by MOET. Although HEIs are allowed to adjust the contents of these curricula, around 30 per cent of their contents are obligatory units, for example, Communist Party history, political economics, defence, and physical education. Once these curricula are registered with MOET, they have to be kept fixed for the whole training period. With the proportion of such teaching fixed for HEIs, they cannot move smoothly around their isoquant. In addition, the governance system is complicated and fragmented. HEIs are governed by different ministries and even by local authorities. This has led to challenges for HEIs in financial and human resource management (Dao, 2014; Hayden, 2012; Tran, 2014). As a result, HEIs find it difficult to be consistent in allocative efficiency and mix input efficiency such as recruiting more qualified academic staff with a satisfactory salary level and/or expanding floor area for academic spaces to be able to enrol more students. Clearly, higher education quality cannot be guaranteed by the management systems currently in place (Pham, 2012). This can cause a productivity shortfall due to poor input mix efficiency. The inflexibility of the guiding rules and regulations are likely to result in some degree of inefficiency, exacerbated by input mix inefficiency in response to changes in educational circumstances.

Third, upgrading colleges to universities has been a recent trend in Vietnamese higher education. Some colleges have expected to be upgraded to university status because they have more conducive conditions that enable them to increase enrolment quotas and expand into new disciplines to meet the demands of the educational market. However, policymakers have argued that both universities and colleges play pivotal roles in the national education system in providing knowledge for learners and meet requirements of the national socio-economic development. Thus, upgrading colleges to universities without careful consideration can cause degradation in the education quality and the efficiencies of HEIs (Hoang, 2013b; Pham, 2013). According to the 2012 *Law of Higher Education*, although universities and colleges are both categorised as HEIs, their operating environments are relatively different. Specifically, undergraduates of universities are trained for a period of four years, whereas those of colleges are trained for a period of three years. Only universities can have postgraduate programs. Moreover, research outputs of universities focus on academic research, whereas those of colleges are primarily related to the projects of technological transfers and consultant services. Finally, colleges tend to train students with more practical skills, whereas universities teach students research skills. It can be said that there are distinct differences between the teaching technologies of universities and those of colleges. Accordingly, their performance may be different depending on their individual teaching technology and operating environments. By placing them into a common context, the so-called metafrontier technology, the difference between the individual frontier efficiency and metafrontier efficiency reflects how well they operate with respect to their own teaching technology. The DEA metafrontier method can be used to investigate these differences to provide more explicit evidence for managers of HEIs and policymakers about the role and the performance of universities and of colleges in the sector.

Finally, financial resources are an important factor that needs to be addressed in the production process of HEIs, especially public HEIs. Although Decree 49/2010/ND–CP of the government on tuition fees allowed public HEIs to increase their tuition fees, they are required to observe the basic guidelines for tuition fees. Hayden (2012) argued that although the government has provided a schedule of increasing tuition fees during 2010/11–2014/15 for public HEIs, the fee rates seem not to be sufficient for the development of HEIs because these rates were not calculated on the basis of real operations of HEIs. Chau and Tran (2015) asserted that increasing tuition fees could be an appropriate solution, but more importantly HEIs should aim to achieve financial efficiency in their operations. Duong (2013) claimed that the government budget seemed to make public HEIs less proactive and effective in their performance because of the top-down distribution mechanism. Kent (2005) asserted that the government incentives via the budget were useful tools for policy implementation in higher education. He added, however, that these incentives should prove their validity and enhance the performance of public HEIs. In the higher education context, financial efficiency refers to the ability to use financial resources as an important intermediate stage to support academic (teaching and research) operations in the production process. The overall technical efficiencies of HEIs can mainly stem from academic and financial efficiencies. In the context of financial considerations, it is very useful to examine what the financial efficiencies of public HEIs are in the network structure and to identify how strongly the financial efficiencies are linked to academic efficiencies that contribute to the overall efficiencies of HEIs.

3. Objectives and research questions

In view of the challenges and problems outlined above, the main objectives of this study are to evaluate the performance of Vietnamese HEIs and to investigate to what extent contextual factors affect their performance. Specifically, this thesis aims to:

1. Present an overview of the Vietnamese higher education sector in the reform process and discuss the role and advantages of measuring productive efficiency in the Vietnamese tertiary context. Specific research questions for the first objective are:
    - What progress has the Vietnamese higher education sector made during the reform process?
    - What are the current challenges facing Vietnamese HEIs?
    - What is the role and what are the advantages of gathering HEI performance measurements, and how can this information be used by educational managers and policymakers to advance Vietnamese higher education?
2. Obtain indicators of the operational efficiencies of HEIs and examine the factors affecting their performance. Research questions for this objective are:
    - How efficiently do Vietnamese HEIs operate?
    - Are there any differences in the efficiencies of public and private HEIs?
    - What factors contribute most to changes in the efficiencies of HEIs?

3. Examine the impacts of contextual variables on the use of inputs of HEIs and filter out their effects to obtain adjusted measures of efficiencies for HEIs. Research questions are the following:
   - To what extent do environmental factors affect the input usages of HEIs?
   - After adjusting for the effects of environmental factors on input usages, to what extent are the efficiencies of HEIs improved?
   - Using the bootstrap method to eliminate serial correlation biases and unobserved disturbances, how efficient are Vietnamese HEIs?
4. Evaluate input mix efficiency of individual HEIs and examine the effects of contextual variables on this indicator. This objective addresses the following questions:
   - What is the nature and what are the sources of input mix efficiencies of HEIs, both universities and colleges?
   - Are there any differences in the indicators for private and public HEIs?
   - What are the factors affecting input mix efficiencies of HEIs?
5. Examine technological differences and the efficiencies of universities and colleges under the metafrontier teaching technology and obtain estimates of metatechnology ratios. The research questions for this objective are:
   - What are the efficiencies of universities and colleges relative to their own technology?
   - What are the levels of inefficiencies of HEIs under a common production environment?
   - What are the metatechnology ratios of universities and colleges represented by the metafrontier technology?
6. Investigate dynamic changes in the financial efficiencies and their relationship to academic efficiencies and the overall performance of HEIs in their production process across multiple periods. This objective focuses on the following research questions:
   - What are the dynamic efficiencies of financial and academic divisions of public HEIs, universities and colleges, in the network structure?
   - What are dynamic changes in the operational efficiencies of HEIs across multiple periods under a network structure?
   - How strongly are the financial efficiencies correlated with the academic and overall efficiencies of public HEIs?

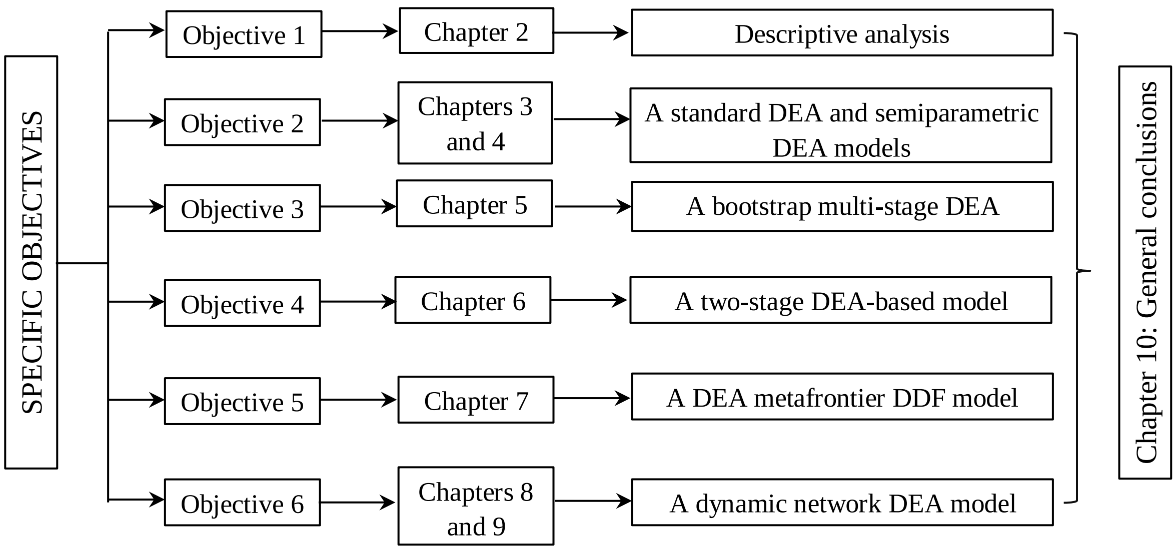
4. Methodological approaches

4.1. Empirical framework

To address the key objectives presented above, the empirical analyses are presented in a portfolio paper-based format. Each paper is defined by the key objectives outlined above and is delineated by the method of analyses used. Overall, the main methods in the thesis are a combination of descriptive and nonparametric analyses. In particular, descriptive and exploratory analyses are used in Chapter 2 to address the research questions outlined for key Objective 1. This chapter provides an overview of the progress and challenges of the Vietnamese higher education system after the reform process and proposes a possible way to provide useful information for HEIs to improve their performance by evaluating the productive efficiencies of HEIs. The information in this paper establishes an important basis for the remaining empirical studies.

For the empirical studies, the principal method used in this study is the well-known data envelopment analysis (DEA) framework. Under DEA, different variants are used to address the research questions outlined for each objective. To address Objective 2, standard and bootstrapped DEA models are used to compute the efficiencies of HEIs with cross-sectional and panel data in Chapters 3 and 4, respectively. The double bootstrap method is applied to examine the effects of various contextual factors on the performance of HEIs. For Objective 3, a multi-stage DEA model is applied and results are presented in Chapter 5. This method allows us to estimate the performance of HEIs after accounting for the impacts of determinants on input slacks. In Chapter 6, a DEA-based framework is used to estimate the Färe-Primont productivity index, which is disaggregated into measures of technology, technical efficiency, scale efficiency, and mix efficiency using an input orientation. In addition, this chapter examines contextual factors impacting on input mix efficiency of HEIs. Chapter 7 focuses on Objective 5 by integrating the directional distance function (DDF) into the metafrontier framework to measure technological differences in the efficiencies of universities and colleges and the metatechnology ratios under the unrestricted teaching technology. Finally, for Objective 6, Chapters 8 and 9 employ the dynamic network DEA model to investigate dynamic changes in the financial, academic and overall efficiencies of public universities and colleges with the network structure across multiple periods. It can be observed that the specific objectives of this thesis are integrated and constructed as a building block in terms of the DEA-based advanced single models to thoroughly explore different aspects of the performance of HEIs in their production process. The contents of the thesis are outlined in Figure 1 below.

Figure 1: Framework for empirical analyses



4.2. Dataset

Data used for most empirical papers in this study are balanced panel data, which follow a given sample of individuals over the same time periods, and, thus, provides multiple observations on each individual in the sample (Hsaio, 2003; Wooldridge, 2001). These data were collected from MOET for the period of the three years, 2011–2013, except for one paper with cross-sectional data for 100 HEIs for the academic year 2011/12. The dataset includes 112 universities and 141 colleges, accounting for 60 per cent of the total current HEIs in Viet Nam. These HEIs illustrate their commitment to guidelines stipulated by the government. Data sources are mainly drawn from the archives of MOET that were checked for accuracy and reliability for analysis. HEIs must ensure the accuracy of their reports submitted to MOET. This dataset is used for all empirical papers to respond to the specific objectives. Details of input, output and contextual variables are described in detail as part of the individual chapters.

5. Structure of the thesis

This thesis is divided into three parts. The contents of each part are briefly discussed below.

PART 1: CONTEXTUAL BACKGROUND OF THE STUDY

This part is divided into two chapters. Chapter 1 presents the background of the study, discussion of the research problem, the aims and focus of the study, the significant contributions of the study. An overview of Vietnamese higher education and the role of productive efficiency analysis are presented in Chapter 2. This chapter focuses on the higher education sector by analysing progress, challenges and future directions of the Vietnamese higher education sector. This chapter also provides the contextual information with regards to the importance of obtaining performance indicators from the perspective of input-output relationships. It is organised as a self-contained paper that provides background information for the subsequent empirical analyses.

PART 2: EMPIRICAL ANALYSES OF THE PERFORMANCE OF HEIs

This part presents the empirical findings on the performance of Vietnamese HEIs. As previously noted, empirical results are presented in seven papers which effectively address each of the individual research objectives. Specifically, Chapter 3 offers a preliminary analysis of the performance of 50 universities and 50 colleges for the academic year 2011/12 and investigates the impacts of some contextual factors on efficiencies of HEIs. Chapter 4 provides more thorough analyses by using panel data for the three years, 2011–2013 with a larger sample size of 112 universities and 141 colleges. Chapter 4 also examines the effects of different contextual factors on the performance of universities and colleges, respectively. In Chapters 3 and 4, the contextual variables are assumed to affect the technical efficiency of individual HEIs. However, it is also possible that these contextual factors directly influence the input usages then affect the technical efficiencies of HEIs. Chapter 5 fills this gap and addresses the impacts of contextual factors on input usages by using a multi-stage DEA approach to filter out the impacts of contextual factors on input usages of HEIs. Accordingly, a new stage with bootstrapping is also proposed in this procedure to eliminate serial correlation and unobserved disturbances to provide more robust results of efficiencies of HEIs.

To obtain a deeper understanding of the potential sources of inefficiency in Vietnamese higher education, Chapter 6 considers input mix inefficiency, referred to as productivity shortfall, which is linked to nonoptimal input mixes, using the advanced DEA model. The influences of contextual factors on input mix efficiencies of HEIs are examined using the two-part fractional regression model. In Chapter 7, a metafrontier directional distance function is used to obtain measures operational efficiencies when both universities and colleges face a common frontier. Results of using the metafrontier analysis allow us to evaluate the implications on capacity utilisation of quasi-fixed inputs. The implications of financial constraints and its effects on efficiency of HEIs are examined in Chapters 8 and 9. In these chapters, the dynamic network DEA model is used to scrutinize the financial efficiencies of public universities and colleges, respectively, and their correlations with the academic and overall efficiencies of HEIs in a network structure.

PART 3: GENERAL CONCLUSIONS AND IMPLICATIONS

This part is composed of a single chapter that presents the key findings from the empirical analyses and discussions of their implications. In Chapter 10, all results and estimates of performance indicators are reconciled to provide a common measure of efficiency for Vietnamese HEIs. Areas for enhancement and suggested areas for future research are presented in this chapter.

Chapter 2: Vietnamese higher education and the role of productive efficiency analysis

1. Introduction

This chapter aims to describe characteristics of the Vietnamese higher education sector, review progress of the sector after the reform process, and highlight the challenges that can potentially hinder the development of higher education. By introducing the concept of measuring organisational performance to HEIs in Viet Nam, the chapter reviews previous studies on the operational efficiencies of higher education elsewhere in the world and offers the analytical framework for the performance of HEIs as background for empirical analyses that are presented in the following chapters.

The structure of this chapter is organised as follows. Section 2 presents an overview of Vietnamese higher education including characteristics and progress during the reform process. This is followed by Section 3 that indicates potential challenges that could hinder the development of higher education. Section 4 reviews the efficiency studies in higher education over the world. Section 5 introduces the role of the productive efficiency of HEIs in Viet Nam and suggests it as an alternative tool to improve the performance and accountability transparency of HEIs as means of advancing Vietnamese higher education. Section 6 presents conclusions.

2. Vietnamese higher education: An overview

2.1 Characteristics of Vietnamese higher education

The Vietnamese higher education system consists of universities (including research institutes) and colleges, following the 2012 *Law of Higher Education*. Universities are responsible for teaching and training for bachelor degrees and higher degrees (master and PhD). Colleges are responsible for teaching associate bachelor degrees and other awards such as vocational diplomas. Research institutes focus on scientific research and training at the PhD level.

The training program for an associate bachelor degree is three years for students with upper-secondary education certificates, or two years for students with secondary vocational certificates in the same disciplines. For bachelor programs, students with upper-secondary education certificates and who have passed the national entrance examination complete their degrees in four to six years in accordance with the disciplines chosen. Master programs are conducted within two years for students with bachelor degrees, whereas doctoral-level programs require three to four years for students with master degrees.

As regulated in Article 6, Item 2 in the 2012 *Law of Higher Education*, the national higher education system includes two types of training: regular full-time training and continuing education. The latter provides opportunities for people for lifelong learning to improve their knowledge, skills, quality of life, and to meet the demanding requirements of society.

The 2012 *Law of Higher Education* indicates that the general objectives of higher education are to develop human resources, enhance the intellectual standards of people, and conduct scientific research to create knowledge and new products for the purpose of meeting the needs of socio-economic development, ensuring national defence and security, and international integration. Its specific objectives are to educate learners in acquiring political and moral qualities, to provide professional knowledge and practical skills relevant to educational levels, and to develop physical health, creative ability, responsibilities in work and adaption to the working environment and awareness of serving people. Currently, there are two kinds of HEIs in Viet Nam that operate to meet these objectives: publicly and privately owned HEIs.

2.1.1 Publicly-owned HEIs

As defined by the 2012 *Law of Higher Education*, publicly-owned HEIs are supported by the government in terms of finance and infrastructure. The 2012 *Law of Higher Education* requires each HEI to establish a governing council to help rectors or boards of management of HEIs in order to build an action plan, appraise the financial plan, and oversee the process of democratisation. The publicly owned HEIs play a crucial role in the national higher education system. They are required to perform at the highest level and to enact the regulations and requirements of government policies.

Currently, Viet Nam has 338 public HEIs comprising 153 universities and 185 colleges. The number of students in public universities accounts for 58.6 per cent of the total number of students in the whole higher education system while public colleges account for only 27 per cent (MOET, 2013). The Vietnamese higher education system has also developed a nationwide network of tertiary institutions in cities and provinces. This growth has created convenient conditions for learners in remote regions and for people in ethnic minorities to access learning opportunities at the higher education level. Findings in MOET (2009) reveal that 35 out of the 63 Vietnamese provinces had the majority of newly established institutions, especially Ho Chi Minh City and Ha Noi City, which account for 43 per cent of the total number of new institutions. The allocation of the number of HEIs by regions in Viet Nam, as illustrated in Figures 1 and 2, reveals that the Red River Delta, where the Ha Noi City government offices are located, has the largest proportion of public HEIs.

Figure 1: Regional map of Viet Nam

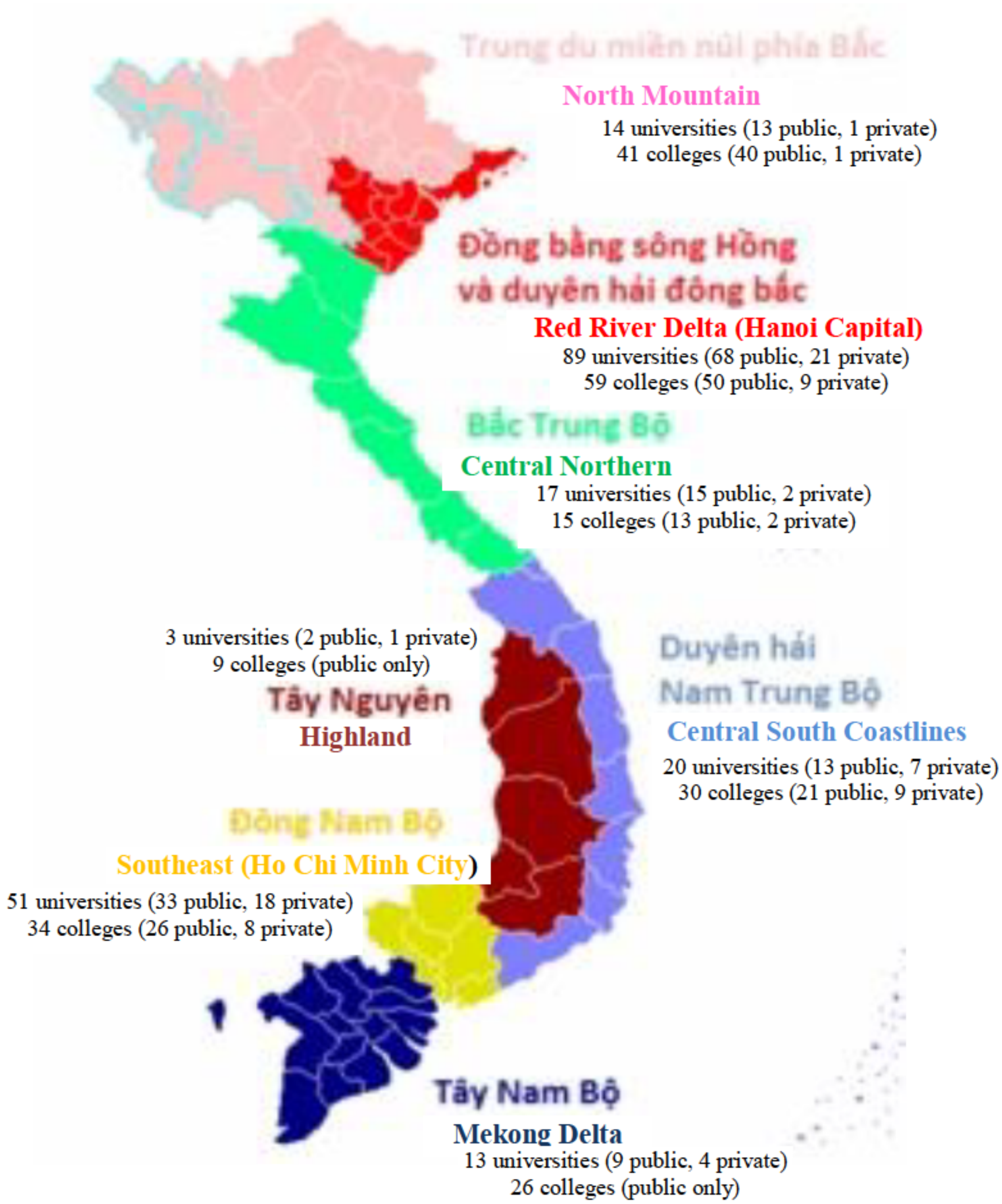
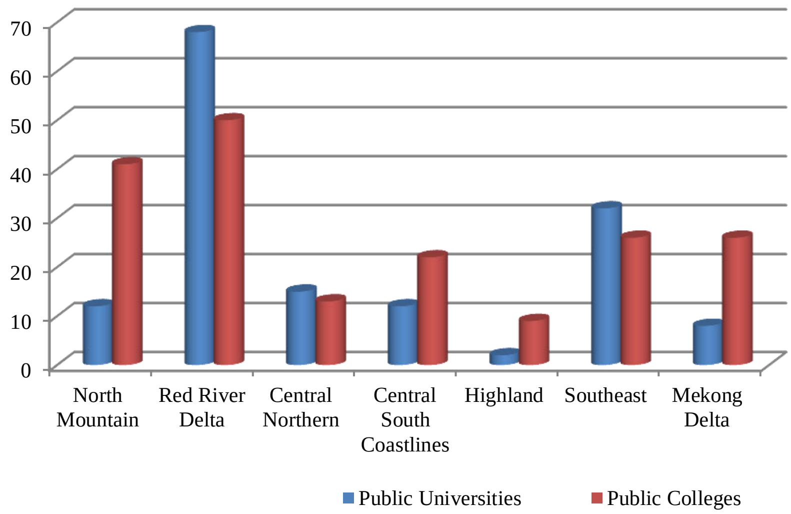


Figure 2: Publicly owned HEIs by main regions in Viet Nam



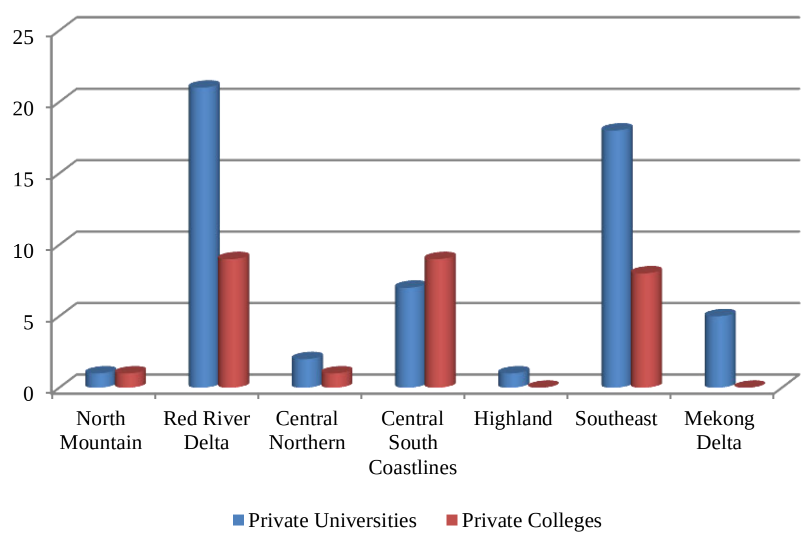
2.1.2 Privately owned HEIs

Privately owned HEIs, as delineated by the 2012 *Law of Higher Education*, are owned and managed by private organisations or individuals in terms of investment in finance and infrastructure. The "private organisations" are private businesses/companies that want to extend their business lines by investing in higher education whereas "individuals" are groups of individuals who have strong financial resources and want to invest in higher education. Private HEIs have a board of management rather than a governing council. The board of management includes private organisations or individuals who have directly invested in these institutions and taken charge of managing all operations. They have not been restricted to financial decision making even though they are still required to follow MOET's regulations about training and enrolments.

Although the number of private HEIs is only just less than 20 per cent of the total HEIs in Viet Nam, their growth within the past 12 years has been remarkable—from 22 HEIs in 1999/2000 to 83 in 2011/12. In this period, the number of private colleges has increased over fivefold from five HEIs in 1999/2000 to 28 in 2011/12, whereas the number of private universities has increased more than threefold—17 in 1999/2000 as compared with 54 in 2012/13 (MOET, 2013). This indicates that private HEIs have steadily played an increasing and important role in the national higher education system and contributed significantly to the educational socialisation strategy of the government by providing better trained human resources, amounting to on average 250,000 graduates per year to the national economy.

Like public HEIs, private HEIs have also been allocated across regions of Viet Nam, as illustrated in Figure 3. The numbers of private universities in the Red River Delta and the Southeast region, where Ha Noi Capital and Ho Chi Minh City are centrally located, take the top positions with the proportions of 37 per cent and 33 per cent of total HEIs, respectively. This is followed by the Central South Coastlines (Hue, the ancient capital) and the Mekong Delta with five and seven universities, respectively. By contrast, there are no private colleges in the Highland and the Mekong Delta regions.

Figure 3: Privately owned HEIs by main regions in Viet Nam



2.1.3 Universities versus colleges

The Vietnamese higher education system focuses on two principal types of HEIs that differentiated by ministries: universities and colleges. The 2012 *Law of Higher Education* defines a university as an HEI that can include dependent members as colleges and institutes of different disciplines to train diversified levels in the higher education system. However, whether or not a particular university has other institutions dependent on it depends on the size and resourcing of that university. At present, the majority of colleges in Viet Nam are operating independently and under the control of MOET. There are some colleges belonging to the two national universities or other regional universities.

The objective of college education is to provide students with professional knowledge and basic practical skills in a profession, with the ability to solve common problems in their field of study.

University education aims to help students acquire in-depth professional knowledge and good practical skills in a profession, with the ability to work independently and creatively as well as to solve problems in their fields of study.

It is widely recognised that various kinds of HEIs create more convenient conditions for students to have appropriate options for their situations. They can choose to go directly to university, otherwise to college and to university later, depending on their capacity to study and their individual situations. Both universities and colleges play a crucial role in the national higher education system. They provide a reciprocal relationship by offering students learning opportunities to improve their knowledge and practical skills for their career development.

2.2 Progress of Vietnamese higher education after the reform process

The reform process of higher education has a strong link to the nationwide economic reform that started in 1986. However, since 1997 when Resolution 90/1997/NQ–CP and then Decree 73/1999/ND–CP of the government on the socialisation policy of education, health, and culture was introduced, in which private education was officially encouraged, Vietnamese higher education witnessed great growth in numbers of HEIs and in numbers of enrolments. Following this, several policies were issued to favour the operating environments of HEIs, especially Resolution 14/2005/NQ–CP on comprehensive reform of Vietnamese higher education, the so-called Higher Education Reform Agenda (HERA) that made significant contributions to the productivity growth of the higher education system.

Enrolments and completions

From Table 1, it can be seen that universities, with 66.7 per cent of the total national enrolments, occupy a crucial role in the higher education sector. However, following Decision 37/2013/QD–TTg of the government on the adjusted plan of the network of HEIs in the phase of 2006–2020, this share is expected to reduce to 56 per cent by 2020. This will ensure a balance of total enrolments between universities and colleges and match the demands of the labour market.

Public education is still a main player in the national higher education system. Eighty per cent of the total number of HEIs are publicly owned which accounts for around 85 per cent of total national enrolments. The HERA envisions 40 per cent of the total enrolment being in private HEIs by 2020. However, figures in Table 1 show that the proportion of private enrolments in 2012/13 was around 14 per cent, so it may be difficult to reach the target of 40 per cent by 2020.The number of graduates who completed degrees has increased nearly three times for universities and six times for colleges over the last 12 years.

Table 1: Institutions, enrolments and completions of HEIs over multiple periods

		1999/2000	2005/06	2012/13
Universities	**Institutions**	69	125	207
	Public	52	100	153
	Private	17	25	54
	Enrolments	719,842	1,046,291	1,453,067
	Public	624,423	933,352	1,275,608
	Private	95,419	112,939	177,459
	Share of total enrolment	80.5%	75.4%	66.7%
	Public	69.9%	67.3%	58.6%
	Private	10.7%	8.1%	8.2%
	Completions	90,791	143,017	248,291
Colleges	**Institutions**	84	154	214
	Public	79	142	185
	Private	5	12	29
	Enrolments	173,912	299,294	724,232
	Public	161,793	277,176	589,039
	Private	12,119	22,118	135,193
	Share of total enrolment	19.5%	21.6%	33.3%
	Public	18.1%	20.0%	27.1%
	Private	1.4%	1.6%	6.2%
	Completions	30,902	67,927	176,917

Source: MOET (2013)

Research Output

Research output as measured by the number of articles published by researchers in selected Asian countries is presented in Table 2. The number of articles from Vietnamese researchers published in international journals shows an increasing trend over the period 2008–2012, 955 to 1731 articles, but the published research volume is still low compared with that of other Asian countries such as Singapore, Malaysia, and Thailand (Hien, 2010; Hoang, 2013; Thanh, 2012). However, the number of publications has not been recorded systematically at the institutional level to provide sufficient data for analysis of the research capacity of each HEI.

Table 2: The number of published articles of Southeast Asian nations in recent years

Nations	2008	2009	2010	2011	2012	Total
Singapore	7,371	8,013	8,822	9,448	10,125	43,779
Malaysia	2,913	4,333	5,951	7,774	7,828	28,799
Thailand	4,345	4,792	5,239	5,785	5,804	25,965
Viet Nam	955	1,007	1,249	1,414	1,731	6,356
Indonesia	736	913	1,030	1,133	1,309	5,121
Philippines	699	756	792	945	879	4,071
Laos	57	59	92	124	141	473

Source: Hoang (2013a)

Expenditure on Education

In Viet Nam, following Resolution 37/2004/NQ–QH11, the government suggested an increase in the public budget for education by 20 per cent of total national expenditure. This policy was implemented gradually in the subsequent years based on the national budget. Table 3 shows that in 2010, public expenditure on education in Viet Nam accounted for 20.9 per cent of total government expenditure and 6.3 per cent of GDP. These proportions are relatively high, equivalent to that of Malaysia and only lower than that of Thailand. The Ministry of Finance (2012) reported that the total national budget for education in 2012 was 11.1 per cent higher than that in 2011. This is indicative of the commitment to advance the restructuring process of higher education in Viet Nam.

Table 3: Public expenditure on education by Asian nations

Nations	Year	% of GDP	% of total government expenditure
Brunei	2013	3.5	9.70
Cambodia	2010	2.6	13.1
Indonesia	2012	3.6	18.1
Laos	2010	2.8	13.2
Malaysia	2011	5.9	20.9
Myanmar	2011	0.8	4.40
Philippines	2009	2.7	13.2
Singapore	2013	3.0	18.1
Thailand	2012	7.6	31.5
Timor-Leste	2011	9.4	7.70
Viet Nam	2010	6.3	20.9

Source: Statistical Yearbook for Asia and the Pacific (2014)

Financial capacity is one of the important incentives to improve the performance of HEIs. In 2010, the government issued Decree 49/2010/ND–CP on tuition fees that allows public HEIs to increase tuition fees within the ceiling tuition framework for the period, 2010/11–2014/15. This means that public HEIs are not allowed to charge students more than the allowed ceiling tuition levels for each field of study as regulated. With this decree, private HEIs are not tied by the tuition fee framework. They can determine their tuition fee levels as long as learners can afford the fees.

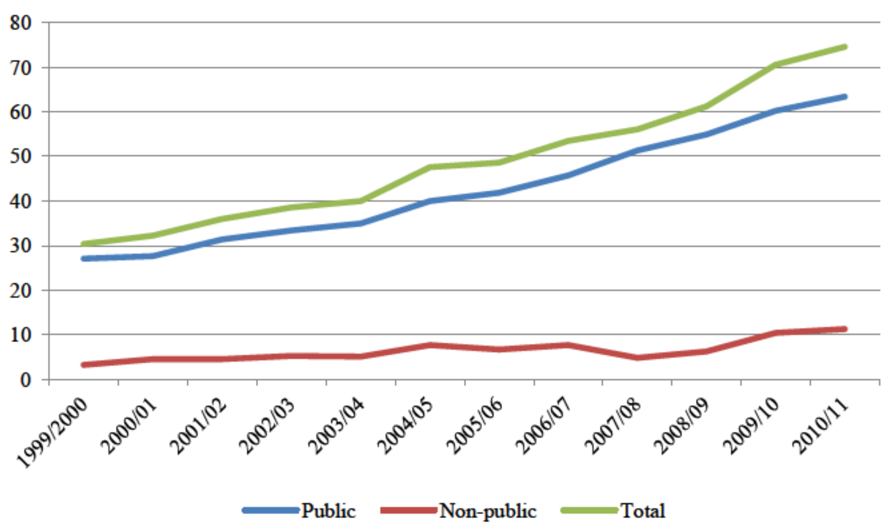
Enrolment requirement

Regarding the national university entrance examination, MOET issued Circular 57/2011/BGD–DT that allows HEIs to set their own enrolment quotas per annum and submit their registration forms to MOET. MOET instructed HEIs to calculate the annual enrolment quotas based on the ratios of student to lecturer for different fields of study and the ratio of floor area for academic spaces per student. The approved enrolment quotas for each HEI are conveyed officially by MOET before the national university entrance examination each year. MOET reserves the right to check the performance of HEIs. If HEIs enrol more than 15 per cent above their approved enrolment quotas, or if they violate the regulations relating to the examination, they are penalised and barred from enrolling new students. It can be observed that MOET desires to give more flexibility to HEIs but also wants to control them to some extent.

Academic staff

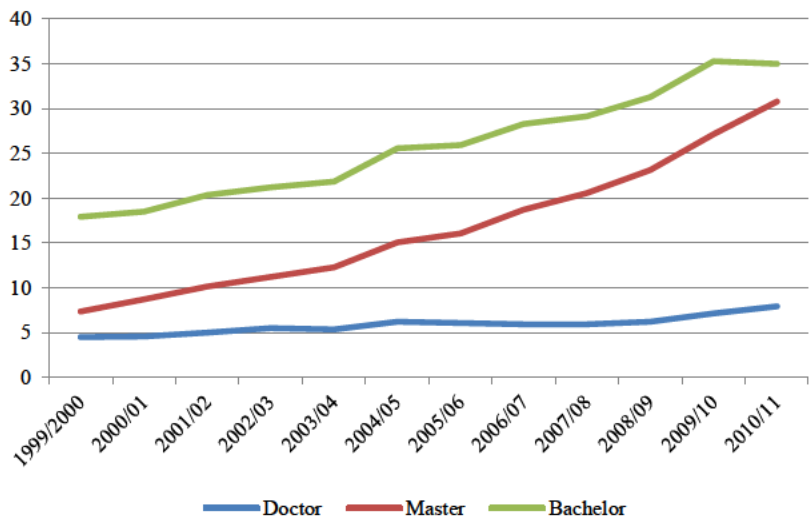
The academic staff are viewed as an important element in the performance of HEIs. For example, the study of McMillan and Chan (2006) revealed that the proportion of active researchers had a positive correlation with the productive efficiency of HEIs. Statistical data from MOET (2013) reveal that in 1999/2000, there were 60,000 academic staff but this increased significantly to nearly 180,000 in 2012/13. The increase in academic staff in the public HEIs was faster than the increase in private ones.

Figure 4: The numbers of academic staff over the years in Viet Nam, 1999–2010 (Unit: 1,000)



There has been a moderate increase in the qualifications of academic staff. In 1999/2000, the number having doctorates was nearly 4,500, which increased twofold to 9,562 in 2012/13. An upgrading of qualifications is clearly a good signal for the higher education sector. However, how this affects the performance of HEIs needs to be investigated.

Figure 5: Professional qualifications by titles in Viet Nam, 1999–2010 (Unit: 1,000)



Education quality

An improvement in the education quality of higher education is also a great concern of the government and educational leaders. The year 2004 was a momentous turning-point in the reform policy of the Vietnamese higher education sector, when a series of legal documents at the national level affirmed the management innovation policy in the educational sector by applying a quality assurance system (Vu, 2012; Do and Ho, 2013). Resolution 37/2004/NQ–QH11 of the government on education indicated that quality control was to become a focal point in higher education management and had to be conducted annually. Also, in that year, MOET issued Directive 25/2004/BGD–DT on missions of the educational system in the academic year 2004/05, where HEIs and authorities at all levels were required to construct a complete framework and deploy systems of examination and educational auditing. In 2009, MOET promulgated the Statute of Public Disclosure that dealt with quality assurance, human resources and facilities, and financial statements. These details are required to be posted publicly on the websites of HEIs, but if an HEI fails to do so, it may lose the right to recruit new students. This aims to provide convenient conditions for the community and learners to observe and evaluate the performance of HEIs. In addition, by 2013, MOET issued Circular 38/2013/TT–BGDDT on the procedure and periods of quality assurance of curricula of universities, colleges and professional high schools. This provides a useful tool set for institutions to assess their curricula quality by different measures, for example, self-assessment, external assessment, and reassessment. All these aim to enhance the quality of education provided by the higher education sector.

In summary, the economic reforms over the whole nation are linked to all sectors in the economy, including education. In the trend of international economic integration, Vietnamese higher education needs to be varied in the performance and quality of education to match the world's higher education standards. There are three highlights in the reform process of Vietnamese higher education: (i) public expenditure on education increased to stimulate the development of the sector; (ii) the gradual provision of more flexibility to HEIs in the confines of regulations; and (iii) increasing focus on providing quality education benchmarked against international best practice.

3. Challenges facing Vietnamese higher education

Viet Nam has made great progress in the reform process of higher education. However, Vietnamese higher education has currently not reached the high international standards of some Asian countries and the world's higher education. According to the global competitiveness report for 2013/14 of the World Economic Forum (Schwab, 2013), the Vietnamese higher education sector was only ranked 95th, a quite low position among the 148 nations involved. In addition, until now no Vietnamese university has been ranked among the world's top universities. This reveals that the biggest challenge facing the sector is how to improve performance and make the sector more competitive. Some of the challenges that might hinder the performance and development of higher education are discussed below.

3.1 Complexity in governance system

Although the HERA suggested removing line management in the higher education system to provide more autonomy for HEIs, this management system still remains complicated and fragmented. Among the 421 HEIs, there are 51 public HEIs under the management of MOET and the remaining HEIs (87.4 per cent) are under the management of 13 ministries and local authorities. All HEIs are operating under the same education law but under different line management systems, depending on which ministry they belong to. This leads to a time-consuming and inefficient reporting system. Partly due to such fragmentation and complexity, statistical information about Viet Nam's higher education system is disjointed and incomplete (Asian Development Bank, 2010). As a result, it is difficult to analyse and evaluate the performance of HEIs.

More autonomy in financial mechanisms is still desirable for public HEIs (Hayden and Lam, 2007; Hayden, 2012; Chau and Tran, 2015). Given that Decree 49/2010/ND–CP of the government has provided more opportunities for public HEIs to increase their tuition revenue, public HEIs must observe the regulated ceiling tuition framework. This means that they are not permitted to raise fees regardless of whether the government-prescribed levels of tuition fees are sufficient for their operations or not. Following Circular 20/2014/TTLT–BGDDT–BTC–BLDTBXH, the government maintains the distribution of state funding to public HEIs based on the difference between the annually-planned budget estimates for operational expenditures and the tuition revenues. Needless to say, public HEIs have to strictly follow financial regulations and are under supervision of several authorised bodies, for example, MOET and their own line managers. These constraints mean that HEIs have to give careful consideration to the employment of more highly-qualified academic staff with satisfactory salaries or to expanding floor area for academic spaces for their academic operations. In 2014, the government issued Resolution 77/NQ–CP detailing the pilot model for the new operations model for public HEIs for the period of 2014–2017. This pilot model has only been applied to ten chosen universities that are allowed to make their own decisions on all their academic operations. After the results of this model have been checked and assessed, it may be widely applied on a larger scale. However, public HEIs still have a long way to go to get to that stage.

It can be seen that the government issued different documents to encourage the socialisation policy in different fields, i.e., education, vocation, health, culture, sports, and the environment (Resolution 05/2005/NQ–CP, Decree 69/2008/ND–CP and Decree 59/2014/ND–CP on adjusting some items of Decree 69/2008/ND–CP). With these regulations, the policy of land usage is a focal point favouring the operations of private education. However, the actual implementation of this policy has not yet been effected and remains controversial. Private HEIs are very concerned about how the policy might impact them. Their annual enrolment quotas could be affected should they not meet the requirements of the government, regarding, for example, the ratio of students to lecturers or floor area per student.

3.2 Internationally recognised universities

Vietnamese higher education does not have a single HEI of internationally-recognised quality in either research or in teaching (Vallely and Wilkinson, 2008). The work of Hien (2010) indicated that although the research intensity is increasing at around 16 per cent, Viet Nam is still in the lowest research intensity group in the Asian region. Pham (2012) argued that, due to insufficient salaries, academic staff undertake excessive teaching hours to earn a living, often undertaking more than one position; thus, their teaching quality is frequently not of a high standard.

Table 4 shows that the adjusted salary scheme has been applied in higher education since 2014. It can be seen that the pay levels are indeed relatively low, and this might affect the teaching quality of lecturers. Currently, the Ministry of Home Affairs is considering increasing basic salary levels for state officers including the higher education sector. As a result of the inadequate salaries and the excessive teaching loads of academics, in 2013/14, there was only one Vietnamese university, Viet Nam Hanoi National University, which was ranked in the top 200 universities in Asia and not any university in the top 400 universities in the world. This has led to great concern in the community and among policymakers about the performance of higher education.

Table 4: Salary scheme for higher education

Job titles	Salary grading								
	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grade 9
Advanced lecturer's coefficient	6.2	6.56	6.92	7.28	7.64	8.00			
Basic salary applied on 1/10/2004	1,798	1,902	2,007	2,111	2,216	2,320			
Monthly pay (1,000 VND)	11,148	12,480	13,887	15,370	16,927	18,560			
Senior lecturer's coefficient	4.4	4.74	5.08	5.42	5.76	6.1	6.44	6.78	
Basic salary applied on 1/10/2004	1,276	1,375	1,473	1,572	1,670	1,769	1,867	1,966	
Monthly pay (1,000 VND)	5,614	6,516	7,484	8,519	9,622	10,791	12,023	13,331	
Lecturer's coefficient	2 34	2.67	3.00	3.33	3.66	3.99	4.32	4.65	4 98
Basic salary applied on 1/10/2004	679	774	870	966	1,061	1,157	1,253	1,349	1,444
Monthly pay (1,000 VND)	1,588	2,067	2,610	3,216	3,885	4,617	5,412	6,271	7,192

Source: Extracted from the unified document 04/2014/VBHN-BNV issued by Ministry of Home Affairs on salary scheme of officers.
Exchange rate: 1 USD = 22,460 VND (02/12/2015)

Currently, the government is seeking to build world-class universities in cooperation with foreign partners and the aid of the World Bank. The most striking project is the construction of four internationally recognised universities, the so-called New Model University Project, using USD 400 million in loans from the World Bank and the Asian Development Bank (Clark, 2010). Another development has been the establishment, in 2008, of the Vietnamese-German University, which aims to become a fully-fledged research institution (Lawrence, 2011). The government has recently approved by Document 325/2014/TTg–KGVX, in principle, to establish an international university in partnership with Japan, under the management of Hanoi National University. Other projects including partnerships with France and the United States are under consideration. The main objectives of these projects are to establish international standard research universities and real autonomy in the management mechanism, including governance, financing, and quality assurance. Recently, the World Bank approved a USD 50 million project to strengthen governance, financing, and quality of Viet Nam's higher education (World Bank, 2013). The specific objectives of the project are to improve the quality of HEIs, enhance the financial transparency, sustainability, and effectiveness of the higher education sector as well as increase the quantitative capacity of the system.

Projects in cooperation with other countries sound quite promising for a significant breakthrough in Vietnamese higher education. However, it may be not easy for newly established universities to reach international standards in a short time (Olsson and Meek, 2013; Pham, 2014). The government continued to complete the national higher education network by designating two national universities in Viet Nam, three regional universities (one in each of the three main regions) and 12 other important universities throughout the country were considered as key universities and expected to become leading HEIs in implementing the reform policy of the higher education system and building research skills in the Vietnamese higher education system. However, facing holistic challenges of Vietnamese higher education, it may also be difficult for these key universities to make significant breakthroughs and become leading universities in the higher education system.

Recently, there has been a trend to upgrade colleges to university status. This was believed to enhance the performance of colleges under the new status with respect to developing new specialisations and increasing the annual enrolment quotas. However, although colleges may operate well in terms of their own teaching technology, this does not necessarily mean that they will be equally effective using advanced university teaching technology, i.e., highly qualified academic staff, high-tech learning facilities and floor area for academic spaces if upgraded to university status. This can cause inadequacies in the operational efficiencies of universities, and of the sector in general. Although policymakers argued that both universities and colleges play crucial roles in the national education system in providing knowledge for learners and meet requirements of the socio-economic development (Hoang, 2013b; Pham, 2013), the performance of individual HEIs has not been investigated; thus, convincing evidence for this argument is not available.

3.3 Accountability transparency and the performance of HEIs

The performance of Vietnamese HEIs has mainly been assessed based on 10 standards for evaluating education quality that are contained in the government's Decision 65/2007/QD–BGDDT and Decision 66/2007/QD–BGDDT, which concern regulations regarding universities and colleges, respectively. The objective of these decisions was to provide a measurement tool for the self-evaluation of the performance of HEIs. By doing well according to this set of standards, HEIs are able to obtain their main goals: continuously improving their training quality, promoting their accountability to society, being acknowledged that the quality standards of the government are being met, and providing sufficient information for the choice of students and employers. Standards for colleges are generally similar to those for universities. However, there are fewer criteria or requirements for colleges. A sample of standards for universities is summarised in Table 5.

MOET (2014) reported that there were 191 universities and 174 colleges that finished their self-evaluation reports at different times between 2005 and 2014. Among these HEIs, 40 universities have been evaluated by external auditing organisations and 124 universities by MOET's Education Project.

Table 5: The set of standards for evaluating education quality of universities

Standard	*Indicators*	*Main contents*	*General requirements*
1	2	Mission and objectives	Relevant to Education Law and resources available, matching the local development strategy.
2	7	Organisation and management	Management structure follows regulations of Charter and is organised well
3	6	Curricula	Based on the framework of MOET, curricula should be relevant, logical, and systematic to meet knowledge and skill needs.
4	6	Training activities	Diversity of training forms, innovation in teaching and evaluation methods, learning results provided timeously
5	8	Administration and academic staff	Ensuring the number of academic staff is sufficient for teaching; creating conditions for staff to join in training courses and conferences
6	9	Students	Providing good facilities and social services for students as regulated by law; students join in the process of evaluating teaching quality
7	7	Scientific research, application and technological transfer	Having a plan for developing research and research services, encouraging academic staff's publications and joining in projects of technological transfer
8	5	International cooperation	Conducting activities of international cooperation as regulated, encouraging student and staff exchange programs and research with foreign universities
9	9	Facilities serving learning process	Well-equipped library with textbooks, computers (with Internet), classrooms, and offices for staff
10	3	Finance and financial management	Having a plan for self-finance in training activities, transparent accountability to the government and internal departments

Source: Extracted and translated from Decision 65/2007/QD–BGDDT

Together with this, HEIs must conform to Circular 09/2009/TT–BGDDT of the government on the statue of disclosure for educational organisations. This statute asks each HEI to make an annual report with information on three areas: commitment to education quality and training quality in practice, conditions for quality assurance, and a financial statement. HEIs need to upload these reports on their website and send a hard copy to MOET. The statute of public disclosure has clearly been useful for the community, parents, and students in providing sufficient information for their decision making. However, not all HEIs follow these regulations of MOET. From 2009/10 to date, on average, 60 per cent of HEIs has followed this rule and sent their annual reports to MOET. MOET (2009) argued that, due to the complicated system of governance in the higher education sector, performance via productive efficiency of HEIs has not been measured. Currently, although two Vietnamese national universities, three regional universities, and 12 other important universities are intuitively considered to be more efficient than others (Banh, 2010), their performance has not really been estimated on economic grounds and their performance is left as an open question. The current self-evaluation system of Vietnamese HEIs seemingly carries a formality rather than real outcomes, and, hence, it presents a dilemma for managers of HEIs to have objective evaluations. They may find it daunting to try to enhance their operations when their performance has not been empirically measured and objectively recognised. This may lead to a lack of accountability and transparency in the operations of HEIs, an absence of internally fair competition among HEIs, and a deficiency of strong motivation to improve their rankings.

Recently, the government promulgated Decree 73/2015/ND–CP on the stratification and ranking of HEIs in Viet Nam. Following this, the top tier is designated "research-orientated" universities, the second tier "applied", and the lowest tier "professional and vocational". The ranking criteria include training size and disciplines, the proportion of academics with PhD degrees, the ratio of students to teaching staff, international publications, and results of accredited education quality. However, little has been revealed about how the policy of stratification and ranking relates to the process of financial allocation and subsidy of public institutions and tuition fees for private institutions (Pham, 2015b; Pham, 2015c). In addition, differences and advantages between the three tiers and three levels of ranking are not clear, thus reducing the motivation of university managers to participate in this process. Further, although the accreditation agencies are called independent because they do not report directly to the government, two of the three centres are agencies within two public national universities. Clearly, this does not fit the accepted international definition of independent accreditation agencies; that is, they are independent, not-for-profit and non-governmental agencies (www.iaagency.org, www.abet.org).

In sum, Vietnamese higher education has made recognised progress during the reform process; however, managerial challenges have hampered any breakthroughs in the performance of HEIs. To vary a management mechanism may take time; thus, the efficiency evaluation of HEIs at the institutional level can be a doable and optional solution to improve the performance of HEIs on the path to advancing Vietnamese higher education. The next section provides a literature review on the efficiency studies of higher education in different nations before proposing an analytical framework for analysis and assessment of the performance of Vietnamese HEIs.

4. Efficiency studies of higher education: A review

Measuring the operational efficiencies of higher education has been the focus of many empirical studies in recent years. The two most common methods for estimating the performance of HEIs are currently data envelopment analysis (DEA) and stochastic frontier analysis (SFA), which have been widely applied for different organisations across various countries. DEA is a well-known linear programming method for measuring the relative efficiencies of decision making units (DMUs) as in the higher education sector (Johnes and Yu, 2008). DEA appeals to researchers, especially management scientists, by assessing the technical efficiency of DMUs with multiple inputs and outputs using only information on input and output quantities without requiring information on prices. In addition, DEA does not require an assumption of the functional form that relates inputs and outputs for the sample of observations in an empirical analysis. The use of DEA to measure efficiency in the tertiary education sector has become widespread since its initial development in 1978. A variety of research (e.g., Ahn, Charnes & Cooper, 1988; Coelli, 1996; Abbott & Doucouliagos, 2003; Flegg et al., 2004; Agasisti & Pohl, 2012) has been conducted at the institutional level to estimate the efficiency of HEIs within one country. This means that all efficiency measurements are relative to the best performers in that country. Furthermore, there is a movement to widen the geographical location of studies where efficiencies are able to be compared across countries. In this section, we summarise the development phases of published studies on efficiencies of HEIs using DEA because this method is relevant and applicable to the Vietnamese higher education context.

Before 2000, the majority of studies focused on assessing efficiencies of HEIs in developed countries such as the US, the UK, Australia, and Canada. Ahn, Charnes and Cooper (1988) estimated the technical and scale efficiency for 161 HEIs that were grouped according to whether or not they had a medical school in 1984/85. The authors argued that medical schools require significantly larger amounts of inputs and, in turn, generate significantly larger amounts of research funding than non-medical schools. Their findings indicate that public institutions without medical schools are more technically efficient than their private counterparts, 0.70 vs 0.64, respectively. Coelli (1996) used the 1994 data to assess the efficiency of Australian HEIs. The findings indicated that the mean technical efficiency scores for the Australian university model were quite high, 0.952. In addition, Athanassopoulos and Shale (1997) applied DEA to estimate the efficiencies of 45 established universities in the United Kingdom during 1992/93. Their findings showed that in the cost efficiency model, the mean efficiency for all institutions was estimated to be 0.83. This means that the UK universities could potentially improve their efficiency by 17 per cent. Later, in 1992/93, McMillan and Datta (1998) employed DEA to evaluate the efficiency of 45 Canadian universities. The results from these DEA analyses show that the mean efficiency score for universities with medical schools was 0.94, whereas that for universities without medical schools was 0.95. The authors expressed the view that efficiencies were generally relatively high but that some aspects of input and output quality were not accounted for. In addition, the small sample size may have also affected the efficiency results.

For the period 2000–2015, studies on the efficiency of HEIs have continued to develop in the advanced countries with deeper analyses and have expanded in European and Asian nations. For example, Avkiran (2001) applied a DEA method to measure the efficiency of 36 Australian universities based on a 1995 dataset. His findings were that the mean efficiency score was 0.955 for the overall model, 0.967 for the model of delivery of services, and 0.634 for the fee-paying enrolments model. Avkiran (2001) asserted that Australian universities were operating at a high level of efficiency. However, both the relatively low mean efficiency score and the high standard deviation showed poor performance in attracting fee-paying students. Salerno (2002) used DEA to evaluate the relative efficiency of 183 research and doctoral-granting institutions in the US with 1993 data. Results indicated that the mean efficiency scores for the high-quality group and the other group were 0.93 and 0.86, respectively. The main conclusions in his study were that input quality and competition positively impacted on productive efficiency and that public and private research universities needed to be analysed jointly in such situations.

Abbott and Doucouliagos (2003) published a third study on the efficiency of Australian universities, again using the same 1995 data as used in the work of Avkiran (2001). Their findings showed that in the model using all 36 universities and the research quantum as a measure of research output, the mean technical and scale efficiency scores were 0.946 and 0.967, respectively. The authors contended that, in terms of efficiency, Australian universities were performing very well. However, further improvements in efficiency could not be ruled out, such as expanding education outputs (teaching and research), given their available inputs. Furthermore, Australian universities compete strongly with other nations to attract overseas students; however, no conclusion was drawn about how efficient Australian universities are compared with institutions in other countries.

Flegg et al. (2004) investigated the technical efficiency of 45 British universities in the period 1980/81 to 1992/93. Their analysis indicated that that there was a substantial rise in the weighted geometric mean technical efficiency score during the reported period, with this rise being most noticeable between 1987/88 and 1990/91. The Malmquist approach used to distinguish between changes in technical efficiency and intertemporal shifts in the efficiency frontier showed that total factor productivity rose by 51.5 per cent between 1980/81 and 1992/93, and that most of this increase could be attributed to a substantial outward shift in the efficiency frontier during this period. Carrington, Coelli, and Rao (2005) measured productivity growth by using DEA methods for 35 universities with annual data over the period 1996 to 2000. The results suggested that universities were relatively efficient and that their efficiency was stable over the period. In addition, Malmquist DEA productivity indexes revealed that university productivity growth was 1.8 per cent per year. The average scale efficiency of 92 per cent showed that universities could potentially increase their productivity by eight per cent given existing inputs if they could achieve optimal size.

By investigating the possibility of measuring the efficiency of HEIs in terms of the advantages and drawbacks of the various methods for measuring efficiency, Johnes (2006) asserted that, with the ability to handle multiple inputs and outputs, DEA was an attractive choice of technique for measuring the efficiency of HEIs. She added, however, its drawbacks, that sampling variation and random errors are not accounted for, cannot be overlooked. The author applied DEA to a dataset of more than 100 British HEIs using data for the academic year 2000/01. The findings indicated that technical and scale efficiencies in the British higher education sector appeared to be high, on average. The bootstrapping estimates of the 95 per cent confidence intervals for the efficiency scores of the reduced model suggested that the difference in efficiency between the worst- and best-performing English HEIs was significant.

Using DEA as a productivity evaluation tool, Anderson, Daim and Lavoie (2007) explored service industry efficiency through the case of university technology transfer. Their findings revealed that the performance of universities varied widely over the 54 US universities studied in the period 2001–2003. Seven universities were found to be relatively efficient whereas the 47 inefficient universities needed to increase licensing income, licenses and patents to be efficient given the current level of research spending. In addition, they indicated that public versus private and the presence of a medical school did not significantly affect the variation in technology transfer efficiencies.

More recently, many studies have tended to analyse the performance of HEIs in different nations at the institutional and national levels. Agasisti and Pohl (2012) used a two-stage analysis to examine and compare the efficiency of 53 Italian and 69 German public universities and their evolution for the years of 2001–2007, respectively. Their findings from the CRS DEA model indicated that the mean efficiency score within the Italian universities was only 0.688, whereas, for the German dataset, the average was 0.768. The authors asserted that the German universities were more efficient than the Italian universities, but that the latter were improving more rapidly than the former. Likewise, Agasisti (2011) used DEA to measure the efficiency of HEIs in 18 nations in the European Union. He divided 18 nations into four clusters based on public expenditure and subsidies. His key findings revealed that there was a small number of efficient nations (e.g., the UK and Switzerland) and that the influence of the public sector appeared to play a role in determining the efficiency scores.

Most recently, Mikusova (2015) estimated the efficiencies of 26 Czech public universities for the year of 2013. The author implemented two analyses, one for the universities and another for three groups with similar cost coefficients. In addition, she tested different eight models, in which each models had only one input and one output. The findings indicate that there was a large variation in efficiency scores among models and groups, from 0.676 to 0.988. The author also acknowledged that, under the DEA model, if the numbers of universities in groups are small, then there would be more efficient universities in the sample involved. As can be seen, using only one input and one output together with a small sample size for cross-sectional data may not provide robust results as expected.

One of the first papers using DEA in research on the efficiency of HEIs in Asian countries was that of Castano and Cabanda (2007a). They estimated the efficiency and productivity growth of 59 State Universities and Colleges (SUCs) in the Philippines over the period 1999–2003. Findings from the Malmquist index model revealed that 49 SUCs were efficient whereas the technical index showed that six SUCs had technological progress. The mean technical efficiencies using the CRS and VRS DEA models and scale efficiency were 0.954, 0.966, and 0.987, respectively. This implied that the SUCs in the Philippines were operating at below the full efficiency level, and thus indicated that appropriate methods needed to be adopted to improve their performance. Also, Castano and Cabanda (2007b) used DEA to measure the efficiency of 30 private HEIs over the period 1999–2003. Their results indicated that deterioration in technical efficiency (0.976) was due to scale inefficiency effects (0.989) and pure inefficiency (0.987). In the analysis of efficiency of 13 colleges at the University of Santo Tomas in the period 1998–2003, using DEA Malmquist indexes, Fernando and Cabanda (2007) showed that the main contributing factor to total factor productivity growth of these colleges was efficiency change with a growth rate of 0.9% per year. In addition, Guzman and Cabanda (2009) applied DEA to measure the technical efficiency of 16 selected colleges and universities in Metro Manila, Philippines, using academic data for the school years 2001–2005. Their findings indicated that with the index score of 0.807, schools needed, on average, an additional 19.3 per cent efficiency improvement to be fully efficient.

Munisamy and Talib (2007) estimated the efficiencies of 15 Malaysian HEIs in the academic year 2001/02 using the CRS DEA model with the assumption that a university's productivity is not affected by its operating scale. Their results showed that the average efficiency score for these HEIs was 0.642, of which seven HEIs were identified as performing below the average efficiency score. Munisamy and Talib (2008) evaluated the impact of age of university on their performance using the same dataset as in their 2007 study. They ran two different CRS DEA models with and without age which is referred to as nondiscretionary input variable. Their findings indicated that the average efficiencies of these models were 0.60 and 0.62, respectively. The authors concluded that age significantly influenced a university's rating. This led to a significant change in the scores of four institutions and adjustment in the rankings among one-third of HEIs. However, except for age of university, the performance of HEIs can be influenced by other environmental factors, such as ownership, location, or policy environment, that to some extent are out of the control of managers. Hence, these external variables should be examined to provide more robustness on the efficiencies of HEIs.

Another study by Johnes and Yu (2008) used DEA to examine the relative efficiency of over 100 selected Chinese universities using data for 2003 and 2004. Their findings indicated that the level of efficiency depended on the presence of a subjective measure of research output in the model. When the reputation variable (based on experts' opinions) was included, the mean efficiency was higher at 0.90, but when it was excluded it was approximately 0.55. Further investigation suggested that regional location, source of funding, and comprehension and specialization of HEIs all contribute significantly to the differences in their performance.

Kuah and Wong (2013) assessed the knowledge management (KM) performance of 19 Malaysian universities using a two-level DEA model in 2011. The findings revealed that the overall KM performance score was, on average, 0.51 and none of the institutions was fully efficient. This implied that Malaysian HEIs were not performing well in KM for the years involved. The authors suggested that further study should use a long span period of data to observe changes the performance of KM over time. The recent work of Husain (2012) who investigated the efficiencies of 20 Malaysian public universities for the period 2006–2008 revealed that the average university efficiency score was 0.867 using the VRS DEA, and 0.743 using the hybrid returns-to-scale (HRS) with trade-offs method. The author asserted that the latter increased the discriminatory power of the DEA assessment as reflected by the lesser number of universities identified as efficient, and smaller efficiency scores. Later, using the same dataset of 20 public universities in Malaysia, Podinovski and Husain (2015) proposed the novel approach that combines the recently developed HRS DEA model with the use of production trade-offs in higher education. An example of such trade-offs refers to the fact that one undergraduate student does not require more teaching resources than one master student. Stating this as a trade-off, they showed that it is technologically possible to teach more undergraduate students if the master students are decreased by the same number without extra teaching resources and keeping research funding and publications constant. However, the authors realised that due to the relatively small number of universities in the sample, the efficiency discrimination of the standard VRS model is somewhat low. In addition, their method requires the critical assumption underlying the HRS model, that is, the assumption of selective proportionality (between student and staff in their study). Thus, the suitability of this model may be limited in practical applications.

Ismail et al. (2014) used a recent robust DEA, the so-called Kourosh and Arash Model (KAM) to measure the relative efficiencies of 20 Malaysian public universities through a transition process of students in the year 2011. Their findings revealed that using the traditional VRS DEA model, the average efficiencies of public universities were 0.913 whereas using the KAM, those of public universities were 0.791. The authors used the KAM scores to rank these universities. However, because the sample size is relatively small as compared with the total number of inputs (3) and outputs (5) used in the cross-sectional data, the correlation problem is inevitable even though the authors argued that the KAM increases the discrimination power of DEA uniquely.

Moreover, the study of Kipesha and Msigwa (2013) used DEA to evaluate the efficiency of seven public universities in Tanzania during the period of 2007/08 to 2011/12. Findings of this model indicated that the average technical efficiency scores were 0.64, 0.86, 0.80, 0.75, and 0.57 for the five years involved, respectively. The authors argued that these HEIs should reduce their dependence on the government and donors and should be looking to find efficient solutions to increase their revenues that facilitate their growth in productivity, and increase quality and technological investment. Furthermore, Duh et al. (2014) investigated the operational efficiencies of 99 Taiwanese universities using cross-sectional data for 2005. Their results showed that the average efficiencies of teaching-related activities and research-related activities were 0.78 and 0.48, respectively. Using the ordinary linear regression to examine the relationship between the internal control implementation (ICI) and the efficiencies of universities, they found that for public universities, ICI did not have significant association with any measures of efficiency. By contrast, there was a positive and significant association between ICI and teaching-related efficiency. The authors suggested that future research may consider studying the effect of internal controls on transparency of financial reports and its relationship with the governance system of universities.

Alip and Jati (2014) applied the CRS DEA model to estimate the efficiencies of 12 Indonesian universities using two inputs and two outputs for a single year. The findings indicated that the average efficiencies of these universities were quite low, at 0.543, in which one university had its efficiency of 0.0475. The problem of this study is that it had too small a sample size which decreases the power of analysis in DEA models. Hence, their results could not demonstrate the real nature of the performance of the 12 Indonesian universities. Likewise, El-Razik (2015) used the input-orientated VRS DEA model to measure the efficiencies of 19 universities in Saudi Arabia in 2010, using four inputs and three outputs. Their findings showed that the average efficiencies of Saudi Arabian universities were 0.952, in which 15 out of 19 universities had the full efficiency of unity. As indicated in the literature, if the number of technically efficient universities is too numerous, it may result from the small sample size relative to the total number of inputs and outputs.

More interestingly, Kulshreshtha and Nayak (2015) used DEA to estimate the efficiencies of seven Indian Institutes of Technology and Science for 2001/02–2004/05. The findings showed that the average efficiencies of the seven Indian institutes were 0.965 and 0.963 for the input- and output-orientated DEA approaches, respectively. It can be seen that the number of decision making units in this study was too small, only seven observations relative to the total number of inputs (3) and outputs (2) even though the authors could use the pooled data for the four-year period. Accordingly, the power of analysis in the DEA models might be problematic.

Nguyen, Thenet and Nguyen (2015) applied the conventional DEA model to measure the technical efficiencies of 30 doctorate-granting universities in Viet Nam, using cross-sectional data for the academic year 2012/13. The authors conducted a sensitive analysis by testing eight different models and using different inputs and outputs. They used space and staff as inputs and enrolments, student numbers and total income as outputs. Then, they divided the input of staff into doctoral and non-doctoral staff, the outputs of enrolments and total students into bachelor, master and PhD degrees, respectively, and combined the number of inputs and outputs in different models. The results indicated that the efficiencies of the 30 universities ranged from 0.812 to 0.921 for the eight models. They stated that the aggregation of variables generated an average lower efficiency and, thus, reduced the chances of universities of being selected as efficient units. However, similar to recent DEA studies, the study of Nguyen, Thenet and Nguyen (2015) used quite a small sample size for only one year relative to the number of inputs and outputs used, thus, the discriminative power of the analysis is problematic. Regardless of the impacts of external factors on the performance of universities, the combination of variables in the various models was not justified to be relevant in the current Vietnamese context. As a result, their findings seem not to reflect the real nature of operations of Vietnamese HEIs and thus do not offer comprehensive results for the performance of the surveyed universities.

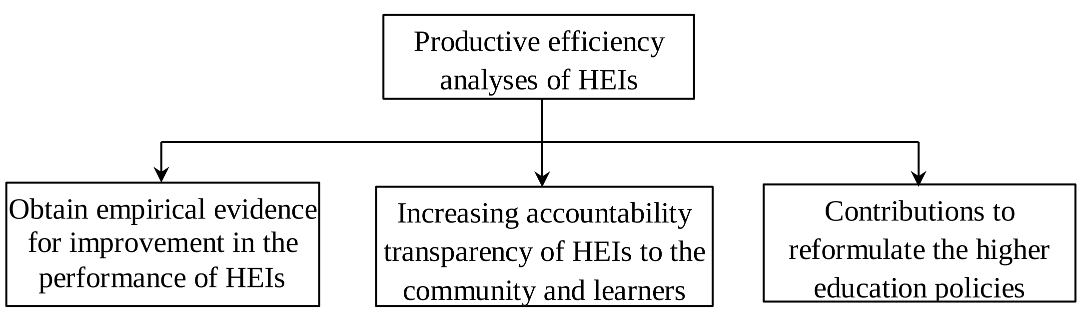
Most recently, Hussain et al. (2015) examined the efficiencies of Pakistani public tertiary schools in 12 different urban and rural areas for 1994–2012 using the traditional DEA model. It was found that the average CRS, VRS and scale efficiencies were 0.823, 0.919 and 0.893, respectively. The authors suggested some solutions to improve the performance of tertiary education in Pakistan such as the role of teacher, financial resources and transportation in rural areas that could be important factors to advance the efficiencies of Pakistani public schools. However, it should be noted that public tertiary schools in different areas, urban versus rural, may have different features in terms of their own teaching technology, i.e., academic staff, and learning and teaching facilities. Hence, using a metafrontier framework would be more appropriate to investigate the gap in technology and efficiencies of these areas.

In sum, assessing the performance of HEIs has been widely studied across different nations of the world. While these studies were conducted in different time periods and using different approaches, they have provided better understandings for HEIs and policymakers to develop more appropriate strategies to improve the performance of higher education. However, such research has rarely been implemented in Viet Nam. Comprehensive research on the performance of HEIs in Viet Nam would bring many benefits via: (a) providing a better understanding of the performance of HEIs in Viet Nam; (b) enhancing transparent accountability of HEIs; (c) offering an alternative tool of efficiency-based ranking; and (d) contributing applications and extensions of the advanced DEA models to the efficiency literature, in which Vietnamese higher education is a case study.

5. Evaluating the performance of Vietnamese HEIs: An analytical framework

In this section, we present the analytical framework of the performance evaluation of Vietnamese HEIs as presented in Figure 6.

Figure 6: Framework of productive efficiency analyses



5.1 Empirical evidence for improvement in the performance of HEIs

In general, estimating the performance of HEIs by using partial productivity measures, such as staff/student ratios, and outcome measures, such as student satisfaction and graduate employment rates, are not the most appropriate because of the diversity and multi-faceted nature of the higher education sector (Carrington, Coelli, and Rao, 2005; Emrouznejad and Thanassoulis, 2005). In reality, HEIs use many inputs, such as academic staff, administrative staff, operating cost, and others, to produce multiple outputs, for example, students, research outputs, and graduates who complete their studies, in their production processes. In this regard, measuring the efficiencies of HEIs involves calculating how their inputs can be saved to maintain the existing outputs or how to increase outputs, given their levels of inputs (Coelli et al., 2005). This approach provides insightful information for HEIs about their productive efficiencies that can lead to improving their performance by exploring the following aspects:

First, measuring the productive efficiencies of HEIs provides us with a better understanding of how efficiently HEIs can utilise input resources to produce outputs. If HEIs are not efficient, they will have information to set their performance targets for future improvement, for example, a decrease in inputs or an increase in outputs. In return, if they then become efficient, they should maintain their position and further improve their performance. Moreover, efficiency estimates provide useful information about peers from which HEIs can get information to improve their production.

Second, in the context of limitations of financial resources, the lack of qualified academic staff, and the inflexibility of the governance system, a decrease in productivities and efficiencies of HEIs is inevitable. This is likely to result in some degree of inefficiency, exacerbated by input mix inefficiency. Therefore, the sources of mix inefficiency and productive efficiency of Vietnamese HEIs need to be investigated. Empirical findings can provide educational leaders and policymakers with a big picture about operational efficiencies and sources of mix inefficiencies of HEIs and, thus, appropriate policies for HEIs can be formulated for the future.

Third, universities and colleges are both categorised as HEIs but they operate under different environments. If assuming that both groups are put into a common context, what are their efficiencies in the unrestricted teaching technology using the metafrontier approach, given that they face some constraints in choosing the full range of teaching technology due to restrictions of resources, regulations, or other determinants? Such empirical studies are able to provide more details for policymakers about their role and position in the national higher education system and, above all, answer the question of whether it is efficient to upgrade colleges to university status. In fact, in the Vietnamese context, the majority of colleges have desired to be updated to universities because it is believed that colleges could have more favourable conditions in increasing the number of new enrolments and developing new specialisations to meet the demands of learners.

Finally, financial efficiency is an indispensable component of academic operations and the overall performance of HEIs. Using financial resources ineffectively under the constraints of public funding would affect the academic efficiencies. Therefore, measuring financial efficiency as an immediate stage of the production process to support the academic stage under the organisational structure will provide both policymakers and HEIs with helpful information to better understand the contributions of financial efficiencies to the overall efficiencies of HEIs and redesign more feasible policies.

5.2 Increasing the accountability transparency of HEIs

Under globalisation forces, there is a call for increased transparency in institutional operations (Denman, 2014). The accountability transparency of HEIs can be enhanced by assessing the efficiencies of HEIs. To obtain data for analyses, HEIs are required to provide transparent and systematic indicators to MOET and society. Specifically, educational managers have to adopt a mandatory and transparent reporting system of their performance indicators, including financial transparency that may be considered a sensitive matter by management. In addition, data on input usages and output production must be stored statistically and published publicly at the institutional and national levels. Moreover, empirical analyses of performance of HEIs should be implemented periodically to provide prompt assessments for further improvement. As a result, accountability of HEIs will become more transparent and thus policymakers have sufficient data to better analyse the performance of HEIs, and propose more relevant policies for the operations of HEIs.

5.3 Contributions of the performance analyses to higher education policy

Implementing the performance evaluation of HEIs brings about many benefits for Vietnamese higher education and will contribute to the higher education reform policy in terms of the following aspects by:

1. Creating a level playing field for HEIs in the context of today's globalisation;
2. Providing sufficient information for HEIs to improve their performance and for policymakers to reformulate and redesign more appropriate regulations;
3. Changing traditional management frameworks to enhance accountability transparency and, thus, catching up with the pace of global educational development; and
4. Constructing a solid foundation for improving Vietnamese universities’ positions on the world university rankings.

6. Conclusions

It is undeniable that the reform policies of the government have resulted in positive effects for the Vietnamese higher education system. However, the innovations of Vietnamese HEIs have not kept pace with the development of Western higher education in terms of three key factors: the complex governance system, the lack of internationally recognised HEIs, and the absence of studies that have evaluated the performance of HEIs. To be involved in today's international integration process, the Vietnamese higher education system needs to make significant progress in tackling challenges from external and internal forces. Whereas a comprehensive transformation in the system of governance requires a long-term plan, reform at an institutional level can be practically implemented. Educational managers and policymakers need to be open-minded and be ready to adopt new approaches in the quest to restructure the Vietnamese higher education sector. Further studies proposed to obtain empirical evaluation of the productive efficiencies of Vietnamese HEIs are presented in the following chapters of this thesis.

PART 2: EMPIRICAL ANALYSES OF THE PERFORMANCE OF VIETNAMESE HIGHER EDUCATION INSTITUTIONS

Based on characteristics, challenges, and suggestions stated in Chapter 2, this part presents the empirical findings on the performance of Vietnamese HEIs obtained from the individual papers. There are seven papers that are presented in the seven chapters of Part 2. Each chapter is organised as a self-contained article. The structure of these papers is relatively similar, comprising introduction, research context, methodology, empirical findings, discussions, and conclusions. The overview of the higher education sector and description of data is included and repeated as part in each chapter to provide contextual background information necessary for each empirical analysis.

The presentation of results provides an indication of the progression of the nature of the models and methods used, from the standard method to more advanced models, all under the general framework of the DEA approach.

Chapter 3: An empirical analysis of the performance of Vietnamese higher education institutions

Chapter 4: Operational efficiencies of Vietnamese higher education institutions: An evaluation using a semiparametric DEA approach

Chapter 5: On the measurement of environmentally-adjusted efficiencies of Vietnamese higher education institutions: An analysis using a bootstrap multi-stage DEA approach

Chapter 6: Measuring input mix efficiencies of higher education institutions in Viet Nam

Chapter 7: Technological heterogeneity and efficiencies in Vietnamese higher education institutions: A metafrontier directional distance function approach

Chapter 8: Financial efficiencies of Vietnamese public universities: A dynamic network DEA approach

Chapter 9: Measuring efficiencies of Vietnamese public colleges: An application of the DEA-based dynamic network approach

Chapter 3: An Empirical Analysis of the Performance of Vietnamese Higher Education Institutions [1]

Abstract

This paper provides an analysis of the academic performance of higher education institutions (HEIs) in Viet Nam with 50 universities and 50 colleges in 2011/12. The two-stage semiparametric data envelopment analysis is used to estimate the efficiencies of HEIs and investigate the effects of various factors on their performance. The findings reveal that there are still potential avenues to improve the current performance of HEIs in the sample involved. There appears to be a difference in the efficiencies of public and private HEIs in the reported year. It is noted that the inefficiencies of HEIs are not entirely a result of managerial performance, but are also influenced by other factors such as location, age, and the contribution of tuition fees. Our results are expected to provide more understanding of the operational efficiencies of HEIs to help educational managers and policymakers find possible solutions to improve the performance of Vietnamese higher education.

Keywords: Efficiency, performance, data envelopment analysis, semiparametric model

[1] Tran, C.D.T.T. and Villano, R.A. (2016). An empirical analysis of the performance of Vietnamese higher education institutions. *Journal of Further and Higher Educatio*n. DOI: 10.1080/0309877X.2015.1135886

1. Introduction

In the current trends of globalisation and internationalisation, higher education institutions (HEIs) are receiving increasing interest from policymakers and educational leaders. This is because a nation's human resources significantly affect its socio-economic development (Agasisti and Pohl 2012). Recently, public deficits and increasing debts in the fiscal budgets of many countries have augmented concern for public governance reform and the call for greater efficiency in the distribution of public goods and services. Given the difficult status of public funding, evaluating the performance of HEIs has become a central point in the management and governance of national education systems (Agasisti et al. 2012; Sav 2012). In Western countries, HEIs, especially public ones, cannot escape political and taxpayers' scrutiny of their activities. Therefore, studies on estimating the efficiencies of HEIs remain an important issue in times of financial challenges (Agasisti and Pohl 2012; Sav 2012). In developing countries, such studies are crucial for re-evaluating educational reform policies, increasing financial accountability to the society and better using the scarce input resources of universities (Castano and Cabanda 2007a; Hayden 2012).

As in other developing nations, economic reforms in Viet Nam that started from 1986 are strongly linked to the higher education sector. After nearly 30 years of the economic reform policy, the higher education sector in Viet Nam has witnessed remarkable growth in the numbers of students (122 percent) and of universities and colleges (117 percent) for the period of 2001–2010 (General Statistics Office 2012). In addition to this, the government has increased investment in education and issued several policies in favour of the higher education sector with respect to tuition fees, academic staff, and teaching quality (MOET, 2013). All these have resulted from implementing the Higher Education Reform Agenda (Resolution 14/2005/NQ–CP) and the educational renovation strategy for the period of 2001–2010 (Decision 201/2001/QD–TTg), which have been favourable for the reform progress of higher education in meeting the requirements of socio-economic development.

Although Vietnamese higher education has made remarkable growth in the past two decades, there are still challenges facing the governance system that may hinder the development of HEIs. The majority of previous studies on Vietnamese tertiary education (e.g. Hayden and Lam 2007; Hayden 2012; Pham 2012; Tran 2014) addressed the advantages and drawbacks of government policies and suggested feasible solutions for the sector. These qualitative studies offered helpful insights for the government to redesign more appropriate regulations for higher education. However, evaluating the operational efficiencies of individual HEIs has not been addressed to see whether they are operating efficiently under the current legal environment and whether they are being affected by any particular factors in this environment. Our paper offers to bridge this gap in operational research in the context of Vietnamese higher education.

The objectives of this study are twofold. First, we respond to the research question of whether HEIs are operating efficiently by providing empirical evidence on their efficiency scores using data development analysis (DEA). Second, the determinants that are expected to influence the performance of HEIs are examined using the semiparametric model to confirm the hypotheses of interest. The findings are expected to provide insightful information for policymakers to better understand the performance of HEIs and seek more appropriate solutions for moving the sector forward.

The structure of the paper is organised as follows: Section 2 briefly discusses the main features of the Vietnamese higher education sector. Section 3 presents the method of analysis, data sources, and variables. The empirical results of the study are presented in Section 4 and concluding remarks are provided in Section 5.

2. Higher Education in Viet Nam

Viet Nam has achieved rapid economic growth and impressive accomplishments in many socio-economic aspects during the period of transition to a market-orientated economy. The economic reform, known as *Doi Moi* (renovation), launched in 1986, has contributed to the Vietnamese economy becoming one of the fastest growing in the world—its GDP growing by more than seven percent per annum, on average, during the period 1989–2010 (World Bank 2011). This has created a strong impetus for Viet Nam to innovate in its higher education system. In 2010, government investment in the educational sector accounted for 20.9 percent of total national expenditure and public expenditure per student in tertiary education occupied 39.8 percent of GDP per capita (Economic and Social Commission for Asia and the Pacific 2014). The Ministry of Finance (2012) reported that the total national budget for education in 2012 increased by 11.1 percent as compared with that in 2011. This illustrates the extent of the government's efforts to restructure the higher education system.

According to MOET (2013), Viet Nam currently has a total of 421 HEIs including 207 universities and 214 colleges. This figure is projected to increase to a total of 460 with 224 universities and 236 colleges by 2020 following Decision 37/2013/QD–TTg of the government on adjusting the network planning of tertiary institutions for the period of 2006–2020. During the period 1997–2013, a twofold increase in the number of HEIs resulted from the government's socialisation policy in 1997. Private education was officially encouraged from that year. The government issued some resolutions and decrees [2] to encourage the role of private education in the national education system across different periods. With this policy, privately owned institutions have been established, owned and managed by private organisations or individuals, who have sufficient financial resources to invest in human resources and infrastructure as indicated in the 2012 *Law of Higher Education*. In 1999, Viet Nam had only 22 private HEIs, but this figure increased nearly fourfold by 2013, with 54 universities and 29 colleges. The enrolment of private HEIs rose remarkably, going from 107,538 students in 1999/2000 to 312,652 in 2012/13 (MOET 2013). It is noted that their current share of enrolment only occupies 14.4 percent of the total national enrolment.

Public education has an important place in the national education system. The number of publicly-owned HEIs is currently 338, of which 153 are public universities. The average enrolment of public HEIs was 5,517 students in 2012-2013, whereas that of private ones had an average enrolment of 3,767 students in the same year. Public higher education is considered as a key incentive to provide highly-qualified human resources to the labour market. More flexibility has been given to public higher education since 2010 when the government issued Decree 49/2010/ND–CP on tuition fees that allows public HEIs to increase tuition fees in the period 2010/11–2014/15. With this policy, public HEIs can increase annual revenue for their academic operations within the confines of the allowed tuition rates for each year. In 2011, MOET promulgated Circular 57/2011/BGD–DT that allows HEIs to set the enrolment quota per annum based on their available floor area per student and the ratio of students to lecturer, and requires them to submit their registration form to MOET. However, it is noticeable that MOET reserves the right to ban any HEI from enrolment if they violate the regulations, such as inaccurate calculations of the enrolment quota for every discipline. Arguably, the government desires to increase the autonomy of HEIs but also wants to control them to some extent. Thus, real autonomy, as expected, may still be questionable in the current context of higher education.

The management system of higher education in Viet Nam still remains complicated and fragmented. Among 421 HEIs, there are 51 public HEIs under the management of MOET and the remaining HEIs (87.4 percent) are under the management of 13 ministries and local authorities. All HEIs are operating under the same education law but under different line management systems, depending on the ministry to which they belong. Partly due to this fragmentation and complexity, statistical information about Viet Nam's higher education system is disjointed and incomplete.

[2] Resolution 90/1997/NQ-CP on socialisation policy of education, health and culture; Decree 73/1999/ND–CP on encouraging socialisation policy of education, health, culture and sports; Decree 69/2008/QD–TTg on encouraging socialisation policy of education, vocational education, health, culture, sports, and environment; and Decree 59/2014/ND–CP on adjusting some contents of Decree 69/2008/QD–TTg.

Furthermore, there is no systematic recording system of performance indicators for individual institutions.

Realising this challenge, in 2009, MOET issued Circular 09/2009/TT–BGDDT to require all HEIs to implement the regulations of "three contents in public" including student numbers, staff numbers and academic facilities, and financial data. HEIs have to submit their annual reports based on this information to MOET and publish them publicly on their website. From 2010/11, on average, 60 percent of HEIs have followed this rule for each academic year (MOET 2013). This is clearly a positive signal for building a database for performance indicators of HEIs even though not all HEIs have strictly followed these regulations. Based on the available data stored officially at MOET, an analysis is necessary to understand the level of performance of Vietnamese HEIs, and, thus, provide insights for policymakers to design more appropriate policies for higher education in Viet Nam.

3. Methodology

3.1 Data Envelopment Analysis (DEA)

DEA is a linear programming method that can be used for measuring the relative efficiencies of decision making units (DMU) by constructing a nonparametric piece-wise surface over the data (Coelli, Rao, O'Donnell and Battese 2005). DEA is a well-known tool that has been applied in different fields, especially where prices and subsidies are still regulated and dominated by government bodies, as is the case in the higher education sector (Johnes and Yu 2008). DEA appeals to researchers, especially management scientists, for assessing the relative efficiencies of DMUs with multiple inputs and multiple outputs using only information on input and output quantities without requiring information on prices. However, DEA assumes that all deviations from the efficient frontier are due to inefficiency without allowing one to distinguish between managerial inefficiency and statistical noise (Jacobs 2001).

In the current context of Vietnamese higher education, the DEA approach is the appropriate instrument to measure the operational efficiencies of HEIs. The reason for this is that measuring efficiency in the higher education sector is difficult because of its multi-faceted nature, diversity, and complexity. Many indicators are not able to be measured in monetary terms such as qualifications of academic staff, quality of articles published in international journals or quality of students (Avkiran 2001; Carrington, Coelli and Rao 2005; Emrouznejad and Thanassoulis 2005). In addition, the DEA model does not require assumptions about the relationship between explanatory and dependent variables. This is relevant in the context of Vietnamese higher education in the renovation process with many new policies and regulations that have been promulgated that may affect the performance of HEIs in different ways. Further, using the DEA approach can initially differentiate efficient and inefficient HEIs, build performance targets for inefficient HEIs, and strengthen efficient units for further improvements as well.

The DEA model was officially proposed by Charnes, Cooper and Rhodes (1978) to measure the technical efficiency of a given observed DMU assuming constant returns to scale (CRS), using multiple inputs and multiple outputs. This assumption is appropriate when all DMUs are operating at an optimal scale. However, in reality, some factors such as imperfect competition, government regulations, and constraints on finance can affect their optimal operating scale (Coelli et al. 2005). Later, Banker, Charnes and Cooper (1984) extended this model to account for variable returns to scale (VRS) that allow the calculation of technical efficiency without scale effects. The details of the mathematical programming of the DEA model are illustrated in Section A of the Appendix.

An input-orientated DEA approach was chosen to measure the performance of HEIs. This approach allows HEIs to contract their inputs to obtain the existing outputs. In Viet Nam, HEIs have until recently based their decisions on academic operations within the confines of government regulations. It is noted that the budget-related thresholds imposed on the enrolment quotas of tertiary institutions are no longer an instrumental policy. Instead, HEIs can set their annual enrolment quotas but these quotas should strictly follow Circular 57/2011/BGD–DT of MOET relating to floor area for academic spaces per student and the ratio of students to lecturer. This means that HEIs cannot expand their enrolment quotas without meeting some governmental requirements. The best solution for them is to use the available input resources efficiently to obtain the existing outputs in terms of given educational quality.

Following the 2012 *Law of Higher Education*, although universities and colleges are classified as HEIs in the Vietnamese higher education system, they are operating in relatively different environments. Whereas undergraduates at universities are trained for a period of four years, those in colleges are trained for only three years. Only universities offer postgraduate programs. Moreover, research outputs of universities focus on academic research but those of colleges are primarily related to research, extension, and consultant services. Finally, colleges tend to train students with more practical skills whereas universities teach students research skills. Hence, the DEA models are estimated separately for universities and colleges to provide appropriate measurements relative to their own cohorts.

The estimated efficiency scores from the standard DEA approach could contain potential biases because sampling variation and random errors are not accounted for (Simar and Wilson 2000). To overcome this, the bootstrap technique was introduced by Simar and Wilson (1998) to analyse the sensitivity of measured efficiency scores to sampling variation. Bootstrapping allows the assigning of measures of accuracy to sample estimates such as bias, variance, and confidence intervals. Our paper implements this method to obtain robust efficiency estimates.

3.2 DEA efficiency and the effects of determinants

To examine the factors that may explain the variation in technical inefficiencies of HEIs, we implemented the semiparametric DEA method with bootstrapping, the so-called double-bootstrap DEA model, proposed by Simar and Wilson (2007). Double bootstrap refers to two phases of bootstrap: one in the original DEA estimation in equation (1) of the Appendix and another in the second-stage truncated regression model of DEA estimators on environmental factors, as presented below. This method allows one to solve the serial correlation and bias of estimated efficiencies as well as the correlation between error terms and explanatory factors (Z).

Following Simar and Wilson (2007), the truncated regression model is expressed as follows:

$$\hat{\theta}_{VRS} = f(Z_j, \beta_j) + u_j$$

where $\hat{\theta}_{VRS}$ is bias-corrected efficiency scores obtained by using equation (1) in the Appendix (Shephard distance function efficiency scores that are greater than one); Z_j represents the explanatory variables that can affect the efficiency scores of institutions; and u_j is an error term with distributional assumptions that are defined by $u_j \sim N(0, \sigma_u^2)$ with left-truncated at $(1 - z_j\hat{\beta}_j)$. Details for the bootstrap procedure are presented in Section B of the Appendix.

3.3 Variables, data and data sources

3.3.1 Output and input variables

In this study, we chose the outputs and inputs of education and research that were consistent with the literature and relevant to the Vietnamese tertiary education sector. The first set of teaching outputs involved the numbers of full-time equivalent (FTE) students in undergraduate and graduate education separately for universities, and the number of FTE students in associate undergraduate programs for colleges. Under the production function, they are referred to as resource users of HEIs. These outputs have been widely used in recent studies such as Abbott and Doucouliagos (2003; 2009), Castano and Cabanda (2007a, 2007b), Thanassoulis et al. (2011), and Miranda, Gramani, and Andrade (2012).

The second type of output is the completion rate. Stevens (2005) used the ratio of first- and upper-second-class degrees as a consistent measure of degree quality, whereas Fu and Huang (2009) applied the average monthly starting salary of graduates to measure the performance of colleges of business in Taiwanese universities. Daghbashyan (2011) indicated that the employment possibilities after graduation are likely to be taken as an indicator of the quality of students. In the Vietnamese context, because the statistical data for single institutions are incomplete, the completion rate per annum is used in this paper as an indicator to measure the performance of students of each HEI.

Third, research output has received considerable attention in evaluating the performance of HEIs. Some studies have selected number of journal publications to control for research output. However, the research output of HEIs may include conference papers, book reviews, and patents. Thus, by choosing only one of them, the empirical results may be biased. The choice of research funding, proposed by Robst (2001) and Abbott and Doucouliagos (2003), has been used as a research output. In our study, due to limited data, research output is measured by incomes from research-related activities, excluding tuition fees and government funding.[3]

On the input side, five input variables were used. The first was the *total number of FTE academic staff*. Most academics participate in teaching and research activities. The second input was the *number of FTE non-academic staff*. Non-academic staff members are involved with administering students, teaching and research staff, and generally facilitating the teaching and research process. In the context of this study, the non-academic category included general and administrative staff as well as delivery support staff. The third input was *floor area for academic spaces*. This was quite important for enrolment quotas of Vietnamese HEIs because MOET has asked each HEI to meet the standards of floor area per student as a basis for calculating enrolment quotas. The fourth input was *operating expenditures* of HEIs. These expenditures are used for annual operations of HEIs. Finally, the quality of the students admitted was added as the fifth input in the model. *The average national entry exam (NEE) marks* was considered as a proxy for the input quality of each HEI.

[3] We acknowledge that using research funding does not account for quality and differences in disciplines. Given the limited data availability in the case of Viet Nam, the use of research funding as an output indicator is warranted. Daghbashyan (2011) also used total research funding to account for research output.

3.3.2 Determinants of the performance of HEIs

In this section, we define and discuss the variables that are expected to be determinants that impact on the operational efficiencies of HEIs in the truncated regression models. These are the age of the HEI, location, the proportions of lecturing staff who have postgraduate, the total tuition fees, and the amount of public funding for each HEI. These input variables are more precisely defined in Table 1. For these explanatory variables in our regression models, we were interested in the following hypotheses:

- *Age of HEIs* is expected to be positively related to the efficiency scores because the older HEIs have much more experience in managing their academic operations;
- *Location is expected to be positively correlated with the efficiencies of HEIs.* Those HEIs that are located in one of the main cities, Ha Noi, Ho Chi Minh, Da Nang or Hue City, have more advantages because they can access the available resources for teaching and learning;
- *The proportion of lecturing staff with postgraduate (doctoral and master) degrees* is expected to be positively related to the efficiency scores.
- Finally, *the contribution of tuition fees is expected to be positively significantly associated with the efficiency scores of universities and colleges*. This factor was tested to give a preliminary signal about the relationship between tuition fees and the efficiencies of HEIs after Decree 49/2010/ND–CP on tuition fees had been in effect since 2010. This Decree allows HEIs to increase their tuition fees within the framework as regulated by the government for the period 2010/11–2014/15. To attribute the change in the efficiencies of HEIs to this Decree is beyond the scope of our study. The complex nature of causal correlation in our context is not easy to identify, but the correlation between tuition fees and the efficiencies of HEIs provided us with useful information for managerial implications. The same holds for government funding, only tested in the college case, which most public colleges in the sample involved heavily rely on because of the limited financial resources obtained from tuition fees and income from other activities.

It is noted that in the DEA models, the operating costs input was used to better reflect the real nature of an expenditure input necessary for the operating process of HEIs, rather than tuition fees or government funding. In addition, it is also an appropriate indicator for measuring the efficiencies of HEIs regardless of the ownership of HEIs.

Definitions of all input, output, and explanatory variables in the truncated regression are presented in Table 1

Table 1: Description of input, output, and explanatory variables

Output variables	***Input variables***	***Explanatory variables***
Y_1. Full-time equivalent (FTE) undergraduate students	X_1. Number of academic staff	E_1. Age of HEI (number of years since its establishment)
Y_2. FTE postgraduate students (for the university model)	X_2. Number of non-academic staff	E_2. Location of HEI: 1 if HEI is located in a main city, 0 otherwise.
Y_3. Completion rate	X_3. Floor area for academic spaces	E_3. The proportion of lecturing staff with a postgraduate degree.
Y_4. Research output, proxied by revenue income from research-related activities	X_4 Operating expenditures	E_4. Total tuition fees
	X_5. The average scores of national entrance exam of each HEI	E_5. Amount of Government funding

3.4 Data and data sources

In this study, the sample data were collected from 100 Vietnamese HEIs in 2011/12, involving 50 universities and 50 colleges. Data sources came from MOET, where the performance indicators of HEIs via their annual reports are recorded. The academic year of 2011/12 was chosen to implement a preliminary analysis for the performance of HEIs for the following reasons: (a) this was the year after the education renovation strategy for the phase of 2001–2010 was completed; (b) this was the first year HEIs started to apply Decree 49/2010/ND–CP on the new tuition-fee framework; and (c) the findings from these cross-sectional data provide benchmarking for later studies involving data for a longer time span.

4. Empirical findings

As stated above, we present separately the empirical findings of the efficiencies of universities and colleges in 2011/12 in Sections 4.1 and 4.2, respectively. This is followed by Section 4.3 discussing the impacts of determinants on the inefficiencies of two types of HEIs with different models.

4.1 Efficiencies of universities

Table 2 presents summary statistics of outputs and inputs used in the universities model. On average, universities trained nearly 6,000 undergraduate students and around 300 postgraduate students during 2011/12. Some private HEIs recruited fewer students than public HEIs.

Table 3 illustrates the efficiencies of universities from the standard and bootstrapped DEA models. It can be observed that the bootstrapped DEA model uses the same input and output dataset as the standard DEA model, but with bootstrapping there is a resampling technique with 2,000 replications. This method allowed us to obtain the Shephard efficiency scores (greater than one) (Wilson, 2008). For ease of interpretation, we transformed these scores to the Farrell efficiency scores by taking the reciprocals that are bounded between zero and one. This indicates that universities with an efficiency score of exactly unity are considered fully technically efficient. Otherwise, they are inefficient at the reported period and need to improve their performance.

Table 2: Summary statistics of output and input variables for universities

	Unit	Mean	Standard Deviation	Minimum	Maximum
Output					
Undergraduate	FTE student	5,973	5,747	298	21,150
Postgraduate	FTE student	294	586	0	3,317
Research income	Billion VND	23.0	62.7	0	400
Graduates	Percentage	83.8	9.7	60	100
Inputs					
Academic staff	Person	374	324	66	1,758
Non-academic staff	Person	141	108	36	545
Floor area	1,000 m^2	38.3	60	5.1	395
Operating costs	Billion VND	29.4	29.4	3.1	119
Average NEE	Mark	16.0	3.8	12	27.5

The efficiency estimates in Table 3 illustrate the potential for universities to improve their performance. The efficiency scores of universities from the standard DEA model were, on average, 0.982, suggesting that universities could potentially improve their efficiency by 1.8 percent. However, with the bootstrapped DEA model, the average efficiency score was 0.96. Whereas 36 universities of the sample involved obtained the full efficiency scores of one in the standard DEA model, no university was fully efficient in the bootstrapped DEA model. This shows that, after eliminating random effects, all universities could potentially improve more their efficiencies.

Table 3: Technical efficiencies of universities

	Standard VRS DEA			Bootstrapped DEA		
	Public	Private	Average	Public	Private	Average
Mean	0.979	0.994	0.982	0.957	0.971	0.960
Standard deviation	0.052	0.013	0.047	0.048	0.008	0.043
Max	1.000	1.000	1.000	0.986	0.979	0.986
Min	0.726	0.960	0.726	0.717	0.948	0.717
Coefficient of variation (%)	5.3	1.3	4.8	5.0	0.9	4.5
Fully-efficient universities	28	8	36	-	-	-

Public and private universities were placed under the common frontier to estimate their efficiencies. Accordingly, to avoid biases due to differences in their nature of ownership, the operating costs rather than government funding or tuition fees were used as an input in the DEA models. It is interesting to observe that the efficiency scores of private universities were slightly higher than those of public universities in both models. The average efficiency of private universities was 0.971 whereas that of public universities was 0.957 in the bootstrapped model. This was similar in the standard DEA model, 0.994 and 0.979 for public and private universities, respectively. Although the Wilcoxon rank tests show that these differences are not statistically significant at the 5% level of significance, the explanation for this could be that because private universities have used their own capital for all operations without support from the government, they may need to calculate carefully how to use inputs in the most efficient way for their operations, given their current education quality. For public universities, because they are being supported by the government, they may be more generous in their use of input resources such as floor area for academic spaces or staff without pressures of investing in land or paying salaries. This would lead us to be more concerned about the role of the government policies and management effectiveness of HEIs.

There are 17 so-called *vital* universities in Viet Nam that include two national universities, three regional universities and 12 other universities. These universities play an important role in the government's Higher Education Reform Agenda presented in Resolution 14/2005/NQ-CP on the comprehensive renovation of Vietnamese higher education. They are leading in the implementation of innovative policies in higher education in terms of educational quality and operational efficiency. In return, more support from the government has been given to them to improve academic activities. Thus, their performance is expected to be better than that of other public universities. Table 4 presents the efficiency estimates for 14 vital universities in our reported sample. The findings reveal that, on average, the efficiency score of the vital university group is slightly higher than that of the university sample mean in both the two models. The number of vital universities that obtained full efficiency scores accounts for 24 per cent of the sample involved. This may be because they operate in a more favourable environment. However, their average scores were still less than the full efficiency of one. Thus, they could potentially improve their efficiency by 3.6 percent.

Table 4: Efficiencies of some vital universities

	Standard DEA	Bootstrapped DEA
Mean	0.989	0.964
Standard deviation	0.038	0.041
Max	1	0.986
Min	0.859	0.849
Coefficient of variation	3.8	4.2
Fully efficient universities	12	-

4.2 Efficiencies of colleges

Table 5 presents basic information about inputs and outputs used in the college model. On average, colleges trained nearly 2,500 students and the proportion of graduates was 82.2 percent. Their average research income was around 2.4 billion VND. The number of academic staff was, on average, about double that of non-academic staff. A variation in using inputs to generate the outputs of colleges depends on their training size and the annual enrolment quotas based on the number of academic staff and floor area for academic spaces. For the college DEA model, three outputs and five inputs were utilised to calculate their efficiency scores.

Table 5: Summary statistics of output and input variables for colleges

	Unit	Mean	SD	Minimum	Maximum
Outputs					
Associate undergraduate	FTE student	2,441	1,732	230	8,382
Research income	Billion VND	2.4	3.0	0	13.47
Graduated students	Percentage	82.2	9.8	60	98
Inputs					
Academic staff	Person	127	56	36	295
Non-academic staff	Person	57	19	26	105
Area of academic spaces	1,000 m^2	18.6	20.1	3.2	140.3
Operating costs	Billion VND	10.4	6.1	3.21	30.6
Average NEE	Mark	11.6	2.4	10	20.5

Table 6 shows the relative efficiencies of the colleges in the sample. On average, colleges could potentially improve their efficiencies by 3.8 percent in the standard DEA model and 6.1 percent in bootstrapped DEA model. Around 58 percent of the colleges obtained the full efficiency scores of 1 in the standard model, and the rest of the colleges were inefficient and need to improve their performance. However, there were no colleges that were fully technically efficient in the bootstrapped model. The coefficient of variation of technical efficiency is 8.1 percent and 7.9 percent for the standard and bootstrapped DEA models, respectively. This shows the relatively wide scatter in the sample relative to the mean.

Table 6: Technical efficiencies of colleges

	Standard VRS DEA			Bootstrapped DEA		
	Public	Private	Average	Public	Private	Average
Mean	0.961	1.000	0.962	0.937	0.975	0.939
Standard deviation	0.080	-	0.078	0.075	0.018	0.074
Max	1.000	1.000	1.000	0.997	0.987	0.997
Min	0.523	1.000	0.523	0.514	0.962	0.514
Coefficient of variation (%)	8.3	-	8.1	8.0	1.8	7.9
Fully efficient colleges	27	2	29	-	-	-

It can be observed that private colleges have better performance than their public counterparts. For the bootstrapped model, private colleges, on average, obtained the efficiency score of 0.975, whereas public ones had a lower mean efficiency score of 0.937. For a one-tail test, using the Wilcoxon rank sum test, this distinction was statistically significant at the 5% level of significance (Z value=1.73). The explanation for this could be that managers of private colleges have utilised their investment capital for all academic operations in a more efficient way, at least in the reported year.

4.3 Determinant effects on the inefficiencies of HEIs

In this section, the effects of determinants on the inefficiencies of HEIs are examined by using truncated regression models with bootstrapping. It should be noted that the Shephard efficiency scores, estimated in the first step, a value greater than unity indicates the inefficiency. Thus, the sign of coefficients in these truncated regression models should be interpreted inversely on efficiencies of HEIs. That means the estimated coefficients with positive signs impact negatively on the efficiencies of HEIs and vice versa.

4.3.1 University model

Table 7 demonstrates the regression results for the university model. The empirical results reveal that most of the coefficients of the variables in the model were significant at the 5% significance level. Only the two explanatory variables, age of HEIs and their tuition fees, have their significance level at 10%, with *p*-values of 0.058 and 0.065, respectively. For a one-tailed test, these two variables are statistically significant at the 5% level.

Table 7: Truncated regression results for the university model

	Coefficient	Bootstrap std. error	z	p>|z|
Constant	1.07	0.13	8.03	0.000
Location	-0.074	0.032	-2.31	0.021
Age	-0.021	0.011	-1.9	0.058
Tuition fees	0.00149	0.00081	1.84	0.065
Age-Tuition fees	-0.00014	0.000065	-2.16	0.031
Proportion of lecturers with Postgraduate degrees	-0.28	0.20	-1.42	0.156
Age-Postgrad degrees	0.045	0.018	2.48	0.013
Sigma	0.066	0.019	3.47	0.001
Wald χ^2	10.9			
Log likelihood	118.9			

Note: The number of replications for bootstrapping was 2,000.

The coefficient of age indicates that the older universities were more efficient. This may be because they have had more experience in managing their operations, at least in the reported year. Unexpectedly, tuition fees have a negative effect on efficiency. However, the interaction between age and tuition has a positive impact on the efficiencies of universities. This may reflect the fact that the long-standing established universities can impose a slightly higher level of tuition fees without worrying about reduction in new enrolment because they are well known and have had an established reputation in the higher education sector. They are believed to do better in both teaching quality and scientific research. Almost all the vital universities in Viet Nam are senior institutions and key players in Vietnamese tertiary education.

Although the coefficient of this interaction is statistically different from zero at the 5% significance level, its value is very small. It could be that the surveyed year was the first in which the new tuition framework was applied, thus its influence on efficiency of HEIs was not really large. In addition, at the 5% significance level, the coefficient of location indicates that universities located in the main cities are more efficient than those outside these cities. It can be seen that city universities find it easier to access modern teaching and learning facilities and, thus, this helps to attract more new students.

In addition, the ratio of postgraduate degrees has a positive impact on efficiency, although these coefficients are not statistically significant. Clearly, academic staff with postgraduate degrees would contribute more significantly to the efficiencies of universities via academic research and teaching activities. Surprisingly, the interaction between age and the ratio of academic staff with postgraduate degrees has a significantly negative effect on the efficiencies of universities. In the sample involved, the proportion of postgraduate staff in universities only accounts for 20 percent, on average. Thus, these findings show that the ratio of postgraduate degrees in these older universities is small and insufficient to make a significant contribution to the efficiencies of universities, especially in research. Instead, universities may find it more efficient to have staff with undergraduate degrees in teaching and administrative activities.

4.3.2 College model

Regarding the college model, government funding has been added as an explanatory variable to estimate its impact on the efficiencies of colleges, whereas other independent variables are similar to those for the university model. In the Vietnamese context, public colleges operating in the educational environment have less comparative advantages than public universities with respect to enrolments and academic research, thus they rely heavily on government funding rather than on tuition fees. Further, an increase in tuition fees may negatively affect new enrolments of colleges because students may choose to study in private universities with higher tuition fees for a bachelor degree, rather than study in public colleges to get a lesser degree.

The results in Table 8 show that the majority of variables are significantly different from zero at the 5% significance level, except for location with the significance level of 10%. As in the universities' case, given that the expectation of this variable has a positive effect, for a one-tail test, the coefficient of location is statistically significant at the 5% level of significance. A positive impact of location on the efficiencies of colleges implies that colleges located in the main cities are more efficient than their counterparts elsewhere because the former can access more advanced facilities for learning and teaching and, thus, attract more students. The coefficient of age is not statistically significant. The contribution of government funding has a positive impact on the efficiencies of colleges, whereas that of tuition fees has an inverse effect. It can be observed that tuition fees have not yet contributed significantly to the efficiencies of colleges.

The findings in Table 8 show that the coefficient of postgraduate degrees is negatively correlated with the efficiencies of colleges at the 5% significance level. This may reflect the fact that in Viet Nam a bachelor degree may be a sufficient requirement for academic staff to work in colleges, where teaching activities are emphasised rather than academic research. In contrast, the higher ratio of postgraduate degrees may cause an increase in operating expenditures for colleges. Thus, the academic staff with undergraduate, rather than postgraduate, degrees still occupy an important role in colleges.

Table 8: Truncated regression results of the college model

	Coefficient	Bootstrap std. error	z	p>|z|
Constant	-22.4	9.4	-2.39	0.017
Location	-1.80	0.99	-1.82	0.069
Age	0.76	0.47	1.61	0.106
Tuition fees	0.30	0.12	2.44	0.015
Government funding	-0.29	0.12	-2.42	0.016
Proportion of lecturers with postgraduate degrees	26	11	2.26	0.024
Age-Postgrad degrees	-0.82	0.82	-0.99	0.321
Sigma	0.70	0.21	3.28	0.001
Wald χ^2	10.7			
Log likelihood	90.33			

Note: The number of replications for bootstrapping was 2,000.

5. Implications and conclusions

This study attempts to implement an analysis of the performance of Vietnamese HEIs with cross-sectional data for 100 universities and colleges. The two-stage, semiparametric DEA model is used to estimate the operational efficiencies of HEIs and examine the possible impacts of determinants on their performance. Our findings are expected not only to offer useful insights for policymakers to consider possible solutions for improving the performance of HEIs, but also to provide a significant benchmark for the following comparative studies on the performance of higher education in Viet Nam. Using the two-stage DEA model with bootstrapping, we obtained the efficiency estimates of HEIs and examined what determinants significantly affect their performance.

For the university case, the findings reveal that, on average, universities in our sample involved were less than the full efficiency of one in the standard and bootstrapped models, with mean efficiencies of 0.982 and 0.960, respectively. Private universities appeared to be more efficient than their public counterparts in the years involved. The impact of the proportion of the academic staff with postgraduate degrees on the efficiencies of universities was not significant in the regression models. However, this impact became significantly positive on the efficiencies of older universities. In addition, location positively influenced the efficiencies of universities. This implies that the universities in the main cities clearly have more opportunities than their counterparts elsewhere in accessing better learning facilities and thus attracting more enrolments.

For the college case, the results of the standard and bootstrapped models showed that colleges were not fully efficient in their operations in the surveyed year, with efficiency scores of 0.962 and 0.939, respectively. Potential improvements are necessary for colleges to obtain full efficiency by using input resources more appropriately. Private colleges obtained the full efficiency of unity. However, because the proportion of private colleges in our sample was small, the result may need to be confirmed with a larger sample size. The role of government funding and location were factors positively affecting the efficiencies of colleges. In contrast, the ratio of staff with postgraduate degrees and the contribution of tuition fees were negatively related to the efficiencies of colleges.

From the above results, the study suggests particular managerial implications. First, universities and colleges in our sample were not efficient in their academic operations in the reported year, given their educational quality. This suggests that a large-scale survey with multiple periods is desirable to better estimate the extent of efficiency in Vietnamese HEIs. With this information, HEIs would find it useful to properly use scarce input resources for their operations, and thus contribute significantly to the objectives of enhancing their educational quality. Specifically, to obtain full efficiency, HEIs should implement the strategy of input saving for individual inputs such as the numbers of academic and non-academic staff, floor area for academic spaces and research income, assuming that these inputs are purely disposable (see part C of the Appendix for more detail). On the other hand, they could also potentially expand their outputs to use up these input surpluses. It is noted that to boost the quantities of teaching outputs, HEIs must follow MOET's regulations relating to floor area per student and the ratio of students to lecturers.

Second, the proportion of academic staff with postgraduate degrees was not significantly correlated with the efficiencies of universities. This implies that a more attractive recruitment policy, for example, a good salary and a flexible working environment should be used to employ and retain highly-qualified academic staff who would be helpful in enhancing the academic operations of HEIs. To obtain this, government support, especially to public HEIs, is essential to provide HEIs sufficient flexibility in their management of financial and human resources to expedite this process.

Finally, unexpectedly, tuition fees were related negatively with the efficiencies of HEIs in our sample. This reveals that although the government has allowed HEIs to increase their tuition fees within a regulated tuition framework for the four years 2010/11–2014/15, this increase seemed to be trivial and insufficient for their operating expenditures. As stated before, although we are unable to attribute this correlation to the influence of the tuition-fee policy only, because of the difficulty of disaggregating the deterministic and casual relationship involved, reconsidering this policy may be necessary to enhance the performance of HEIs.

Our paper made an attempt to provide a preliminary analysis on the performance of HEIs in Viet Nam in a particular year. Although we note some interesting findings above, some limitations need to be addressed. First, our sample is small involving cross-sectional data; a larger sample size and a longer span of data are desirable to gain a clearer picture about the possible variations in the efficiencies of HEIs over time. Second, other necessary inputs and outputs should be included in future studies. For example, in our study, research output is estimated by research income from research activities, whereas publications of academic staff are not included. Finally, a combination of DEA and stochastic frontier analysis would be useful to isolate the effects of random noise from managerial performance and environmental impacts. Hence, the results of measuring efficiency would be more robust.

Appendix

A. The mathematical programing DEA model

The variable return to scale (VRS) DEA model is described as follows: Assume that each DMU uses a vector of m discretionary inputs $X = (x_1, \ldots, x_m)$ to produce a vector of s outputs $Y = (y_1, \ldots, y_s)$. Inputs and outputs for $DMU_j (j = 1, \ldots, n)$are given by $X_j = \left(x_{1j}, \ldots, x_{Mj}\right)$ and $Y_j = \left(y_{1j}, \ldots, y_{Sj}\right)$ The VRS empirical production possibility set is given by

$$L_v = \left\{ \begin{array}{c} (X, Y);\ \sum_{i=1}^{N} \lambda_i y_{si} \geq y_s, \sum_{i=1}^{N} \lambda_i x_{mi} \leq x_m, \sum_{i=1}^{N} \lambda_i = 1, \lambda_i \geq 0 \\ s = 1, \ldots, S; m = 1, \ldots, M; i = 1, \ldots, N \end{array} \right\} \quad (1)$$

where λ_i are the intensity variables to contract or expand the observed operations of HEI i $(i = 1, \ldots, N)$ for the purpose of constructing convex combinations of the observed inputs (x_i) and outputs (y_i). Relative to the reference technology L_v constructed in (1), the estimator of the efficiency score θ can be obtained by solving the following programming problem:

$$\hat{\theta}_{VRS} = min \left\{ \theta > 0 \middle| y_s \leq \sum_{i=1}^{n} \lambda_i y_{si}, \theta x_m \geq \sum_{i=1}^{n} \lambda_i x_{mi}, \sum_{i=1}^{n} \lambda_i = 1, \lambda_i \geq 0, i = 1, \ldots n \right\} \quad (2)$$

where $\hat{\theta}_{VRS}$ is the projection of an observed HEI (x, y) to the efficient frontier, and provides the initial technical efficiency of the i^{th} HEI. For all $(x, y) \in L_v, \hat{\theta}_{VRS} \leq 1$, the HEI is fully technically efficient if $\hat{\theta}_{VRS} = 1$.

B. The bootstrap procedure

Details of this bootstrap procedure in the second-stage regression are given as follows:

1. $\hat{\theta}_{VRS}$ are estimated efficiency scores from equation (1) with bootstrapping using original data (Shephard distance function efficiency scores greater than 1)
2. Use the method of maximum likelihood (truncated at one) to obtain an estimate $\hat{\beta}_j$ of β_j and an estimate $\hat{\sigma}_u$ of σ_u from $\hat{\theta}_{VRS} = f\left(Z_j, \beta_j\right) + u_j$ at left truncated point of one.
3. The computation of L (i.e. L = 2,000) bootstrap estimates for $\hat{\beta}^*$ and $\hat{\sigma}_u^*$ as follows:
   3.1 For each j = 1 …, n, draw u_j from the $N(0, \hat{\sigma}_u^2)$ distribution with truncation at $1 - z_j\hat{\beta}_j$
   3.2 Compute $\hat{\theta} = f\left(Z_j, \beta_j\right) + u_j$ again for each j= 1, …, n.
   3.3 Using the maximum likelihood method to estimate the truncated regression of $\hat{\theta}^*$ on z_j, yielding bootstrap estimates ($\hat{\beta}^*$, $\hat{\sigma}_u^*$)
4. Use the bootstrap values and the original estimates $\hat{\beta}_j$ and $\hat{\sigma}_u$ to construct estimated confidence intervals for each element of β_j and σ_u.

C. Input target and saving from the DEA models

Table C1: Average input target and savings of universities

Input	Unit	Current	Target	Saving
National exam mark	Marks	16.33	15.91	0.12
Academic staff	Person	373.78	348.72	20.28
Non-academic staff	Person	140.66	134.48	3.91
Floor area	1,000 m^2	38.29	35.42	2.52
Research income	Billion VND	29.44	25.37	3.53

Table C2: Average input target and savings of colleges

Input	Unit	Current	Target	Saving
National exam mark	Marks	11.62	11.03	0.06
Academic staff	Person	127.18	108.11	14.37
Non-academic staff	Person	57.12	47.39	7.26
Floor area	1,000 m^2	18.62	13.53	2.28
Research income	Billion VND	10.42	7.46	2.57

Notes:

- Current inputs are the existing levels of inputs being used by HEIs
- Input target is the level of inputs suggested to obtain the full efficiency
- Input saving is the level of inputs that should be saved to reach the full efficiency.
- For the levels of input saving for individual HEIs, please contact the authors for more detail.

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Chapter 4: Operational efficiencies of Vietnamese higher education institutions: An evaluation using a semiparametric DEA method

Abstract

This paper aims to evaluate the managerial performance of higher education institutions (HEIs) in Viet Nam with 112 universities and 141 colleges between 2011 and 2013. The two-stage semiparametric data envelopment analysis is proposed to estimate the efficiencies of HEIs and investigate the effects of contextual factors on their performance. The findings revealed that HEIs in the sample involved were not managerially efficient in their operations. To obtain the full efficiency of unity, HEIs could potentially improve their efficiencies, on average, 30.6 per cent for universities and 37.7 per cent for colleges. There were no significant differences in the efficiencies of public and private universities in the years involved. However, in the case of the colleges, private colleges were more efficient than their public counterparts. It is noted that the inefficiencies of HEIs were not entirely a result of managerial performance. Instead, contextual factors including location, age, tuition revenue and the proportion of postgraduate staff were found to influence the efficiencies of HEIs. Our results are expected to provide more understanding of the operational efficiencies of HEIs for educational managers and policymakers in their endeavour to find solutions to improve the performance of Vietnamese higher education.

Keywords: Efficiency, performance, data envelopment analysis, semiparametric model, Viet Nam

1. Introduction

With today's globalisation and internationalisation, higher education institutions (HEIs) have been receiving increasing attention from policymakers and educational leaders. This is because a nation's human resources significantly affect its socio-economic development (Agasisti and Pohl, 2012). Recently, public deficits and increasing debts in the fiscal budget of many countries have augmented concern for public governance reform and the call for greater efficiency in the distribution of public goods and services. Given the importance of public funding, evaluating the performance of HEIs has become a central point in the management and governance of national education systems (Agasisti et al., 2012; Sav, 2012). In Western countries, HEIs, especially public ones, cannot escape political and taxpayer scrutiny of their activities. Therefore, studies on estimating the efficiencies of HEIs remain an important issue in times of financial challenges (Agasisti and Pohl, 2012; Sav, 2012). In developing countries, such studies are crucial for re-evaluating educational reform policies, increasing financial accountability to society, and better using the scarce input resources of universities (Castano and Cabanda, 2007a; Hayden, 2012).

As in other developing nations, economic reforms, which started from 1986 in Viet Nam, are strongly linked to the higher education sector. However, since 1997, when Resolution 90/1997/NQ-CP of the government on socialisation of education, health, and culture was introduced, in which private education was officially encouraged, Vietnamese higher education has made remarkable growth in the numbers of students (122 per cent) and in the numbers of universities and colleges (117 per cent) for the period 2001–2010 (General Statistics Office, 2012). Government investment in education has been gradually increased; for example, in 2010, investment in the educational sector accounted for 20.9 per cent of total national expenditure and public expenditure per student in tertiary education occupied 39.8 per cent of GDP per capita (Economic and Social Commission for Asia and the Pacific, 2014). The Ministry of Finance (2012) reported that the total national budget for education in 2012 increased by 11.1 per cent compared with that in 2011. This illustrates the extent of the government's efforts to restructure the higher education system.

The government has issued several policies benefiting the higher education sector with respect to tuition fees, academic staff and teaching quality. All these have resulted from the implementation of the Higher Education Reform Agenda (Resolution 14/2005/NQ-CP) and the educational reform strategy for the phase of 2001–2010 (Decision 201/2001/QD-TTg), which have stimulated the reform process of higher education and helped it to meet the requirements of socio-economic development. However, whether they are operating efficiently under the currently legal environment and whether external uncontrolled factors can affect their performance has not been investigated and, thus, this has been left as an open question.

The main objective is to fill a gap in empirical research on the higher education sector in Viet Nam. Such an evaluation is fitting and timely to better understand the performance of HEIs as they aim to find the most appropriate solutions for moving the sector forward. The structure of our paper is organised as follows. Section 2 briefly discusses the main features of the Vietnamese higher education sector. Section 3 presents the method of analysis, data sources, and variables. The empirical results of the study are presented in Section 4, and concluding remarks are provided in Section 5.

2. The higher education sector in Viet Nam

Viet Nam has achieved rapid economic growth and impressive achievements in many socio-economic aspects during the period of transition to a market-orientated economy. The economic reform, known as *Doi Moi* (reform), launched in 1986, has made the Vietnamese economy become one of the fastest growing in the world with GDP growing by more than seven per cent per annum, on average, during the period 1989–2010 (World Bank, 2011). This has created a strong impetus for Viet Nam to innovate in its higher education system. According to the Ministry of Education and Training (MOET, 2013), Viet Nam currently has a total of 421 HEIs comprising 207 universities and 214 colleges. A twofold increase in the number of HEIs during the period 1997–2013 resulted from the government's socialisation policy in 1997. Private education was officially encouraged from this year. The government issued some resolutions and decrees [4] to encourage the role of private education in the national education system across different periods. In accordance with this policy, privately owned institutions are established, owned and managed by private organisations or individuals who have sufficient financial resources to invest in human resources and infrastructure; i.e., at least they have five hectares of land for the campus and VND250 billions of chartered capital for initial operations (Decision 64/2013/QD–TTg on necessary conditions for establishing a private HEI). In 1999, Viet Nam had only 22 private HEIs, but this number increased

[4] Resolution 90/1997/NQ-CP on socialisation policy of education, health and culture; Decree 73/1999/ND-CP on encouraging socialisation policy of education, health, culture and sports; Decree 69/2008/QD-TTg on encouraging socialisation policy of education, vocational education, health, culture, sports, and environment; and Decree 59/2014/ND-CP on adjusting some contents of Decree 69/2008/QD-TTg.

nearly fourfold by 2013 with 54 universities and 29 colleges. The enrolment of private HEIs rose remarkably from 107,538 in 1999/2000 to 312,652 students in 2012/13 (MOET, 2013). However, their current share of enrolment is only 14.3 per cent of the total national enrolment.

Public education has an important place in the national education system. The number of publicly-owned HEIs is currently 338, of which 153 are public universities. Average enrolment of public HEIs was 5,517 students in 2012/13, whereas the private sector had an average enrolment of 3,767 students in the same year. Public higher education is considered a key incentive in providing highly-qualified human resources to the labour market. More flexibility has been given to public higher education since 2010 when the government issued Decree 49/2010/ND–CP on tuition fees that allowed public HEIs to increase tuition fees in the period 2010/11–2014/15. This policy capped public HEIs to increase annual revenue income for their academic operations within the confines of the allowed tuition rates for each year. Following this, in 2011, the government issued Circular 57/2011/BGD-DT on identifying the enrolment quotas of PhD, master, and bachelor degrees and of other qualification levels that allowed HEIs to set the enrolment quota per annum based on their available facilities and academic staff and submit their registration form to MOET. However, MOET reserves the right to bar any HEIs from enrolment if they violate the regulations such as inaccurate calculations of the enrolment quota for each discipline. Arguably, the government desires to increase the autonomy of HEIs but also wants to control them to some extent. Thus, 'real' autonomy, as expected, may still be questionable in the current context of Vietnamese higher education.

The management system of higher education in Viet Nam still remains complicated and fragmented. Among 421 HEIs, there are 51 public HEIs under the management of MOET and the remaining HEIs (87.4 per cent) are under the management of 13 ministries[5] and local authorities. All HEIs are operating under the same education law but under different line management systems, depending from which ministry they belong. Partly due to this fragmentation and complexity, statistical information about Viet Nam's higher education system is disjointed and incomplete. Thus, evaluating the performance of HEIs is a difficult due to the lack of systematically recorded data. Realising this challenge, in 2009, MOET issued Circular 09/2009/TT-BGDDT to require all

[5] Ministry of Industry and Trade; Ministry of Agriculture and Rural Development; Ministry of Culture, Sports and Tourism; Ministry of Foreign Affairs; Ministry of Finance; Ministry of Public Health; Ministry of Transport; Ministry of Construction; Ministry of Labour, War Invalids and Social Welfare; Ministry of Interior; Ministry of Natural Resources and Environment Ministry of Planning and Investment; and Ministry of Justice.

HEIs to implement the regulations of "three contents in disclosure", including student numbers, staff numbers and academic facilities, and financial data. HEIs have to submit their annual reports based on this information to MOET and publish them publicly on their website. Starting from 2010/11, on average, 60 per cent of HEIs have followed this rule for each academic year (MOET, 2013). This is clearly a positive signal for building a database for performance indicators of HEIs even though not all HEIs have strictly followed these regulations.

In such a context, a preliminary analysis with panel data may be necessary to understand what the performance of Vietnamese HEIs has been over multiple periods, and, thus, it would be useful for policymakers to design more appropriate and informed policies for the development of higher education in Viet Nam.

3. Methodology

3.1 Data envelopment analysis (DEA)

DEA is a linear programming method used for measuring the relative efficiencies of decision-making units (DMUs) by constructing a nonparametric piece-wise surface over the data (Coelli, et al., 2005). DEA is a well-known tool applied in different fields, especially where prices and subsidies are still regulated and dominated by government bodies, as is the case in the higher education sector (Johnes and Yu, 2008). DEA appeals to researchers, especially management scientists for its ability to assess the relative efficiencies of DMUs with multiple inputs and outputs using only information on quantities without requiring information on prices. However, DEA assumes that all deviations from the efficient frontier are due to inefficiency without allowing one to distinguish between managerial inefficiency and statistical noise (Jacobs, 2001). It is widely known that statistical noise refers to the unexplained variation or randomness that is found within a given data sample or model.

In the current context of Vietnamese higher education, the DEA approach is an appropriate instrument to measure the operational efficiencies of HEIs. The reason for this is that measuring efficiency in the higher education sector is difficult because of its diversity and multi-faceted nature. Many indicators are not able to be measured in monetary terms, such as qualifications of academic staff, quality of articles published in international journals, or quality of students (Avkiran, 2001; Carrington, Coelli and Rao, 2005; Emrouznejad and Thanassoulis, 2005). In addition, the DEA model does not require assumptions about the functional form between explanatory and response variables. This is relevant to the Vietnamese higher education sector with many new policies and regulations that are promulgated in the reform process and may affect the performance of HEIs in different ways. Further, using the DEA approach can initially differentiate efficient and inefficient HEIs, build performance targets for inefficient HEIs, and strengthen efficient units for further improvements as well.

The DEA model was officially developed by Charnes, Cooper and Rhodes (1978) to measure the technical efficiency of a given observed DMU assuming constant return to scale (CRS), using multiple inputs and outputs, meaning that when increasing the number of inputs leads to an equivalent increase in the output. This assumption is appropriate when all DMUs are operating at an optimal scale. However, in reality, some factors, such as imperfect competition, government regulations, constraints on finance, etc., can affect their optimal operating scale (Coelli et al., 2005). Later, Banker, Charnes and Cooper (1984) extended this model to account for the variable returns to scale (VRS) situation that allows the calculation of technical efficiency without scale effects.

This model was applied to the Vietnamese higher education sector and is described as follows:

Assume that each DMU uses a vector of m discretionary inputs $X = (x_1, \dots, x_m)$ to produce a vector of s outputs $Y = (y_1, \dots, y_s)$. Inputs and outputs for $DMU_i (i = 1, \dots, N)$ are given by $X_i = (x_{1i}, \dots, x_{Mi})$ and $Y_i = (y_{1i}, \dots, y_{Si})$. The VRS empirical production possibility set is given by:

$$L_v = \left\{ \begin{matrix} (X,Y);\ \sum_{i=1}^{N} \lambda_i y_{si} \geq y_s, \sum_{i=1}^{N} \lambda_i x_{mi} \leq x_m, \sum_{i=1}^{N} \lambda_i = 1, \lambda_i \geq 0 \\ s = 1, \dots, S; m = 1, \dots, M; i = 1, \dots, N \end{matrix} \right\} \quad (1)$$

where λ_i are the intensity variables to contract or expand the observed operations of HEI i ($i = 1, \dots, N$) for the purpose of constructing convex combinations of the observed inputs (x_i) and outputs (y_i). Relative to the reference technology L_v constructed in (1), the estimator of the efficiency score θ can be obtained by solving the following programming problem:

$$\hat{\theta}_{VRS} = min \left\{ \theta > 0 \middle| y_s \leq \sum_{i=1}^{n} \lambda_i y_{si}, \theta x_m \geq \sum_{i=1}^{n} \lambda_i x_{mi}, \sum_{i=1}^{n} \lambda_i = 1, \lambda_i \geq 0, i = 1, \dots N \right\} \quad (2)$$

where $\hat{\theta}_{VRS}$ is the projection of an observed HEI (x, y) to the efficient frontier, and provides the initial technical efficiency of the i^{th} HEI. For all $(x, y) \in L_v, \hat{\theta}_{VRS} \leq 1$, the HEI is fully technically efficient if $\hat{\theta}_{VRS} = 1$.

The estimated efficiency scores from the standard DEA approach ,defined by equation (2), could contain potential biases because sampling variation and random errors are not accounted for (Simar and Wilson, 2000). To overcome this, the bootstrap technique was introduced by Simar and Wilson (1998) to analyse the sensitivity of measured efficiency scores to sampling variation. Bootstrapping allows the assigning of measures of precision to sample estimates such as bias, variance, and confidence intervals. Our paper implements this method to obtain more robust efficiency estimates.

The input-orientated DEA approach was chosen to measure the performance of HEIs. This approach allows HEIs to contract their inputs to obtain the existing outputs. In Viet Nam, HEIs can make decisions for their academic operations within the confines of regulations. For example, HEIs can set their annual enrolment quotas but these quotas should strictly follow MOET's regulations relating to floor area for academic spaces and the ratio of students to academic staff. This means that HEIs cannot expand their enrolment quotas without meeting regulated requirements. The best solution for them is to use the available input resources efficiently to obtain existing outputs in terms of given education quality.

It is generally known that DEA results can be sensitive to outliers because this method is a deterministic frontier approach without accounting for random noise in the data-generating process. Thus, before implementing the performance analysis of HEIs, we made an effort to identify these outliers. We adopted the procedure of identifying outliers that was used by Thanassoulis (1999) and used the concept of super-efficiency introduced by Andersen and Petersen (1993) to identify HEIs with exceptional achievement relative to the efficient boundary drawn on the remaining HEIs. Then, based on the super-efficiency measure, we assessed how far these HEIs were from the rest of the colleges and decided whether they should be treated as outliers or not. A threshold difference of super-efficiency of 10 percentage points can be applied to identify outliers (Thanassoulis, 1999). Accordingly, a subset of HEIs that had super-efficiency over 100 per cent and were separated from other inefficient colleges by a gap of 10 percentage points was identified as outliers. Once outliers were detected, they were removed from the dataset. Then, the super-efficiency measure was implemented again on the new subset of data to identify whether outliers existed in the subsample. This process continued until there was no gap of 10 percentage points in super-efficiency in the sample. This means no HEI in the final dataset lay more than 10 percentage points in efficiency further away than some other units. It should be noted that this procedure was processed separately for universities and colleges. Consequently, 16 university outliers and 9 college outliers were identified. Following suggestions of Thanassoulis et al. (2011), after the outliers were identified, we did not allow them to affect the position of the efficiency boundary but held them with their data adjusted to sit on the boundary drawn on non-outlier HEIs.

3.2 DEA efficiency and the effects of contextual factors

Examining the effects of contextual factors on DEA efficiency in a second-stage analysis has received much attention of researchers regarding econometric models used. It is widely recognised that the ordinary least-squares (OLS) model is inappropriate because the predicted values of the dependent variable may be outside the unit interval, and its estimated coefficients are also not compatible with both the bounded nature of DEA scores and the presence of many points at unity in their distribution (Thursby, 2000; Thursby & Kemp, 2002, Leitner et al., 2007). On the other hand, the two-limit Tobit model with limits at zero and unity used for the second-stage DEA analysis is also questionable. It is observed that the accumulation of observations at unity is a product of the way DEA scores are defined rather than the result of censoring. Additionally, the DEA efficiency scores of zero are not observed, thus the domain of the two-limit is different from that of the DEA scores (Ramalho, Ramalho, and Henriques, 2010; Simar and Wilson, 2007). The logit fractional regression model, proposed by Papke and Wooldridge (1996), in the second-stage DEA has been implemented in the recent studies of Hoff (2007) and McDonald (2009). By comparing various approaches for modelling the second stage of DEA, these authors supported the use of the linear regression model. However, McDonald (2009) acknowledged the advantages of Papke and Wooldridge's model to obtain more refined analyses.

The study of Simar and Wilson (2007) was the first to describe a coherent data-generating process (DGP) for DEA scores, which is essential to select a suitable functional form for the regression model that relates these scores to the environmental variables. They provided a set of assumptions in which the use of estimates rather than true efficiency scores does not affect the consistency of the second-stage regression parameters. Simar and Wilson (2007) proposed two alternative bootstrap methods, Algorithm 1 (without taking account of the bias term in the first stage) and Algorithm 2 (accounting for the sampling variability of DEA scores) to make a valid statistical inference about these parameters. Two assumptions, suggested by Simar and Wilson (2007), are typically relevant because they assume that a separability condition holds, in which determinants are allowed to affect the efficiency scores but not the frontier; then, the true efficiency scores follow a truncated normal distribution (Ramalho, Ramalho, and Henriques, 2010).

Banker and Natarajan (2008) proposed a linear relationship between the logarithm of efficiency scores and the environmental variables in one of their specifications and implied that using OLS yields consistency of the parameters in the second-stage regression model. However, their DGP is less restrictive than that of Simar and Wilson (2007). In addition, distributional assumptions about the error term of the second stage are needed to re-estimate efficiency scores because the dependent variable is the logarithm, rather than the level, of DEA scores.

More recently, Ramalho, Ramalho, and Henriques (2010) proposed several alterative regression models of efficiency scores in the second stage using fractional regression models and tests of the specification chosen for the regression model using simple statistical tests. They also suggested that two-stage fractional regression models may be useful when the percentage of unity scores is large. However, their method did not consider the sampling variability of DEA scores, as in the method of Simar and Wilson (2007); thus they did not deal with how to make inferences about the regression parameters. Ramalho, Ramalho, and Henriques (2010) acknowledged that bootstrap procedures similar to those proposed by Simar and Wilson (2007) seem to be the only feasible way to make valid inference in their framework.

In this study, we adopted the Simar and Wilson (2007) Algorithm 2 for the second-stage DEA analysis to examine environmental impacts on efficiencies of HEIs. We implemented the semiparametric DEA method with bootstrapping, the so-called double-bootstrap DEA model in the second-stage regression. Double bootstrap refers to two phases of bootstrap: one in the original DEA estimation in equation (1) to obtain the Shephard distance function efficiency and another in the second-stage truncated regression model of DEA estimators on determinants, as presented below. This allows us to account for the serial correlation and bias of estimated efficiencies as well as the correlation between error terms and determinants (Z).

Details of this bootstrap procedure in the second-stage regression are given as follows:

1. $\hat{\theta}_{VRS}$ are estimated efficiency scores from equation (1) with bootstrapping using original data (Shephard distance function efficiency scores greater than 1);

2. Use the method of maximum likelihood (truncated at one) to obtain an estimate $\hat{\beta}_j$ of β_j and an estimate $\hat{\sigma}_u$ of σ_u from $\hat{\theta}_{VRS} = f(Z_j, \beta_j) + u_j$ at the left-truncated point of one;

3. The computation of L (i.e., L = 2,000) bootstrap estimates for $\hat{\beta}^*$ and $\hat{\sigma}_u^*$ as follows:

   a. For each j = 1 …, n, draw u_j from the $N(0, \hat{\sigma}_u^2)$ distribution with truncation at $1 - z_j\hat{\beta}_j$;

   b. Compute $\hat{\theta} = f(Z_j, \beta_j) + u_j$ again for each j = 1, …, n;

   c. Use the maximum likelihood method to estimate the truncated regression of $\hat{\theta}^*$ on z_j, yielding a bootstrap estimate ($\hat{\beta}^*$, $\hat{\sigma}_u^*$);

4. Use the bootstrap values and the original estimates $\hat{\beta}_j$ and $\hat{\sigma}_u$ to construct estimated confidence intervals for each element of β_j and σ_u.

4. Data and variables

4.1 Output and input variables

In the efficiency literature, until now there has not been a definitive study to guide the selection of inputs/outputs in the DEA applied studies in higher education. Outputs can be commonly classified as teaching, research, and services. However, finding true measures for these dimensions is difficult regarding the goals, and their relative importance, by the stakeholders of education; for example, emphasis could be placed on short-term, intermediate or long-term outcomes and prospects in higher education (Bessent et al., 1982; Ahn and Seiford, 1993; Worthington, 2001). Hence, it is possible for researchers to select a set of desired outputs to reflect the sector or the setting examined with respect to the different inputs. In addition, the accepted theories for measuring efficiency can be used as a background to choose the inputs and outputs (Castano and Cabanda, 2007a).

The production function was used in this study to investigate the relationship between inputs and outputs. Based on the production theory, the general agreement on inputs of universities can be categorised as human and physical capital, and outputs as arising from teaching and research activities (Lindsay, 1982; Johnes, 1996). In general, controllable inputs directly involved in the production process and the outputs of particular interest to managers of HEIs are preferred to reflect the relative importance of the goals of the institutions.

As stated before, in the Vietnamese context, we chose to use the DEA input-orientated measure which is prone to reduce technical inefficiency in the use of inputs, given the existing outputs.

Accordingly, four input variables were used in this study. The first was the *total number of full-time equivalent (FTE) academic staff*. Most academics participate in teaching and research activities. The second input was the *number of FTE non-academic staff*. Non-academic staff are involved with administering students, teaching and research staff, and generally facilitating the teaching and research process. In the context of this study, the non-academic category includes general and administrative staff as well as delivery support staff. The third input was *floor area for academic spaces*. This is quite important for the Vietnamese HEIs for the determination of new enrolments because MOET has asked each HEI to meet the standards of floor area per student as a basis of calculating enrolment quotas. The final input is *operating expenditures* of HEIs. These expenditures are used for annual operations of HEIs.

Under the chosen DEA input-orientated model, the outputs of HEIs are number of graduates, number of students enrolled, and amount of research income. The number of graduates refers to students who leave with completed degrees at the end of each year. Students enrolled refer to the number of students enrolled in a given year. They are considered as input resource users of HEIs embodied in the process of teaching and research. Carrington, Coelli, and Rao (2005) argued that certain students require more resources to teach than others. For example, postgraduate students require more input resources than undergraduate students. Thus, separate output measures were developed for postgraduates and undergraduates. Sullivan et al. (2012) asserted that both enrolments and completions have been shown to be important in labour market studies and thus only using one of them may miss a critical output dimension. Such outputs have been used in recent studies, such as those of Abbott and Doucouliagos (2003; 2009), Castano and Cabanda (2007a; 2007b), Guzman and Cabanda (2009), Daghbashyan (2011), de Franca, de Figueiredo, and Lapa (2010), Fernando and Cabanda (2007), Miranda, Gramani and Andrade (2012), Martin (2006), Tajnikar and Debevec (2008) and Thanassoulis, et al. (2011). As for research output, some studies have selected the number of journal publications to control for research outputs. However, the research output of HEIs may include conference papers, book reviews, and patents. Thus, by choosing only one of them, the empirical results may be biased. The choice of research funding, proposed by Robst (2001) and Abbott and Doucouliagos (2003), is used as a research output. In our study, due to limited data, research output was measured by incomes from research-related activities, excluding tuition fees and government funding.

4.2 Impacts of contextual factors on the performance of HEIs

We chose to examine determinants that may impact on the operational efficiencies of HEIs in the truncated regression model, including age of the HEI, location (in main cities or outside main cities), the proportion of academic staff with postgraduate degrees, and tuition revenue proxied as a key financial resource of HEIs. The following hypotheses were tested in the truncated regression model:

- Location is expected to be positively correlated with efficiencies of HEIs. Those that are located in main cities such as Ha Noi, Ho Chi Minh, Da Nang, and Hue have more advantages because they may find it more convenient to access the available resources for teaching and learning.
- Type of ownership of HEIs is positively associated with the efficiencies of HEIs. Public HEIs may be more advantageous because they receive more funding from the government.
- The national entrance examination (NEE) marks are anticipated to influence the efficiencies of HEIs. Its effects can be positive or negative because the higher the NEE marks can make a decrease in both the number of enrolments of HEIs and staff.
- Age of HEIs, the number of years since establishment, is expected to be positively related to the efficiency scores because the older HEIs have a good reputation and their leaders have much more experience in managing schools; therefore, their performance may be better.
- The proportions of academic staff with postgraduate degrees are expected to be positively related with the efficiency scores of HEIs
- Tuition fees, as a proxy for an indirect impact of the years following Decree 49/2010/ND-CP of the government issued in 2010, are expected to be positively significantly associated with the efficiency scores.

All input, output, and contextual factors are presented in Table 1.

Table 1: Description of input, output, and contextual factors

Input variables	*Output variables*	*Contextual factors*
X_1: Number of academic staff	Y_1: Full-time equivalent (FTE) undergraduate students	E_1: Location of HEI: 1 if HEI is located in main cities, 0 otherwise
X_2: Number of non-academic staff	Y_2: FTE postgraduate students (for the university model)	E_2: Type of HEIs: 1 for public, 0 for private
X_3: Floor area for academic spaces	Y_3: Completions (FTE)	E_3: NEE marks
X_4: Operating expenditures	Y_4: Research output proxied by revenue income from research activities.	E_4: Age of HEI
		E_5: The proportion of academic staff with postgraduate degrees
		E_6: Tuition fees

4.3 Data sources

In this study, the sample data were collected for 253 Vietnamese HEIs between 2011 and 2013, involving 112 universities and 141 colleges. Data sources were from MOET, where performance indicators of HEIs via their annual reports are recorded. These HEIs complied with the rules of MOET to send in their annual reports for all three years. Our sample accounted for 60 per cent of the total number of HEIs in Viet Nam. Whereas a long span of data is desirable, our sample over a period of three years is expected to provide preliminary analyses of the performance of HEIs in Viet Nam.

5. Empirical findings

We present separately the empirical findings of the efficiencies of universities and colleges for the period 2011–2013 in Sections 5.1 and 5.2, respectively. We separate them because, although universities and colleges are classified as HEIs, they operate under different teaching environments. Hence, investigating separately their efficiencies allow us to provide appropriate measures relative to their own cohorts. In Section 5.3, we discuss the impacts of exogenous factors on the inefficiencies of these two types of HEIs with different models before reaching the conclusions in Section 6.

5.1 Efficiencies of universities

Table 2 presents summary statistics of inputs and output variables used in the universities model. On average, universities trained 6,700 undergraduate students and around 596 postgraduate students during 2011–2013.

Table 2: Summary statistics of input and output variables for universities

	Unit	Mean	Standard deviation	Minimum	Maximum
Outputs					
Postgraduates	Student	596	1,047	0	5,513
Undergraduates	Student	6,709	6,367	48	30,816
Completions	Student	2,010	1,854	13	9,544
Research income	Billion VND	15.5	35.2	0.001	331.67
Inputs					
Academic staff	Person	375	301	45	1617
Non-academic staff	Person	154	125	39	713
Floor area [a]	1000 m^2	28	31	1.60	277.18
Operating costs	Billion VND	80	77	0.51	479.85
Contextual factors [b]					
Age	Years	16	11	4	59
NEE	Marks	16.9	3.5	13	28
Ratio of staff with postgraduate degrees	Percentage	0.68	0.14	0.207	100
Tuition revenue	Billion VND	56	64	0.00	330.71

Note: [a] Floor area for academic spaces (classroom, library, etc.); [b] Excluding location and type that are dummy variables

For the university model, we used four outputs and four inputs to estimate the efficiencies of universities in the sample involved. Table 3 illustrates the efficiencies of universities from the standard and bootstrapped DEA models. It can be observed that the bootstrapped DEA model uses the same input and output dataset as the standard DEA model but includes bootstrapping, which is a resampling technique with 2,000 replications. This method allows us to obtain the Shephard efficiency scores (greater than one) (Wilson, 2008) that were used for the regression models in the next section. For ease of interpretation, we transformed these scores to the Farrell efficiency scores as the reciprocals that are bounded between zero and one. This indicates that universities with an efficiency score of exactly unity were considered fully technically efficient. Otherwise, they were inefficient for the period involved and need to improve their performance.

Table 3: Efficiencies of universities over three years

	Standard VRS DEA				Bootstrapped VRS DEA			
	2011	2012	2013	Sample	2011	2012	2013	Sample
Mean	0.830	0.763	0.737	0.777	0.736	0.684	0.661	0.694
SD	0.187	0.197	0.207	0.172	0.153	0.165	0.176	0.143
Min	0.384	0.295	0.331	0.366	0.352	0.267	0.302	0.336
Max	1	1	1	1	0.933	0.917	0.939	0.916
Efficient units [a]	43	22	24	11	0	0	0	0
Hotelling's test [b] (F value)				1160***				

Note: [a] the number of universities with efficiency scores of 1; *** denotes significance at the 1% level.
[b] Hotelling's test for equal means for the standard and bootstrapped DEA scores.

The efficiency estimates in Table 3 illustrate the potential for universities to improve their performance. The efficiency scores of universities from the standard DEA model were, on average, 0.777, suggesting that universities could potentially improve their efficiency by 22.3 per cent. However, with the bootstrapped DEA model, this percentage increased to 30.6 per cent with the average efficiency score of 0.694. Whereas 11 universities in the sample obtained the full efficiency scores of one in the standard DEA model, no university reached this in the bootstrapped DEA model. This shows that after filtering out unobserved noises, universities need to further improve their efficiencies.

Figure 1: Frequency distribution of the efficiencies of universities

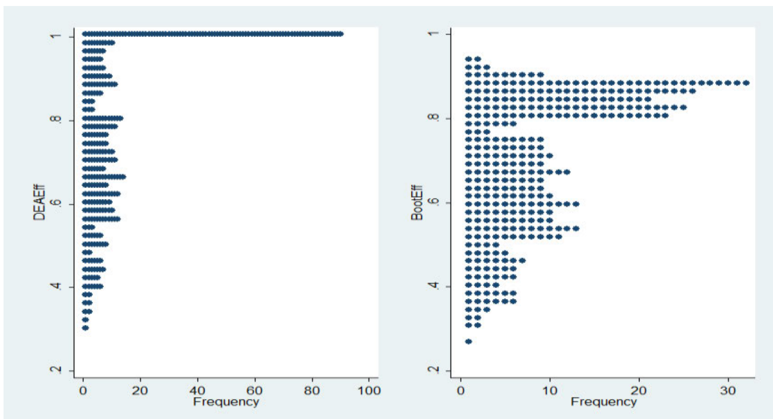


Figure 1 demonstrates the frequency of efficiency distribution of universities over three years. With the standard DEA model, the efficiency distributions of universities are quite dense and converge at the value of one. By contrast, with the bootstrap model, the density of the efficiency distribution of universities is sparse and less than the value of unity.

Table 4: Efficiencies of universities classified by ownership

	Standard VRS DEA				Bootstrapped VRS DEA			
	2011	2012	2013	Sample	2011	2012	2013	Sample
Public	0.838	0.774	0.727	0.780	0.741	0.691	0.651	0.694
Private	0.807	0.733	0.762	0.768	0.721	0.666	0.691	0.693
Wilcoxon rank-sum test (Z value)[a]				-0.488				-0.500

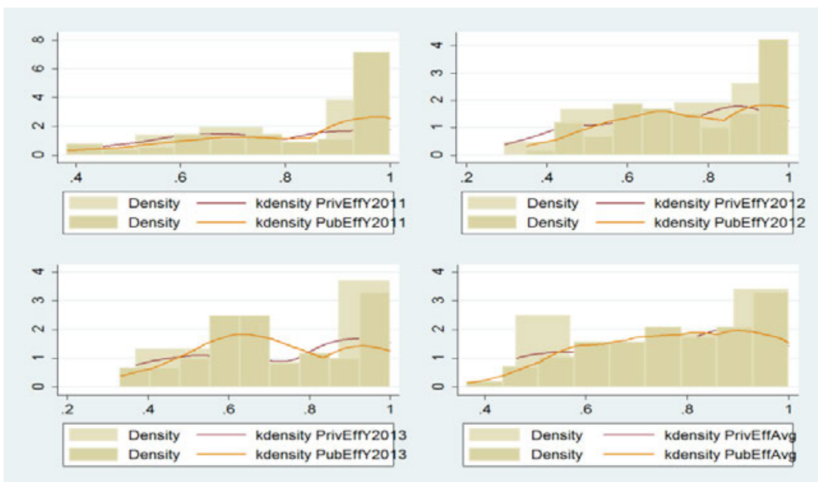
Note: [a] The Wilcoxon rank-sum test for equal means between scores of public and private HEIs

It is interesting to observe that the efficiency scores of private universities are slightly less than those of public universities in both models. The average efficiency of private universities is 0.693

whereas that of public universities is 0.694 in the bootstrapped model. This is similar in the standard DEA model, being 0.780 and 0.768 for public and private universities, respectively.

However, these differences are not statistically significant. These findings were expected because public universities have been supported by government funding whereas private ones have to use their own capital for all academic operations. Hence, they should be efficient in their performance. However, both public and private universities are currently less than the full efficiency of one, and, on average, could potentially improve their efficiencies by 30.6 and 30.7 per cent, respectively. Figure 2 illustrates a moving trend to the right near one with the higher efficiencies for universities each year and over years after adjusting for the effects of external variables and implementing a bootstrap procedure.

Figure 2: Histograms of the efficiencies of public and private universities



5.2 Efficiencies of colleges

Table 5 presents basic information about the inputs and outputs used in the college model. On average, colleges trained about 2,113 students and the number of graduated students was 554. Their average research income was around VND3.6 billion. The number of academic staff was more than double that of non-academic staff. A variation in using inputs and outputs of colleges depends on their training size and the annual enrolment quotas based on the number of academic staff and floor area for academic spaces. For the college model, three outputs and four inputs are utilized to calculate their efficiency scores.

Table 5: Descriptive statistics of inputs and outputs for colleges

	Unit	Mean	Standard deviation	Minimum	Maximum
Outputs					
Undergraduates	Student	2113	1499	83	7116
Completions	Student	554	399	14	1623
Research income	Billion VND	3.6	7.7	0.001	55
Inputs					
Academic staff	Person	129	67	32	438
Non-academic staff	Person	54	21	25	160
Floor area [a]	1000 m^2	13.29	0.81	0.12	4.22
Operating costs	Billion VND	18	13	0.9	67.76
External factors [b]					
Age	Year	12.1	6.5	4	39
NEE	Mark	11.5	2.1	10	21.75
Ratio of postgraduate staff	Percentage	0.43	0.14	0.063	0.779
Tuition revenue	Billion VND	8.4	9.3	0.038	70.22

Note: [a] Floor area for academic spaces (classroom, library, etc.), [b] Excluding location and type that are dummy variables

Table 6 shows the relative efficiencies of the colleges in the sample. On average, colleges could potentially improve their efficiencies by 30.3 and 37.7 per cent in the standard and bootstrapped DEA models, respectively. Ten out of the total number of colleges obtained the full efficiency scores of one in the standard model, and the rest of the colleges are inefficient and they need to improve their performance. However, there was no college that was fully technically efficient in the bootstrapped model.

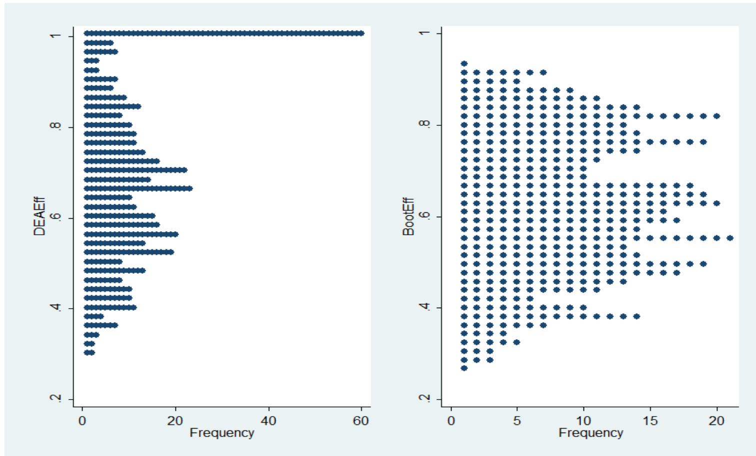
Table 6: Efficiencies of colleges over three years

	Standard VRS efficiency				Bootstrapped VRS efficiency			
	2011	2012	2013	Overall	2011	2012	2013	Overall
Mean	0.717	0.680	0.694	0.697	0.639	0.610	0.619	0.623
SD	0.197	0.199	0.184	0.175	0.163	0.167	0.146	0.143
Min	0.295	0.305	0.337	0.325	0.258	0.277	0.308	0.297
Max	1	1	1	1	0.925	0.916	0.917	0.891
Eff.units [a]	24	17	18	10	0	0	0	0
Hotelling's test [b] (F value)				1051***				

Note: [a] The number of colleges with efficiency scores of 1; *** denotes significance at the 1% level.
[b] Hotelling's test for equal means for the standard and bootstrapped DEA scores.

Figure 3 illustrates the histogram of efficiencies of the colleges over the three years. The distribution of efficiencies of colleges in the standard DEA model is quite dense and focuses on the value of one, whereas that in the bootstrap model is sparse and less than one. This implies that, after isolating noise, the efficiencies of colleges decrease and reflect nearly the nature of their performance.

Figure 3: Distribution of the efficiencies of colleges



It is observed that private colleges illustrate better performance than their public counterparts. For the bootstrapped model, public colleges, on average, obtained the lower efficiency score of 0.614 compared with private colleges with the mean efficiency score of 0.692. This distinction is significant at the one per cent significance level. It can be seen that managers of private colleges have utilized their investment capital for all academic operations in the more efficient way, at least in the years involved.

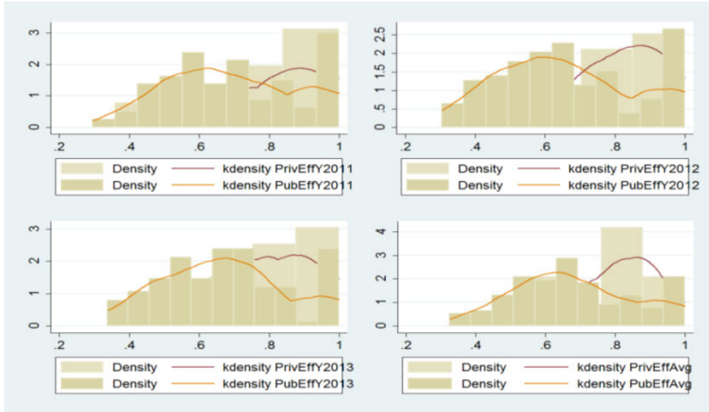
Table 7: Efficiencies of colleges classified by ownership

	Standard VRS efficiency				Bootstrapped VRS efficiency			
	2011	2012	2013	Overall	2011	2012	2013	Overall
Public	0.705	0.670	0.680	0.685	0.633	0.602	0.607	0.614
Private	0.810	0.764	0.803	0.792	0.690	0.677	0.710	0.692
Wilcoxon rank-sum test (Z test)[a]				3.71***				3.328***

Note: [a] The Wilcoxon rank-sum test for equal means between scores of public and private HEIs.

Figure 4 illustrates a moving trend to the right near one with the higher efficiencies for private colleges each year and over years after implementing a bootstrap procedure. By contrast, the efficiencies of public colleges have a downward trend to the right with the lower efficiencies.

Figure 4: Histograms of the efficiencies of public and private colleges



5.3 Effects of contextual factors on the inefficiencies of HEIs

In this section, the effects of contextual factors on the inefficiencies of HEIs are examined by using truncated regression models with bootstrapping. It is noticeable that the Shephard efficiency scores, estimated in the first step, are to be greater than unity that illustrates the inefficiency of HEIs. Thus, the sign of coefficients in these truncated regression models should be interpreted inversely as efficiencies of HEIs. This means that the coefficients with positive signs impact negatively on efficiencies of HEIs and vice versa. It is noted that we test the two models separately for universities and colleges, respectively.

5.3.1 University model

Table 8 demonstrates the regression results for the university model. The findings reveal that the majority of the coefficients were significant at the one per cent significance level. Unexpectedly, age is negatively correlated to the efficiencies of universities. This implies that the older universities were less efficient. Likewise, tuition fees have an unpredictably negative effect on efficiency. However, the interaction between age and tuition has a positive impact on the efficiencies of universities. This may reflect the fact that the older universities can impose a slightly higher level of tuition fees without worrying about reduction in new enrolments. In addition, they may not be concerned about how to better use input resources because they have had a determined reputation in the tertiary sector. Although the coefficient of this interaction is statistically different from zero at the one per cent significance level, its value is very small.

Table 8: Truncated regression results for the university model

	Coefficient	Bootstrap std. error	z	P>|z|
Location	-0.11	0.21	-0.53	0.598
Type	0.36	0.24	1.51	0.130
NEE	-0.060	0.034	-1.74	0.081
Age	0.050	0.011	4.45	0.000
Ratio of Staff with PG Degrees	-2.45	0.75	-3.29	0.001
Tuition	0.013	0.0033	3.99	0.000
Age × Tuition	-0.00052	0.00013	-4.02	0.000
Constant	2.11	0.61	3.48	0.001
Sigma	0.799	0.094	8.46	0.000
Wald χ^2	33.12			
p value > χ^2	0.000			

Note: The number of replications for bootstrapping was 2,000.

Further, the coefficient of location indicates that universities located in the main cities are more efficient than those in remote regions. However, this coefficient is not statistically significant. For the one-tail test, the NEE is positively and significantly related to the efficiencies of universities. The ratio of staff with postgraduate degree has a significantly positive impact on efficiency at the one per cent significance level. Clearly, academic staff with postgraduate degrees contribute more significantly to the efficiencies of universities via academic research and teaching activities.

5.3.2 College model

As for the college model, the regression results are presented in Table 9. The variables are significantly different from zero at the one per cent significance level. Location has a positive impact on the efficiencies of colleges which implies that colleges located in the main cities are more efficient than their non-city counterparts because the former can access more advanced facilities for learning and teaching and, thus, attract more students. It is interesting that the NEE is positively correlated to the efficiencies of colleges. This could be explained that the higher the NEE, new enrolments can be declined to some extent, thus colleges may use fewer of their input resources, e.g., academic staff, relative to their outputs. Unexpectedly, both age and tuition fees are not correlated with the efficiencies of colleges. It can be observed that, in the years following Decree 49/2010/ND-CP, revenues from tuition fees of colleges have not yet contributed significantly to the efficiencies of colleges.

Table 9: Truncated regression results of the college model

	Coefficient	Bootstrap std. error	z	P>|z|
Location	-0.40	0.13	-3.040	0.002
Type	0.52	0.19	2.710	0.007
NEE	-0.061	0.025	-2.380	0.017
Age	0.007	0.012	0.570	0.571
Ratio of Staff with PG Degrees	0.61	0.38	1.600	0.110
Tuition	0.023	0.015	1.560	0.120
Age*Tuition	-0.0015	0.0011	-1.360	0.174
Constant	1.34	0.34	3.950	0.000
σ^2	0.697	0.053		
Wald χ^2	24.16			
p value > χ^2	0.001			

Note The number of replications for bootstrapping was 2,000.

The findings in Table 9 show that the ratio of staff with postgraduate degrees is negatively correlated with the efficiencies of colleges. Although this coefficient is not statistically significant, this may reflect the fact that in Viet Nam a bachelor degree may be a sufficient requirement for academic staff to work for colleges that are inclined to be teaching-focused. By contrast, the higher ratio of staff with postgraduate degrees may make an increase in operating expenditures for colleges. Thus, academic staff with an undergraduate degree still occupy an important role in colleges.

6. Discussion and conclusions

This study attempts to implement an analysis of the performance of Vietnamese HEIs with panel data for 253 universities and colleges in the period 2011–2013. The two-stage, semiparametric DEA model is used to estimate the operational efficiencies of HEIs and examine the possible impacts of determinants on their performance. Our findings are expected not only to offer useful insights for policymakers to consider possible solutions for improving the performance of HEIs, but also to provide a significant benchmark for the following comparative studies on the performance of higher education in Viet Nam.

Using the two-stage DEA model with bootstrapping, we obtained the efficiency estimates of HEIs and examined what determinants affected their performance. For the university case, the findings reveal that, on average, universities in our sample are not fully efficient but have efficiencies of 0.777 and 0.694, in the standard and bootstrapped models, respectively. There is no significant difference in the efficiencies of public and private universities in the years involved. The impact of the proportion of academic staff with postgraduate degrees on the efficiencies of universities was significant in the regression model. This implies that the higher the share of staff with postgraduate degrees, the greater the efficiencies of universities. Thus, increasing this ratio is one of the important objectives for universities to improve their performance.

For the college case, the results of the standard and bootstrapped models showed that colleges were not efficient in their operations in the years involved, with efficiency scores of 0.697 and 0.623, respectively. Potential improvements are necessary for colleges to obtain the full efficiency of unity by using input resources more appropriately. Unexpectedly, public colleges are less efficient than their private counterparts, 0.614 and 0.692, respectively. The location and the NEE are external factors positively affecting the efficiencies of colleges. By contrast, revenue from tuition fees and the ratio of staff with postgraduate degrees were not significantly related to the efficiencies of colleges.

From the above results, the study has the following managerial implications. First, universities and colleges in our sample were not managerially efficient in their academic operations in the years involved, given their education quality. The efficiencies of HEIs had a downward trend over the three years involved. In fact, from 2011, MOET suggested that universities and colleges should reduce their enrolment quotas for some fields of study, such as economics, finance, accounting and education, because the unemployment rate of graduates of these study fields had been mounting and caused an imbalance of the labour force in the market. Consequently, the enrolment quotas for these study fields went down gradually and, especially, sharply decreased in 2013. This influenced financial resources of HEIs via tuition fees, especially public HEIs in the years involved, even though public HEIs were allowed to increase the level of their tuition fees higher than in previous years. The decreased enrolments and financial resources may have caused a decrease in the efficiencies of HEIs. However, whether this decrease can be attributed to the influence of the policy intervention is beyond our study because deterministic and causal relationships in this context are difficult to identify.

Second, the proportion of academic staff with postgraduate degrees was significantly correlated with the efficiencies of universities. This implies that these academic staff play a crucial role in improving the performance of universities, as expected. Increasing the share of staff with postgraduate degrees should be of concern to enhance the academic operations of HEIs. To obtain this, government support, especially to public HEIs, is essential to provide them with sufficient flexibility in the management mechanism of financial and human resources to facilitate this process. For the college model, the shares of staff with postgraduate and undergraduate degrees did not have significant impacts on the efficiencies of colleges. This needs to be perused more in future studies.

Finally, interestingly, tuition revenues were related negatively with the efficiencies of HEIs in our sample. This reveals that although the government has allowed HEIs to increase their tuition fees within a regulated tuition framework for the period 2010/11–2014/15, this increase seems to be trivial, and insufficient for their operating expenditures. Thus, removing restrictions on tuition fees and enrolments may be helpful for improving the performance of HEIs.

Our paper has provided a thorough analysis of the performance of HEIs in Viet Nam with panel data for the period 2011–2013. In addition to the empirical findings mentioned above, some limitations need to be addressed. First, although our sample is sufficient large for the analysis of DEA models, a longer span of data would be necessary to have a larger picture of the possible variations in efficiencies of HEIs over time. Second, other necessary inputs and outputs should be included in future studies. For example, in our study, research output is estimated by research income from research activities whereas publications of academic staff are not included. In addition, the quality of graduates, such as their study record or evaluation by employers, should also be taken into account. Further, qualifications of academic staff should be measured by actual numbers and weighted by different levels. Finally, in the Vietnamese context, some determinants could impact directly on input usages and thus cause a decrease in the efficiencies of HEIs. Future studies should account for this point to supplement our findings.

Chapter 5: On the measurement of environmentally-adjusted efficiencies of Vietnamese higher education institutions: An analysis using bootstrap multi-stage DEA approach

Abstract

This paper analyses the impacts of environmental factors on the input usages and operational efficiencies of Vietnamese higher education institutions (HEIs) with 112 universities and 141 colleges in the period 2011–2013. A new stage is proposed to integrate the bootstrap procedure into the environmentally-adjusted multi-stage data envelopment analysis approach to estimate the efficiencies of HEIs. The findings indicate that the input usages of HEIs are strongly influenced by exogenous variables such as age, ownership, location and financial capacity. After the effects of the determinants and unobserved biases are filtered out, the relative efficiency scores of universities and colleges are, 0.822 and 0.852, respectively. Private HEIs appear to be more efficient in using available input resources to obtain the existing output production. Some managerial implications are discussed in improving the performance of HEIs.

Key words: Efficiency, data envelopment analysis, multistage, universities, colleges, Viet Nam.

1. Introduction

Education, in general, and higher education, in particular, has been closely linked to economic development because of its important role in a nation's human resources. Higher education is considered as one of the important efficiency enhancers for nations to improve their competitiveness capacity beyond the simple production process (Schwab, 2013). However, considering the global financial challenges and lack of flexibility in reform policies, as well as the scarcity of resources for universities in general (Agasisti and Pohl, 2012; Castano and Cabanda, 2007a; Sav, 2012), public production of higher education inevitably faces difficulties in improving the performance and maintaining quality of education.

Vietnamese higher education plays a crucial role in the national educational system and has made a significant contribution to the workforce of the economy after the initiation of the economic reform in 1986 and the education reform policy in 1997. The number of higher education institutions (HEIs) increased nearly twofold, from 222 in 2000, to 421 in 2013 (Ministry of Education and Training [MOET], 2013). The number of enrolments increased 137 per cent over the period 2000–2012. Public expenditure on education has been considerably increased, accounting for 20.9 per cent of total government expenditure in 2010, equivalent to 6.3 per cent of national gross domestic product (Economic and Social Commission for Asia and the Pacific, 2014; Ministry of Finance, 2012). Also, the government issued several policies benefiting the higher education sector, such as policies on tuition fees, enrolment quotas, and teaching quality. These incentives have facilitated the reform progress of higher education in its endeavour to meet the requirements of national socio-economic development.

As in most other developing countries, however, where the government plays a dominant role in managing the national education system, higher education in Viet Nam has witnessed systematic pressures within its management mechanism that work against efficiency (Hayden, 2012; Pham, 2012; Tran, 2014). This refers to a form of incentive failures that result in the inability of public organisations to obtain their expected outcomes (Dollery and Wallis, 1999, 2003; Friedman, 2003). Although the government has made many efforts to provide more flexibility for HEIs relating to finance and enrolment, this so-called autonomy is still limited. HEIs still have to strictly observe the regulated framework of all government rules. Departing from these rules may result in them experiencing trouble in their operations. It can be said that the autonomy currently granted does not provide sufficient autonomy for HEIs to achieve the desirable efficiency in their educational operations (Hayden and Lam, 2007; Brooks, 2010; Dao, 2014; Tran, 2014). Further, the management system has remained complicated and fragmented, and may not necessarily be compared to other like-mined countries. Apart from MOET, other ministries have been involved in the management of HEIs as direct line managers. This has caused more complexities for HEIs in reporting systems. In addition, the lack of qualified academic staff has not been able to strengthen the research capability of HEIs (Hien, 2010; Thanh, 2012), which is one of the crucial standards in the world university ranking system (Marginson, 2008). Finally, the lack of assessment on the performance of HEIs might lead to less transparent accountability and unfair competition (i.e., reputation, geographical location, and policy environment) within HEIs. MOET (2009) argued that, due to the complexity of the management systems of all HEIs in Viet Nam, the performance of HEIs has not been evaluated. Some questions may arise regarding what the operational efficiencies of HEIs under the current legal environment are, and whether it is the operating environment or managerial inefficiency that affects their performance. Addressing these questions is necessary to provide useful information for HEI managers and policymakers in their efforts to seek solutions to advance Vietnamese higher education.

Our main objective is to implement an empirical analysis of the performance of Vietnamese HEIs based on data envelopment analysis (DEA) across multiple periods. Using the multi-stage DEA model with bootstrapping, we filter out the impacts of contextual factors on input usages and estimate the operational efficiencies of HEIs. After the environmental adjustment, the inefficiencies of HEIs can be attributed to managerial inefficiency that is worth considering for improving the performance of HEIs.

The remainder of the paper is organised as follows. Section 2 contains an overview of the higher education sector in Viet Nam. Section 3 provides some information about DEA efficiency studies in higher education. This is followed by Section 4 that discusses the empirical model of the DEA multi-stage approach and the dataset available for analysis. Section 5 presents our empirical findings for the universities and colleges models. Discussion of these results and conclusions are presented in Section 6.

2. Higher education sector in Viet Nam: An overview

Viet Nam has become one of the fastest growing nations in the world since the economic reform started in 1986. The GDP of Viet Nam increased by more than seven per cent per annum, on average, during the period 1989–2010 (World Bank, 2011). This has provided a strong incentive for Viet Nam to innovate in its higher education system. The year 1997 witnessed a turning point in Vietnamese higher education when the government Resolution 90/1997/NQ–CP on socialisation policy of education, health, and culture was introduced, in which private education was officially encouraged. Following this, the government issued Decree 73/1999/ND–CP to provide guidelines for stakeholders to implement the educational socialisation policy of the government. As a result, the number of private HEIs increased nearly fourfold for the period 1999–2013, from 22 to 83 including 54 private universities and 29 private colleges. Likewise, the number of private enrolments increased almost threefold from 107,538 in 1999/2000 to 312,652 students in 2012/13 (MOET, 2013).

Currently, Vietnamese higher education has a total of 421 HEIs comprising 207 universities and 214 colleges. There are 83 private HEIs, which account for about 20 per cent of the total number of HEIs. Within 10 years, the number of academic staff rose remarkably to more than 87 thousand in 2012–2013, being 2.5 times greater than the number in 1999/2000 (MOET, 2013). The number of articles by Vietnamese researchers published in international journals has shown an increasing trend over the period 2008–2012, from 955 to 1,731 articles, but is still quite low compared with other Asian nations such as Singapore, Malaysia, and Thailand (Hien, 2010; Thanh, 2012). Regarding the curricula framework, following Decision 1505/2008/QD–TTg of the government on the project of implementing advanced curricula in some Vietnamese universities for the period of 2008–2015, MOET, in cooperation with foreign universities, developed 23 advanced curricula at 17 chosen universities. These programs use English as the medium of teaching and learning and they are assessed against standards of foreign universities (Vu, 2012).

Together with this, Resolution 37/2004/NQ–QH11 of the government on education suggested an increase in the public budget for education to 20 per cent of total national expenditure. This policy has been implemented step by step in the years since 2004. For example, in 2010, public expenditure per student in tertiary education accounted for 39.8 per cent of GDP per capita (Economic and Social Commission for Asia and the Pacific, 2014). Also, the Ministry of Finance

(2012) reported that the total national budget for education in 2012 was 11 per cent higher than that in 2011. This shows the commitment of the government to improve higher education.

More flexibility has been given to higher education since 2010, when the government promulgated Decree 49/2010/ND–CP on tuition fees that allowed public HEIs to increase tuition fees over the period 2010/11 to 2014/15. According to this policy, public HEIs can increase annual revenue income for their academic operations. However, they are not allowed to charge students above the ceiling tuition levels regulated for each group of study fields. Private HEIs are not affected by these ceiling tuition levels and are allowed to set their own tuition fees. In 2011, MOET issued Circular 57/2011/BGD–DT on identifying the quotas of enrolments for PhD, master, and bachelor degrees and of other award levels that has provided HEIs with more autonomy to set their enrolment quotas per annum and submit their registration form to MOET for approval. In this Circular, MOET instructed HEIs to compute their own enrolment quotas based on their available facilities and academic staff. However, MOET reserves the right to bar HEIs from enrolling students if they violate the regulations, for example, having a student enrolment exceeding 15 per cent of total enrolments approved. This may reflect the fact that the government desires to increase the autonomy of HEIs but also wants to control them, to some extent. Thus, real autonomy of public HEIs is still questionable in the current context of higher education.

Another issue worth mentioning is the fragmentation and complexity in the management system of Vietnamese higher education. Apart from 51 public HEIs under the management of MOET, 87.4 per cent of the remaining HEIs are under the management of 13 other ministries and local authorities. Operating under the same education law, HEIs are governed by different line management systems, depending on which ministry they belong to. Partly due to such fragmentation and complexity, the reporting system of Viet Nam's higher education system is time consuming, disjointed, and incomplete. Accordingly, the performance indicators of individual HEIs have not been recorded in a systematic way to facilitate a comprehensive analysis of higher education. From 2009, Circular 09/2009/TT–BGDDT of the government requires all HEIs to implement the regulations of "three contents in disclosure" including student numbers, staff numbers and academic facilities, and financial data. HEIs have to submit their annual reports based on this information to MOET and publish them publicly on their websites. However, not all HEIs have strictly followed these regulations. On average, 60 per cent of HEIs have followed this rule for each academic year (MOET, 2013).

Empirical analyses are fitting and timely in the Vietnamese context to better understand the performance of Vietnamese HEIs as well as increase their transparent accountability. This would be useful for educational managers and policymakers so that they have more relevant educational development strategies for the next phase. Research on the performance of Vietnamese HEIs has not been done before, and so it will contribute to the literature on efficiency.

3. Efficiency studies in higher education using DEA

Efficiency estimation in the higher education sector has received much attention in the literature because of its importance for national competitiveness. Many studies have used DEA to examine the performance of the tertiary sector (e.g., Abbott and Doucouliagos, 2003; 2009; Agasisti et al., 2012; Agasisti and Pohl, 2012; Castano and Cabanda, 2007; Fu and Huang, 2009; Johnes, 2006; Johnes and Johnes, 2009; Kuah and Wong, 2013) through explaining the variation in the efficiencies of universities or comparing efficiency scores for different groups. However, the assumption of homogenous environments for all DMUs in the standard DEA method is often violated and this leads to a bias in the efficiency measurement of units. Some multi-stage DEA-based approaches are proposed to filter out the impacts of determinants.

Coelli et al. (2005) summarised some possible methods to take into account the impact of exogenous variables on efficiency. If the environmental variable has a detrimental effect that can be ordered from least to greatest, the model of Banker and Morey (1986) is representative. On the other hand, the approach of Charnes, Cooper and Rhodes (1981) can be used if the environmental variable is a categorical variable. However, both models only allow one environmental variable affecting efficiency of DMUs. In addition, the comparison set is reduced considerably, which reduces the effectiveness of the analysis. Another method is to include determinants directly into the DEA model, as in Bessent and Bessent (1980) and Ferrier and Lovell (1990). To use this model, the external variables should not be categorical variables.

The two-stage DEA approach seems to be preferable because it overcomes the shortcomings of the models described above. In this method, the efficiency scores obtained by a first-stage DEA analysis involving only traditional inputs and outputs are regressed upon the environmental variables in a second-stage analysis, which can involve ordinary least-squares regression or estimating a Tobit model (McCarty and Yaisawarng, 1993). An advantage of the two-stage DEA approach is that the effects of environmental variables on efficiency scores can be assessed by both signs and significance of the coefficients. However, the main drawback of the two-stage approach is that the estimated results are likely to be biased if input and output variables are highly correlated with the external variables in the second stage. In other words, the conventional inference methods are not valid because the second-stage independent variables are correlated with the error term (Coelli et al., 2005).

The three-stage DEA method was proposed by Ruggiero (1998), Muniz (2002) and Fried et al. (2002). The four-stage DEA method was introduced by Fried, Schmidt and Yaisawarng (1999). Among these models, the Fried et al. (1999, 2002) models have been widely applied in different sectors such as education, healthcare, manufacturing, environment, and energy (e.g., Chen, Chang and Lai, 2014; Cordero-Ferrera, Pedraja-Chaparro and Salinas-Jiménez, 2008; Cordero-Ferrera, Pedraja-Chaparro and Santín-Gonzalez, 2010; Ferrera, Cebada, and Zamorano, 2014; Fang, Hu and Lou, 2013; Macpherson, Principe, and Shao, 2013; Sav, 2013). This is because these methods take account of information about the input and/or output slacks and, thus, reduce misleading interpretations involving the impacts of determinants on efficiency. However, their methods have not accounted for the influence of serial correlation and biases between unadjusted outputs (or inputs) and unobserved errors in the DEA final stage to estimate the efficiencies of DMUs after adjusting the impacts of determinants. Thus, to address this problem, we suggest a further stage to the Fried et al. (1999) model with bootstrapping, as presented in the next section.

4. Methodology and data

DEA is a well-known nonparametric method applied in different fields to measure the relative efficiencies of firms, especially where prices and subsidies are still regulated and dominated by government bodies (Coelli et al., 2005; Johnes and Yu, 2008). Estimating efficiency of higher education has been recognised to be difficult and complicated due to its diversity and its multi-faceted nature.

Several indicators are not able to be measured in monetary terms, such as qualifications of academic staff, quality of articles published in international journals, or quality of students (Avkiran, 2001; Carrington, Coelli, and Rao, 2005; Emrouznejad and Thanassoulis, 2005). Hence, DEA is a theoretically relevant method to estimate efficiency of HEIs using multiple inputs and multiple outputs without price information. In addition, the DEA approach is also useful to initially differentiate efficient and inefficient HEIs, to build performance targets for inefficient HEIs, and to strengthen efficient units for further improvements as well.

However, the efficiencies of HEIs are difficult to measure because the impacts of determinants are, to some extent, outside the control of managers, among them ownership, age, location, and national entrance examination (NEE) marks. In the Vietnamese context, these factors may affect the performance of HEIs. For example, calculated on the basis of the difference between their operating expenditures approved and revenues from tuition fees, public HEIs may be relatively more favourable than private ones regarding their financial capacity because they are supported by government funding. In return, private HEIs have fewer restrictions on imposing tuition fees and management structure than their public counterparts. In addition, age of HEIs also plays a significant role in the efficiencies of HEIs. It is widely recognised that the older HEIs have more experience in managing their academic operations; thus, they may be more efficient than more recently-established HEIs. The NEE marks can affect the new annual enrolments, and, thus, influence the performance of HEIs in a particular period. In this sense, it is important to take into account the effects of these factors in measuring the operational efficiencies of HEIs in Viet Nam.

In this study, we extend the four-stage DEA approach of Fried, Schmidt and Yaisawarng (1999) by integrating the bootstrap procedure at different stages to filter out the impacts of determinants and remove biases caused by unobserved factors. The originality in our paper is the development of a new stage with bootstrapping on the efficiency estimation after adjusting the impacts of determinants, which, to our knowledge, is a method that has not been seen before in the literature. With this extended model, we expect to provide more robust analysis of the operational efficiencies of HEIs that allows us to eliminate the impacts of determinants on input usages of HEIs, and their estimated inefficiencies can be attributed to managerial performance.

4.1 Empirical model and estimation procedure

In this section, the efficiency estimation framework with the bootstrap procedure is introduced to examine the effects of environmental factors on input usages and filter out their effects to more appropriately estimate the efficiencies of HEIs. In Viet Nam, HEIs can make decisions about their academic operations within the confines of regulations. For example, HEIs can set their annual enrolment quotas but these quotas should strictly follow MOET’s regulations relating to facilities and academic staff. This means that HEIs cannot expand their enrolment quotas without meeting regulated requirements. The best solution for them is to use the available input resources efficiently to obtain existing outputs.

In this context, we propose an empirical model using the DEA input-orientated approach that allows HEIs to seek the contraction of inputs to obtain given outputs. With this model, we employ a five-stage procedure that integrates DEA with an econometric model and the bootstrap method to measure the efficiencies of HEIs with adjustments of the influences of determinants on input slacks. Instead of using the four-stage approach suggested by Fried, Schmidt and Yaisawarng (1999), we develop a further stage, the so-called Stage 5, with bootstrapping on real outputs and the adjusted inputs from Stage 4. This improves the robustness of the empirical results by eliminating unobserved biases among outputs, inputs and disturbances.

The DEA multi-stage approach with bootstrapping is defined as follows.

Let the inputs be denoted by the vector $x \in \mathfrak{R}_+^M$ and the outputs by the vector $y \in \mathfrak{R}_+^S$. The input-orientated distance function is defined as follows:

$$d_i(x, y) = sup\{\lambda: (x/\lambda, y) \in L(y)\} \quad (1)$$

where L(y) is the input production set and λ is the scalar distance which reflects that the quantity input vector can be proportionally reduced, given the output vector with technical feasibility. Accordingly, for all $(x, y) \in L(y), d_i \geq 1$ and $d_i = 1$ if x belongs to the frontier defined by $L(y)$. In terms of the input-orientated measure of technical efficiency (TE), it can be identified by $TE = \left({}^1/_{d_i}\right)$.

The nonparametric piecewise reference technology of $L(y)$ with the variable-returns-to-scale (VRS) property can be estimated by:

$$\hat{L}(y) = \left\{\begin{matrix}(x, y);\ \sum_{i=1}^{N} \lambda_i y_{si} \geq y_s, \sum_{i=1}^{N} \lambda_i x_{mi} \leq x_m, \sum_{i=1}^{N} \lambda_i = 1, \lambda_i \geq 0 \\ m = 1, \dots, M, s = 1, \dots, S, i = 1, \dots, N\end{matrix}\right\} \quad (2)$$

where λ_i is the intensity variable to contract or expand the observed operations of HEI i $(i = 1, \dots, N)$ for the aim of constructing convex combinations of the observed inputs (x_i) and outputs (y_i). Relative to the reference technology, $\hat{L}(y)$, constructed in (2), the estimator of the efficiency score θ can be obtained by solving the following programming problem:

$$\hat{\theta}_{VRS} = min\{\theta > 0 | y_s \leq \sum_{i=1}^{N} \lambda_i y_{si}, \theta x_m \geq \sum_{i=1}^{N} \lambda_i x_{mi}, \sum_{i=1}^{N} \lambda_i = 1, \lambda_i \geq 0, i = 1, \dots, N\} \quad (3)$$

where $\hat{\theta}_{VRS}$ is the projection of an observed HEI (x, y) to the efficient frontier, calculated by the reciprocal of input distance d_i in (1) and provides the initial technical efficiency of the i^{th} HEI. For all $(x, y) \in L(y), \hat{\theta}_{VRS} \leq 1$, the HEI is fully technical efficient if $\hat{\theta}_{VRS} = 1$.

It is noticeable that the DEA results can be sensitive to outliers because this method does not account for random noise in the data-generating process. We attempt to identify the outliers before analysing the performance of HEIs. Adapting the procedure of identifying outliers used by Thanassoulis (1999), and using the concept of super-efficiency, introduced by Andersen and Petersen (1993), a threshold difference of super-efficiency of 10 percentage points can be used to identify outliers. A subgroup of HEIs with super-efficiency over 100 per cent, and being different from other inefficient DMUs by a gap of at least 10 percentage points, are identified as outliers. After outliers are recognised, they are detached. Then, the super-efficiency estimate is executed again on the new subset of data to verify whether outliers remain in the sample. This process is repeated until there is no gap of at least 10 percentage points in super-efficiency in the sample. Accordingly, 16 universities and nine colleges were identified as outliers in our dataset. As suggested by Thanassoulis et al. (2011), after the outliers are identified, we do not allow them to affect the position of the efficiency boundary but hold them with their data adjusted to sit on the boundary drawn from non-outlier HEIs.

From the standard DEA approach, as mentioned above, we implement the procedure of estimating the environmentally adjusted efficiency with the bootstrap method by the following five steps:

Stage 1: A standard DEA frontier is calculated by using traditional inputs and outputs without external variables, as described in equations (1) and (2). At this stage, we obtain the total input slacks including radial measurement and non-radial slacks. These slacks are referred to as the excessive number of inputs that should be reduced to obtain the full efficiency.

Stage 2: Determinants are regressed on total input slacks using the Tobit model with the bootstrap procedure. The main objective of Stage 2 is to quantify the effects of determinants on the excessive use of inputs. If there are M inputs, the M regression equations are specified as:

$$ITS_j^k = f_j\left(Q_j^k, \beta_j, u_j^k\right), \;\; j = 1, \dots, M \; ; \; k = 1, \dots, K \tag{4}$$

where ITS_j^k is unit *k's* total slacks for input *j* based on the standard DEA results from Stage 1; Q_j^k is a vector of determinants for unit k that may affect the utilisation of input j; β_j is a vector of coefficients; and u_j^k is the error term.

It is noted that the choice of regression model for the second-stage of DEA analysis has attracted much concern of researchers relating to its econometric implications. If using DEA efficiency scores (bounded between zero and one) obtained as the dependent variable, we may be concerned about which regression model is appropriate to provide robust results, for example, ordinary least-squares, Tobit, logit factional, or truncated regression models. These models have been discussed in recent studies such as Simar and Wilson (2007), Hoff (2007), Banker and Natarajan (2008), McDonald (2009), and Ramalho, Ramalho, and Henriques (2010).

In our study, the regression models for the second-stage analysis are different from conventional models of the second-stage DEA regression analysis, as discussed above, because the dependent variable in equation (4) is not the efficiency scores obtained from the first stage. Instead, total slacks of inputs are used as the dependent variables and regressed on the proposed determinants. The values of these excessive inputs are real observations truncated at zero, meaning that we observe these values from zero upwards. This is relevant to the Tobit specification (Green, 2003; Fried, Schmidt and Yaisawarng, 1999). Hence, we use the Tobit regression model to estimate the parameters of equation (4). In addition, we implement the bootstrapped variance method for equation (4) to obtain more robust results.

Stage 3: The estimated coefficients from the regression are used to predict total input slacks for each input and for each unit based on its determinants:

$$\widehat{ITS}_j^k = f_j\left(Q_j^k, \beta_j\right), \;\; j = 1, \ldots, M; \; k = 1, \ldots, K \qquad (5)$$

These predicted values are used to correct the original input data for each unit according to the difference between the maximum predicted slack and the predicted slack:

$$x_j^{k\,adj} = x_j^k + \left[Max^k\left\{\widehat{ITS}_j^k\right\} - \widehat{ITS}_j^k\right], \;\; j = 1, \ldots, M; \; k = 1, \ldots, K. \qquad (6)$$

This adjustment puts all firms into a common operating environment, the least favourable environment observed in the sample. According to Fried, Schmidt and Yaisawarng (1999), there are two reasons to do this. First, for a practical reason, firm managers can attain a performance target regardless of their operating environment. Second, if the most-favourable environment is used as the base, the data, which are adjusted by reducing the input levels for firms in the less favourable cases, can carry a negative value; this is problematic in the DEA model. Thus, using the least-favourable environment is beneficial for both reasons.

Stage 4: The new pseudo-dataset created above is used to rerun the DEA analysis under the initial input-output specification and generate new radial measures of inefficiency that are attributed to management.

Stage 5: This is a new stage that we propose to rerun the DEA analysis with the bootstrap procedure (Simar and Wilson, 1998) to remove serial correlation and biases. This is because the determinants could affect real outputs, and unobserved disturbances could also influence the adjusted inputs. Thus, this bootstrap procedure provides more robust estimates of the efficiencies of HEIs after accounting for determinants. In addition, nonparametric tests are conducted to examine significant differences between initial, adjusted and bootstrapped DEA efficiency scores of the sample HEIs.

To capture the change in efficiency scores of HEIs over T periods in a panel dataset, Fried, Lovell, and Schmidt (2008) suggest several options to exploit this ability. The first choice is to pool the data and estimate a single grand frontier with the assumption of an unvarying best-practice technology which may be tenable only for short panels. This option generates T efficiency estimates for each HEI, all against the same standard, and trends in efficiency estimates of individual HEIs may be of interest. On the other hand, the second option is to estimate T separate frontiers, one for each period that allows for technical progress or regress. However, this option can cause excessive volatility in efficiency scores resulting from excessive variation in temporally independent period frontiers. Another choice, known as window analysis, estimates a sequence of overlapping pooled panels; each contains a few time periods of arbitrary length. This option provides a compromise between running DEA with a large pooled panel and running DEA T times on T small cross-sections. In addition, this method also allows estimation of a sequential frontier by continuously adding data from successive time periods. As a result, sample sizes increase sequentially which complicates statistical inference.

In this study, we chose to implement the first option for the DEA analysis with a pooled dataset of three years. This allows us to consider all HEIs against the same standard and track trends of efficiency score of the sample HEIs over the three periods involved. Further, for the purpose of considering the performance of all HEIs operating under the same legal environment, the ownership feature of HEIs is assumed not to affect the common frontier for DEA analysis in our study.

4.2 Dataset and variables used in the empirical model

In this study, the sample data were obtained for 112 universities and 141 colleges in Viet Nam for each of the years, 2011–2013. These HEIs, account for 60 per cent of the total number of HEIs in Viet Nam, are those which complied with the government regulations to submit their annual reports to MOET. These data were available from MOET and are judged to reliable and complete on HEIs operations. Whereas a longer span of data would have been desirable, our dataset for the three-year period is expected to offer credible quantitative analysis about the performance of HEIs in Viet Nam.

In the Vietnamese higher education system, both universities and colleges are considered as HEIs under the 2012 *Law of Higher Education*. However, universities and colleges in Viet Nam operate under different academic environments and are regulated by separate conditions. In addition, policymakers often consider the performance of these two types of institutions separately. In this sense, we aim to assess their performance in separate models to provide appropriate measures relative to their own cohorts. This will be useful for educational leaders and policymakers in their endeavour to find more feasible ways to improve the performance of HEIs in Viet Nam.

Using the DEA input-orientated approach, which tends to reduce technical inefficiency in input resource usage, given the existing outputs, HEIs' outputs are number of graduates, number of students enrolled, and research income. The number of graduates refers to students who leave having completed degrees at the end of each year. Students enrolled refer to the number of students enrolled in a given year. Carrington, Coelli, and Rao (2005) argued that certain students require more resources to teach than others. For example, postgraduate students can require more resources than undergraduate students. Thus, separate output measures were constructed for postgraduates and undergraduates. Sullivan et al. (2012) asserted that both enrolments and completions have been shown to be important in labour market studies and thus only using one of them can miss a critical output dimension. Such outputs have been used in recent studies, such as those of Abbott and Doucouliagos (2003; 2009), Castano and Cabanda (2007a; 2007b), Guzman and Cabanda (2009), Daghbashyan (2011), de Franca, de Figueiredo and Lapa (2010), Fernando and Cabanda (2007), Miranda, Gramani, and Andrade (2012), Martin (2006), Tajnikar and Debevec (2008) and Thanassoulis et al. (2011). As for research output, some studies have selected number of journal publications to control for research outputs. However, the research output of HEIs may include conference papers, book reviews, and patents. Thus, by choosing only one of these, the empirical results may be biased. The choice of research funding, proposed by Robst (2001) and Abbott and Doucouliagos (2003), is used as a research output. In our study, due to limited data, research output was measured by incomes from research-related activities, excluding tuition fees and government funding.

On the input side, four input variables are used in this study. The first is the *total number of full-time equivalent (FTE) academic staff*. Most academics participate in teaching and research activities. The second input is the *number of FTE non-academic staff*. Non-academic staff are involved with administering students, teaching and research staff, and generally facilitating the teaching and research process. In the context of this study, the non-academic category included general and administrative staff as well as delivery support staff. The third input is *floor area for academic spaces*. This is quite important for annual enrolments at each Vietnamese HEI because MOET has asked each HEI to meet the standards of floor area per student as a basis of calculating enrolment quotas. The final input is *operating expenditures* of HEIs. These expenditures are used for the annual operations of HEIs. Together with the key input and output variables discussed above, some contextual factors that can impact on efficiently using input usages include: age of HEI, location (city or non-city), type of HEI (public or private), the national entrance examination (NEE) marks, and revenue income of individual HEIs as a proxy for financial capacity of HEIs. We tested the following hypotheses in the second-stage regressions of total excessive inputs:

- Age of HEIs is expected to be positively related to input usages. This is because the older HEIs often have a larger operating size, and, thus, tend to use more input resources.
- Location of HEIs is a dummy variable, having value 1 for HEIs located in the main cities (e.g., Ha Noi, Ho Chi Minh City, Da Nang and Hue) and 0 for HEIs in other places. This variable can affect positively or negatively input usages.
- Type of ownership is also a dummy variable, having value 1 for public HEIs and 0 for private ones. This variable is assumed to be positively associated with input usages.

- The NEE mark is anticipated to be negatively correlated with input usages. It is recognised that if HEIs want to limit their annual enrolments due to different reasons, they set a higher NEE mark for entry. As a result, fewer input resources are used for teaching activities.
- The financial capacity (revenues) is assumed to be positively related to all input usages. The stronger the financial capacity, the more HEIs would invest in their input usages to enhance their academic operations.

5. Empirical findings

In this section, we present separately the empirical findings for the universities and colleges models, following the estimation process, as discussed in Section 4. For each model, a statistical summary of variables is presented first. This is followed by the regression results of total input slacks (total excessive inputs needing to be reduced) on determinants to address the hypotheses. Then, efficiency scores for the universities and colleges models, after conducting the proposed stages to filter out the impacts of the operating environment on individual input slacks, are discussed.

5.1 Universities efficiency model

Summary statistics for the variables used in the university model are presented in Table 1. It can be observed that some universities have not started to offer postgraduate programs due to insufficient academic staff or lack of facilities as regulated by MOET; thus the total number of postgraduates has a minimum of zero in the particular year. There is a similar case for research income. This leads to a standard deviation (SD) greater than the mean in the sample.

Table 1: Summary statistics for variables used in the universities model

	Unit	Mean	SD	Minimum	Maximum
Outputs					
Postgraduates	Student	596	1,047	0	5,513
Undergraduates	Student	6,709	6,367	48	30,816
Completed students	Student	2,010	1,854	13	9,544.33
Research income	Billion VND	15.5	35.2	0.001	331.67
Inputs					
Academic staff	Person	375	301	45	1617
Non-academic staff	Person	154	125	39	713
Floor area [a]	1000 m^2	28	31	1.60	277.18
Operating costs	Billion VND	80	77	0.51	479.85
Determinants [b]					
Age	Years	16	11	4	59
NEE	Marks	16.9	3.5	13	28
Financial capacity	Billion VND	100	96	0.64	622.31

Note: [a] Floor area for academic spaces (classroom, library, etc), [b] Excluding location and type which are dummy variables.

Table 2 illustrates the estimated coefficients and *p*-values of the regression results for individual input slacks. The coefficient of age exhibits a significantly positive sign on surplus inputs. This suggests that the older HEIs tend to use more academic and non-academic staff, and have greater operating costs and larger floor area for academic spaces. This is because their operating size is larger, given the greater numbers of students.

Financial capacity (revenues) is positively correlated with the number of academic staff, and operating costs reveal that universities with better financial capacity tend to invest more in academic staff and academic operations. The coefficient of type is negatively related to operating cost. This implies that private universities are inclined to invest more capital in their operations. Finally, the coefficient of location, with a significantly negative sign, reflects the fact that universities located outside a central city could have a larger floor area for academic spaces. All impacts of individual determinants on input slacks for universities are as expected and relevant to the practical context of universities in Viet Nam.

Table 2: Bootstrap regression results of total input slacks for the universities model

	Floor area		Non-academic		Academic		Operating cost	
	Coeff	Bootstrap SE	Coeff	Bootstrap SE	Coeff	Bootstrap SE	Coeff	Bootstrap SE
Location	-6411***	1922	-0	11	-31	20	-1.9	4.2
Type	630	1703	12	11	-34	21	-15***	4.8
Age	330**	163	2.3**	1.0	4.5***	1.7	0.93***	0.33
NEE	-335	251	-3.3*	1.8	-1.2	3.6	-0.31	0.67
Revenue	46	32	0.26	0.22	0.67*	0.39	0.25**	0.10
Age*Revenue	-1.1	1.6	-0.01	0.01	-0.0205	0.0172	-0.0069*	0.0037
Constant	7597**	3637	36	26	45	53	6.5	9.6
σ	13674	887	82.5	8.7	166	12	32.8	2.4
Wald χ^2	21.12		17.60		18.59		28.97	
p value > χ^2	0.0017		0.0071		0.0049		0.0001	

Note *, **, *** denote significance at the 10%, 5% and 1% levels, respectively; the number of replications for bootstrapping was 2,000

Table 3 represents a comparison among the initial, the adjusted, and the bootstrapped DEA efficiency scores of universities over the three years using the five-stage approach, as suggested in Section 4. The initial efficiency scores show wide variations in the years involved, from 0.366 to 1 with a mean of 0.777. This suggests that to obtain full efficiency, universities need to improve their current efficiency by 22.3 per cent, on average. However, these scores do not account for the impacts of determinants that can affect the performance of HEIs; thus, the results of these efficiency scores may be not appropriate for the universities operating in an unfavourable environment when compared with their counterparts with a favourable environment.

Table 3: Efficiency scores of universities over the three years

	Initial DEA scores				Adjusted DEA scores				Bootstrapped DEA scores			
	2011	2012	2013	Sample	2011	2012	2013	Sample	2011	2012	2013	Sample
Mean	0.830	0.764	0.737	0.777	0.895	0.868	0.851	0.871	0.849	0.824	0.809	0.827
SD	0.187	0.197	0.207	0.172	0.088	0.102	0.108	0.086	0.075	0.089	0.096	0.075
Min	0.385	0.295	0.332	0.366	0.659	0.544	0.603	0.682	0.635	0.519	0.570	0.649
Max	1	1	1	1	1	1	1	1	0.974	0.972	0.961	0.961
Eff. units [a]	43	22	24	11	27	19	17	8	0	0	0	0
Hotelling's test (F value) [b]				781.8***								

Note: [a] The number of universities with efficiency scores of 1; *** denotes significance at the 1% level.
[b] Hotelling's test for equal means among the initial, adjusted and bootstrapped DEA scores.

It can be observed that the environmentally-adjusted efficiency scores increase up to 0.871, whereas the sample dispersion decreases with a decline in the standard deviation from 0.172 to 0.086. However, this procedure applies for inputs; thus, it could be that the original outputs are impacted by environmental factors. Also, unobserved disturbances can influence the adjusted efficiency scores. At this stage, a further stage with the bootstrap procedure is implemented on the adjusted inputs and outputs to provide more robust findings after excluding the effects of external factors.

The empirical findings from Table 3 indicate that the environmentally-adjusted efficiency scores with bootstrapping are lower than the adjusted scores, 0.827 compared with 0.871, but higher than the initial scores, 0.827 versus 0.777. Hotelling's test for equality of the three mean scores is statistically significantly different at the one per cent significance level. It can be seen that, although the adjusted efficiency scores increase after the adjustment process, the number of fully efficient universities declines moderately for each year and over the three years. It should be noted that the bootstrap procedure often does not generate fully efficient units. The results reveal that, after controlling the variation of determinants and unobserved disturbances, the inefficiencies of universities are assigned to managerial inefficiency.

A closer look at efficiencies of public and private universities is presented in Table 4. The initial efficiency scores of public universities are slightly higher than those of private ones, on average. However, the Wilcoxon nonparametric test indicates that this difference is not significantly different from zero. However, the environmentally-adjusted efficiency scores show that private universities are marginally more efficient than their public counterparts, 0.877 versus 0.869, although the Wilcoxon test does not indicate statistical significance for this distinction.

Table 4: Efficiency scores of universities classified by ownership

	Initial DEA scores				Adjusted DEA scores				Bootstrapped DEA scores			
	2011	2012	2013	Sample	2011	2012	2013	Sample	2011	2012	2013	Sample
Public	0.839	0.775	0.727	0.780	0.895	0.871	0.842	0.869	0.844	0.823	0.799	0.822
Private	0.807	0.734	0.763	0.768	0.895	0.859	0.875	0.877	0.861	0.827	0.836	0.842
Wilcoxon rank-sum test (Z value)				-0.471				0.705				2.647***

Note: [a] The Wilcoxon rank-sum test for equal means between scores of public and private HEIs.

Likewise, in the case of the bootstrapped efficiency score, private universities are more efficient than public ones with efficiency means of 0.842 and 0.822, respectively. The Wilcoxon test indicates that this difference is statistically significant at the one per cent level. This can be explained by the fact that private universities use their own capital for all academic operations, rather than receiving funding support from the government; thus, they need to use their input resources more efficiently.

Figure 1: Histograms and kernel density plots of efficiencies of universities

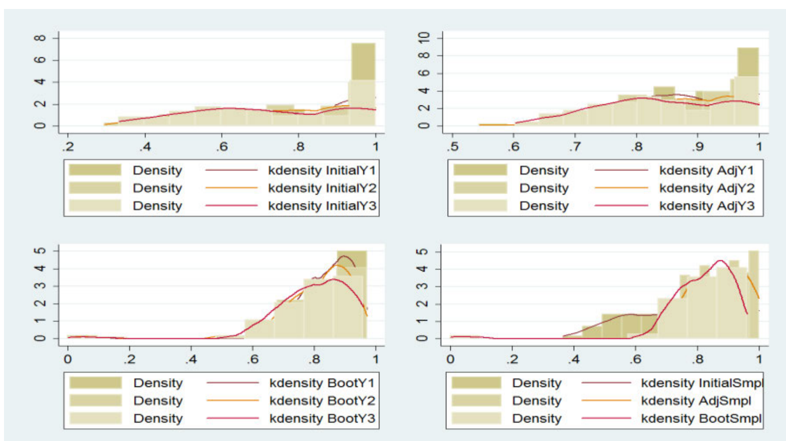


Figure 1 illustrates a moving trend to the right near one with the higher efficiencies for universities each year and over the years involved, after adjusting for the effects of external variables and implementing a bootstrap procedure.

5.2 Colleges efficiency model

Table 5 presents summary statistics of variables used in the colleges model. On average, colleges trained 2,113 students and 554 students graduate annually. Their number of academic staff is, on average, double that of non-academic staff. It should be noted that the academic staff and floor area for academic spaces are important factors for colleges to set the annual enrolment quotas based on the regulations of MOET.

Table 5: Descriptive statistics of variables used in the colleges model

	Unit	Mean	SD	Minimum	Maximum
Outputs					
Undergraduates	Student	2113	1499	83	7116
Completions	Student	554	399	14	1623
Research income	Billion VND	3.6	7.7	0.001	55
Inputs					
Academic staff	Person	129	67	32	438
Non-academic staff	Person	54	21	25	160
Floor area [a]	1000 m^2	13.29	0.81	0.12	4.22
Operating costs	Billion VND	18	13	0.9	67.76
Determinants [b]					
Age	Year	12.1	6.5	4	39
NEE	Mark	11.5	2.1	10	21.75
Revenue	Billion VND	23	16	1.12	84.71

Note: [a] Floor area used for academic spaces (classroom, library, etc.); [b] Excluding location and ownership that are dummy variables.

Table 6: Bootstrap regression results of total input slacks for the colleges model

	Floor area		Non-academic		Academic		Operating cost	
	Coefficient	Bootstrap SE	Coefficient	Bootstrap SE	Coefficient	Bootstrap SE	Coefficient	Bootstrap SE
Location	-560	1278	-1.9	2.8	-21.6***	7.7	-0.3	1.0
Type	3397**	1583	7.0**	3.6	-23	14	1.0	1.2
NEE	-606***	206	-1.66***	0.49	-2.8**	1.1	-0.36*	0.20
Age	-58	125	-0.20	0.32	0.21	0.93	-0.20	0.18
Revenue	-21	56	-0.07	0.15	0.45	0.49	0.16	0.12
Age*Revenue	2.5	4.1	0.017	0.012	0.015	0.035	0.01	0.01
Constant	9960***	2537	30.7***	5.9	84***	18	6.0*	3.1
σ	8029	972	18.4	1.1	45.6	3.9	6.65	0.51
Wald χ^2	16.93		22.83		21.50		47.18	
p value > χ^2	0.0096		0.0009		0.0015		0.0000	

Note *, **, *** denote significance at the 10%, 5% and 1% levels, respectively; the number of replications for bootstrapping was 2,000.

The regression results of total input slacks on determinants are shown in Table 6. It can be seen that the NEE mark is associated negatively and significantly with total input slacks. This reflects the fact that the higher the NEE mark, the lower the new enrolments for the colleges. Thus, it affects indirectly the numbers of staff, operating costs, and floor area of colleges. It is interesting to see that the public colleges tend to have more non-academic staff and greater floor area than their private counterparts. Further, the colleges in the main cities tend to have fewer academic staff. In general, external factors illustrate various impacts on input usages of colleges, and, hence, on the performance of colleges. As indicated in Table 7, the mean initial efficiency score of 0.698 indicates that colleges could potentially improve their efficiency by about 30.2 per cent to obtain full efficiency of one.

Table 7: Efficiency scores of colleges over three years

	Initial DEA scores				Adjusted DEA scores				Bootstrapped DEA scores			
	2011	2012	2013	Sample	2011	2012	2013	Sample	2011	2012	2013	Sample
Mean	0.718	0.681	0.694	0.698	0.908	0.879	0.872	0.886	0.878	0.849	0.838	0.855
SD	0.197	0.199	0.183	0.175	0.072	0.082	0.083	0.069	0.064	0.072	0.072	0.059
Min	0.297	0.305	0.338	0.324	0.695	0.641	0.667	0.731	0.678	0.626	0.640	0.709
Max	1	1	1	1	1	1	1	1	0.978	0.965	0.969	0.964
Eff. units	24	17	18	10	23	16	18	10	0	0	0	0
Hotelling's test (F value)				235.77***								

Note: [a] the number of universities with efficiency scores of 1; *** denotes significant at the 1% level.
[b] Hotelling's test for equal means among the initial, adjusted and bootstrapped DEA scores

After eliminating the effects of external variables, the adjusted mean efficiency score increases considerably to 0.886. It can be seen that determinants substantially affect the performance of colleges when all are placed in a common environment. The bootstrapped efficiency scores are slightly lower than the adjusted efficiency scores but still much higher than the initial scores. Hotelling's test indicates a significant difference at the one per cent significance level among these scores. This indicates the importance of controlling for the effects of the operating environment and removing biases of unobserved disturbances on the efficiencies of colleges, and the inefficiencies of colleges are attributed to managerial performance. After adjusting the impacts of external factors, the number of fully efficient colleges decreases by one in both 2011 and 2012, but remains constant in 2013. For the whole sample, this number is the same as the number of fully efficient colleges before adjustment, at 10 efficient colleges.

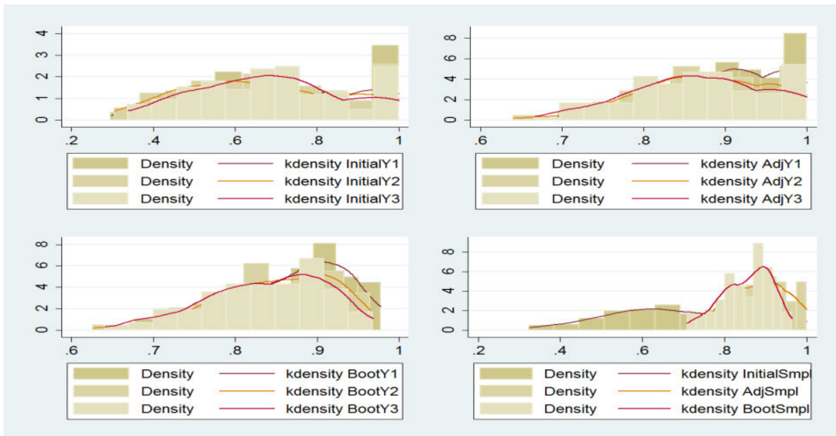
Table 8 illustrates the efficiency scores of colleges classified by their ownership. Our findings reveal that private colleges are more efficient than their public counterparts for all three cases. The Wilcoxon test confirms that the difference of efficiencies between public and private colleges is significant at the one per cent significance level. In addition, it can be observed that efficiencies of private colleges are higher than the sample mean among the three cases. Seemingly, private colleges are key drivers for the performance of colleges for the sample of HEIs involved. These results may interest policymakers to design more appropriate policies to facilitate the operating environment of private colleges.

Table 8: Efficiency scores of colleges classified by ownership

	Initial DEA scores				Adjusted DEA scores				Bootstrapped DEA scores			
	2011	2012	2013	Sample	2011	2012	2013	Sample	2011	2012	2013	Sample
Public	0.706	0.670	0.680	0.685	0.905	0.876	0.868	0.883	0.875	0.846	0.834	0.852
Private	0.811	0.764	0.803	0.793	0.934	0.903	0.904	0.914	0.900	0.877	0.874	0.884
Wilcoxon rank-sum test (Z value)				3.685***				2.93***				7.707***

Note: [a] The Wilcoxon rank-sum test for equal means between scores of public and private HEIs

Figure 2: Histograms and kernel density plots of efficiencies of colleges



The kernel densities of efficiency distributions of colleges for each year and over the three years are illustrated in Figure 2. The estimated densities indicate that relative to the initial efficiency scores, the adjusted- and bootstrapped-efficiency scores for each year and over the three years move to the right near one with higher efficiencies.

6. Discussion and conclusions

This paper measures the efficiencies of Vietnamese HEIs for the period 2011–2013 using multiple inputs and multiple outputs. The bootstrap procedure was introduced to the Fried, Schmidt and Yaisawarng (1999) model to isolate the impacts of environmental factors on total input slacks. We proposed a new stage to this model by implementing bootstrapping on the environmentally-adjusted efficiency scores to remove biases of unobserved disturbances and, thus, give more robust estimates. The operational inefficiencies of HEIs after eliminating the impacts of determinants are associated with the role of managerial performance. Our extended model is the first to be applied to Vietnamese HEIs and provides more understanding of the performance of HEIs and thus reduces asymmetric information in assessing the efficiencies of HEIs without empirical evidence. From our empirical results, policymakers and educational leaders will have more information to seek possible ways to improve the performance of HEIs.

Our paper uses the nonparametric DEA multi-stage approach with bootstrapping to measure independently the efficiencies of universities and colleges. In the universities' case, the empirical results indicated that the mean efficiency scores with the standard DEA approach were not high, 0.777. After accounting for the effects of the operating environment, their adjusted mean efficiency scores increased significantly to 0.855. However, the Wilcoxon nonparametric test for constant mean scores was not statistically significant. The bootstrap procedure was again applied to the efficiency analysis in the final stage to provide more robust efficiency scores for universities. The findings revealed that the bootstrap-corrected mean efficiency score decreased to 0.807, but was substantially higher than the initial mean score. The bootstrap-corrected efficiencies of public universities were less than those of private ones, but this difference was not statistically significant. In the colleges' case, the environmentally-adjusted mean efficiency scores were much higher than the initial mean efficiency scores, 0.698 and 0.886, respectively. This change was statistically significant at the one per cent significance level. The bootstrap-corrected mean efficiency score for colleges declined slightly to 0.855, but was significantly greater than the initial mean score. This increase is statistically significant based on Hotelling's test. The results of the bootstrap-corrected efficiencies showed that private colleges were more efficient than public ones and this difference was statistically significant. Based on these results, it is suggested that there is still room for improving the efficiency of colleges.

The empirical findings also indicate that apart from the managerial inefficiencies, determinants such as age, location, ownership, the national entrance examination marks, and financial capacity are significant factors affecting input usages, and, thus, the performance of HEIs. It is suggested that the older universities would have more academic and non-academic staff and would have higher expenditure for their operations. The NEE had a striking influence on floor area and the numbers of academic and non-academic staff of colleges. It is noted that, in both cases, the efficiencies of universities and colleges show a downward trend over the three years involved.

From our results, managerial implications can be drawn. First, Vietnamese HEIs in our sample were inefficiently operating under the current legal environment during the period 2011–2013. After eliminating the impacts of external factors, the efficiencies of universities and colleges are 0.827 and 0.855, respectively. This means there is room for further improvement in the performance of HEIs. In other words, the inefficiencies of HEIs can be attributed to managerial inefficiency at the government and institutional levels, for example, inflexibility of the governance system and the managerial ineffectiveness of individual HEIs. It can be argued that the governance system in higher education has been gradually changed but is moving slowly (Dao, 2014; Tran, 2014), thus, it has not provided feasible incentives for the reform progress of HEIs. On the other hand, HEIs may need to be more dynamic and efficient in managing their academic operations within the confines of current regulations and maintaining sound education quality.

Second, it can be seen that private HEIs were more efficient than public ones in using input resources to obtain the existing outputs. Although this may need to be re-examined with a larger sample size, it may cause much more concern about the efficiency of public funding granted to public HEIs and the validity of the government policies to regulate operations of the two types of HEIs in the national higher education system. Finally, for HEIs, our findings have provided empirical evidence that environmental variables impact on the input usages and, thus, on their operational efficiencies. Our results can be used to set out specific targets for managerial improvement of HEIs in the future by redistributing input resources more appropriately to obtain a higher level of efficiency in academic operations and even in their quality of education.

Although we endeavour to provide useful information about the performance of HEIs for policymakers and educational leaders, further studies may be necessary to supplement our findings. First, due to limited data, we only used a study period of three years and the efficiency changes of HEIs have not been captured over these periods. Hence, a longer span of data would be preferable to give a clearer picture about these possible variations in the efficiencies of HEIs over time. Second, more variables, such as publications and the quality of students, should be added in the analytic models to provide a deeper assessment of the performance of HEIs. This may have managerial implications in that HEIs should comply with the government regulations by submitting their annual reports to MOET for statistical analysis. This would facilitate researchers and policymakers to analyse and evaluate the operational efficiencies of HEIs. Finally, the impacts of the government policies on higher education, which have not been assessed in our study, need to be investigated to help policymakers make timely changes by reformulating and redesigning higher education-related policies.

Chapter 6: Measuring input mix efficiency of higher education institutions in Viet Nam

Abstract

The main objective of this paper is to focus on the relative importance of input mix as a source of inefficiency. Emphasis in efficiency analysis studies in higher education relies on key concepts of technical and scale inefficiencies that are not sufficient to identify the nature of inefficiency, particularly input mix inefficiency. Higher education institutions (HEIs) are considered to be susceptible to input mix inefficiency because of constraints on movement around the frontier isoquant; deferrals in the adoption of advanced teaching technology underlined in the world's higher education standards; and the potential for inconsistency in simultaneously obtaining allocative efficiency and mix efficiency in input use. We use a nonparametric DEA method to calculate the Färe-Primont productivity index for 112 universities and 141 colleges over the period 2011–2013. This index is then decomposed into measures of technology, technical efficiency, scale efficiency, and mix efficiency for an input orientation. The empirical findings indicate that input mix efficiencies for universities and colleges are 0.829 and 0.842, respectively. Using fractional regression analysis in the second stage, we found that location, age, ownership, and financial capacity have significant influence on the input mix efficiency of HEIs.

Key words: Data envelopment analysis, Färe-Primont productivity index, fractional regression, higher education institutions, input mix efficiency, performance.

1. Introduction

Promoting efficiency in economic sectors including both manufacturing and services industries is a demanding necessity to improve national competitiveness. Higher education plays a crucial role in this process because a nation's human resources, through tertiary education, significantly affect national economic development and competitiveness capacity (Agasisti and Pohl, 2012; Schwab, 2013). In times of global financial challenges and the demand for re-evaluating educational reform policies and better using the scarce resources of universities (Agasisti and Pohl, 2012; Castano and Cabanda, 2007; Sav, 2012), it is imperative for the government and educational leaders to examine the efficiency of input resource use by higher education institutions (HEIs) while making efforts to maintain quality of education.

As in most developing nations, enhancing higher education standards is one of the important strategies being employed to attain competitiveness in Viet Nam. After nearly 20 years of implementing the educational socialisation policy introduced in 1997, Vietnamese higher education has achieved remarkable increases in the number of HEIs and the number of enrolments. In 2013/14, the number of enrolments was over two million, an increase of 144 per cent over the number of enrolments in 1999/2000. Likewise, the number of graduates who completed their degree was also over 400,000, being 2.5 times higher than that of the year 1999/2000. This growth in numbers of HEIs and enrolments has made a significant contribution to providing the highly-qualified labour force for the national economy and improving the educational level of society. However, whether this growth of HEIs has been really sound has still to be examined. In the recent global competitiveness report for 2013/14 of the World Economic Forum (Schwab, 2013), the Vietnamese higher education sector was only ranked 95th, a relatively low position among the 148 nations involved. This raises specific concerns about whether HEIs are efficient in their operations while they are facing changes in the education environment and whether contextual factors are influential on their operational efficiencies.

The efficiency and productivity literature in higher education has mainly focused on the analysis of technical inefficiency as a key notion and then, using advanced methodology, disaggregating it into pure technical inefficiency and scale inefficiency. However, in the context of higher education in the 21st century, which is facing challenges of shrinking public budgets and higher education attainment (Chau and Tran, 2015; Economist Intelligence Unit, 2014; McLendon and Perna, 2014), this advance is insufficient to identify a potentially major source of inefficiency in higher education, namely, mix inefficiency. Input mix efficiency can be attributed as diseconomies of scope on the input side that is closely related to, but different from, cost-allocative inefficiency (O'Donnell, 2014). In this study, input mix inefficiency is referred to as productivity shortfall that is linked to nonoptimal input mix. It can be considered that Vietnamese HEIs are particularly susceptible to input mix inefficiency in many ways. For instance, given the current legal environment, HEIs may be especially prone to input mix inefficiency because of their limited elasticity in varying levels of permanent labour inputs and the shortages of financial resources to meet the learning facilities, that is, floor area per student, in response to changes in the educational environment.

In Viet Nam, public and private HEIs are operating in the same legal circumstances except for differences in the financial management mechanism. Because the governance system is currently complicated and fragmented, it may be difficult to see a short-term change of HEIs to catch up with the pace of development of the world's higher education systems (Asian Development Bank, 2011; Hayden and Lam, 2007). When planning is taking place, all inputs are variable and, thus, can be adjusted; but, once the plans (budget, human resources, and curricula) have been approved, the training process is set in place and cannot be easily changed. As a consequence, failure to take advantage of the flexibility in the governance system can put HEIs in Viet Nam at a productivity disadvantage compared with those in other Asian countries that are given sufficient rights to manage their operations.

Our main objective is to investigate what the input mix efficiency of HEIs is in Viet Nam under the current legal environment. In addition to this, using fractional regression analysis in the second stage, we examine possible impacts of contextual factors on input mix efficiency. Our findings are expected to provide insightful information for HEI managers and policymakers to explore means to improve the performance of HEIs.

The organisation of this paper consists of the following sections. Section 2 briefly presents the empirical context of higher education in Viet Nam. Section 3 then reviews the estimates of efficiency components by decomposing the productivity index in higher education. Section 4 illustrates the methodology, dataset and variables. The empirical results for the input efficiency decomposition of HEIs and the impacts of contextual factors on input mix efficiency are presented in Section 5. The conclusion is presented in Section 6.

2. Empirical context of Vietnamese higher education

2.1 Progress in higher education under the reform policy

Economic reform of Viet Nam started in 1986 when the *Doi Moi* (renovation) policy was strongly linked to education reform. However, not until 1995, did the Vietnamese economy really take off and officially open the door to foreign countries to enhance its economic growth. Viet Nam became one of the fastest growing economies in the world with GDP growing, on average, by seven per cent per annum during the period 1989–2010 (World Bank, 2011). This has created a strong impetus for Viet Nam to renovate its higher education system. In 1997, when Resolution 90/NQ-CP of the government on the socialisation policy of education, health, and culture was introduced, private education was officially encouraged. Following this, the government issued Decree 73/1999/ND-CP to provide guidelines for stakeholders to implement the education socialisation policy. In 1999, Viet Nam had only 22 private HEIs, but, as a result of the Decree, this figure increased nearly fourfold by 2013 with 54 universities and 29 colleges. The enrolments of private HEIs rose remarkably, going from 107,538 in 1999/2000 to 312,652 students in 2012/13 (MOET, 2013).

According to the Ministry of Education and Training (MOET, 2013), Vietnamese higher education currently has a total of 421 HEIs including universities and colleges, of which there are 207 universities and 214 colleges. There are 83 private HEIs which account for 19.7 per cent of the current total HEIs. The number of academic staff increased remarkably to more than 87,000 in 2012/13, which is 2.5 times greater than that in 1999/2000. The number of articles published in international journals showed an increasing trend over the period 2008–2012, 955 to 1731 articles, even though this figure is relatively low, being only 22 per cent and 27 per cent of those of Singapore and Malaysia, respectively (Hien, 2010; Hoang, 2013; Thanh, 2012). For curricula framework, MOET made advances to cooperate with foreign universities to develop 23 advanced curricula at 17 chosen universities.[6] These programs use English as the medium of teaching and learning and are assessed against foreign university standards (Vu, 2012).

Resolution 37/2004/QH11 of the government on education suggested an increase in the public budget for education by 20 per cent of total national expenditure. This policy has been implemented over the following years based on the national budget. For example, in 2010, government investment in the education sector accounted for 20.9 per cent of total national expenditure, and public expenditure per student in tertiary education amounted to 39.8 per cent

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[6] Decision 1505/2008/QD-TTg was issued by the government on the project of implementing the advanced curricula in some Vietnamese universities for the period of 2008–2015.

of GDP per capita (Economic and Social Commission for Asia and the Pacific, 2014). Also, the Ministry of Finance (2012) reported that the total national budget for education in 2012 increased by 11.1 per cent compared with that in 2011. This indicates a positive commitment to advancing the restructuring of higher education in Viet Nam.

Public education has an important place in the national education system. The number of publicly-owned HEIs is currently 338, of which 153 are public universities. The average enrolment of public HEIs was 5,517 students in 2012/13, whereas that of private ones was 3,767 students in the same year. Public higher education is considered a key incentive to providing highly-qualified human resources to the labour market. More flexibility has been given to public higher education since 2010 when Decree 49/2010/ND–CP of the government on tuition fees allowed public HEIs to increase tuition fees in the period, 2010/11–2014/15. With this policy, public HEIs can increase annual revenue income for their academic operations as long as they are within the confines of the allowed tuition rates for each year. No limitations are imposed on tuition fees for private HEIs. By 2011, Circular 57/2011/BGD–DT of the government allowed HEIs to set the enrolment quota per annum based on floor area per student and the ratio of students to lecturer.

Resolution 14/2005/NQ–CP of the government on education, the so-called Higher Education Reform Agenda, suggested removing the line management of the higher education system to provide more autonomy for HEIs, but this management system still remains complicated and fragmented. Among 421 HEIs, there are 51 public HEIs under management of MOET and the remaining HEIs (87.4 per cent) are under management of 13 ministries and local authorities. In actual fact, all HEIs are operating under the same education law but under different line management systems, depending on which ministry they belong to. Arguably, the government desires to increase the autonomy of HEIs but also wants to control them to some extent. Thus, real autonomy may still be desirable for HEIs in the current context of Vietnamese tertiary education.

2.2 Challenges and sources of mix input inefficiency of Vietnamese HEIs

Input mix inefficiency in higher education is discussed in the context of Vietnamese HEIs. In spite of the substantial investment in financial and human resources, including government aid in many different ways, the performance of the sector have lagged far behind the world's leading education standards. Input mix inefficiency can arise from the following sources.

First, inertia is experienced through the lack of flexibility in the governance system when, in response to changes of either the domestic education market or the world's higher education standards, HEIs find it difficult to move smoothly around their isoquant in substituting between inputs for a given teaching technology. The nature of teaching technology in Viet Nam, the context of our analysis, is especially likely to inhibit adjustment in response to changed education circumstances.

Although a credit system has been instituted to lower the total number of required contact hours and allows for greater flexibility in the use of pedagogies, in the short-run, HEIs face some fixed curricula. For example, obligatory patriotic and political themes, where teaching of these themes requires fixed proportions of the input vector resulting in a series of isoquants. An HEI operating on a particular isoquant may need to substitute capital for labour to become mix-efficient in inputs, but may not be able to do so because the nearest approachable point may be even further from the mix-efficient input. Although each case of teaching technology might contribute only small input mix inefficiencies in this way, the presence of multiple of such teaching technologies in higher education is likely to induce a considerable level of mix inefficiencies in total.

A second source of input mix inefficiency in HEIs is the potential for inconsistency when they endeavour to reach points of both allocative and mix efficiency in input use at the same time. It is uncertain in any year that the allocative efficiency combination of inputs is identical to the mix-efficient combination. Given generated innovation, HEIs who adopt "run of mill" teaching techniques that save more on highly qualified inputs, for example, teaching staff with a PhD qualification or modern learning facilities, in response to changes in relative factor prices, are likely to operate more closely to the allocatively efficient point on the frontier isoquant than are high-tech adopters.

The third source of input mix inefficiency arises from overspecialisation in input use in a situation of diminishing returns to inputs, a circumstance commonly found with the single discipline HEIs, the so-called specialised HEIs, for example, information technology, art or music, where teaching staff have limited employment outside their major. In this case, HEIs can be technically efficient but may be not mix-efficient.

Finally, HEIs may suffer from mix inefficiency when changing their operations, which require some calibration before the optimal input mix is obtained. This source of inefficiency is likely to be witnessed through current regulations imposed on the operation of HEIs. For example, although government allowed public HEIs to increase tuition fees over the period 2010/11 to 2014/15, tuition caps remain unchanged. This means that public HEIs are not allowed to charge students above the allowed ceiling tuition levels for each group of study fields. Clearly, the tuition policy has not taken into account whether such ceiling levels of tuition fees would be sufficient for the operations of HEIs. Another instance worth mentioning is Circular 57/2011/TT–BGDDT that asks all HEIs to meet the requirements of indicators for new enrolment quotas such as the ratio of teaching staff to students and ratio of floor area to students. This policy is considered a way to ensure the education quality of HEIs. However, there is not sufficient evidence that it is likely to help to improve the operational efficiencies and enhance the quality of teaching.

The neglect of changes in input mix inefficiency from efficiency and productivity analyses has led to the fact that it has been mixed with estimates of technical and scale efficiency. This omission can make analysts misidentify the nature of teaching technology in higher education and divert attention from the central cause of inefficiency. Hence, solutions to improvement of HEIs seem to be inadequate if they are just advised to better use available input resources or adopt the advanced teaching technology and learning facilities.

In terms of sources of mix input inefficiency, as discussed above, we test our contention by estimating the productivity index of HEIs and decomposing it into technical, scale, and input mix efficiencies, and particularly investigate whether contextual factors affect their input mix efficiency, our indicator of interest. This would provide insightful facts for policymakers and educational leaders to redesign more suitable regulations for enhancing productivity of HEIs.

3. Efficiency decomposition in higher education: A brief review

Measuring efficiency and decomposing the productivity growth into different efficiency indexes of higher education have attracted much attention of scholars and researchers in recent years. Most studies have used the Malmquist data envelopment analysis (DEA) approach proposed by Färe et al.(1994) to decompose productivity growth into efficiency, technical change, and scale efficiency. These studies include Thursby and Kemp (2002); Flegg et al. (2004); Carrington, Coelli, and Rao (2005); Worthington and Lee (2005); Kempkes and Pohl (2006); Castano and Cabanda (2007a; 2007b); Fernando and Cabanda (2007); Johnes (2008); Thanassoulis et al. (2011); Agasisti and Bianco (2009); Agasisti and Perez-Esparrells (2010) and Agasisti and Pohl (2012). However, there are some other indexes that show similar advantages to the Malmquist index.

O'Donnell (2008) proposed that any multiplicatively complete total factor productivity (TFP) index can be exhaustively disaggregated into the product of measures of technical changes and several meaningful measures of efficiency change. O'Donnell (2012b) demonstrated that the class of multiplicatively complete TFP indexes includes the well-known Laspeyres, Paasche, Fisher, Törnqvist, Färe-Primont, and Hicks-Moorsteen indexes, but not the Malmquist TFP index suggested by Caves, Christensen, and Diewert (1982). In addition, O'Donnell (2014) revealed that the decomposition methodology of O'Donnell (2008) does not depend on any restrictive assumption regarding the production technology, firm behaviours, and the level of competition in inputs and outputs markets. Thus, this methodology is used to decompose TFP into economically meaningful factors that could contribute significantly to the needs of policymakers and provide more insights for decision making units to develop better strategies for their productivity. Recently, Arjomandi, Salleh and Mohammadzadeh (2015) applied the Hicks-Moorsteen index to measure the productivity change of 17 Malaysian public universities for the period 2006/07–2008/09. Using an output orientation, their findings showed that the productivity growth was, on average, 43 per cent in the surveyed period. The Hicks-Moorsteen index was decomposed into output technical efficiency (0.975), scale efficiency (0.965) and mix output efficiency (0.933). The authors pointed out that the DEA model works well with a small sample size in their case. However, Paradi, Yang and Zhu (2011) expounded that the number of decision making units should be at least three times the total number of inputs plus outputs used in the models. This ensures enough observations to allow good separation and discrimination between decision making units in DEA models.

In the context of this study, our main interest is to investigate input mix efficiency of HEIs, mainly drawn on decomposing the Färe-Primont TFP index, introduced by O'Donnell (2008; 2012b; 2014), into technical, scale, and mix efficiency for an input orientation. Currently, there is little empirical research that has used this method to investigate the input mix efficiency in higher education; thus, providing us the motivation to implement this paper for Vietnamese higher education. Furthermore, we propose a second-stage regression analysis to take account of the effects of possible contextual factors on the estimated input mix efficiency of HEIs using the fractional regression model (Ramalho, Ramalho, and Henriques, 2010). For Vietnamese HEIs, contextual factors such as ownership, age, location, and financial capacity could affect their input mix efficiencies. For example, public HEIs may be more efficient than private HEIs in using input mix to produce the given outputs due to strong financial capacity supported by government funding. In addition, age of HEIs is a significant factor influencing their input mix efficiencies. The explanation of this could be that the older HEIs, the more available input resources they have to alter their operations in response to changed education circumstances by flexibly using input mix, thus they may be more efficient than the younger HEIs.

4. Methodology

4.1 Measuring input mix efficiency

The method of analysis used in this paper draws primarily on O'Donnell (2008, 2012b, 2014) by using the advanced DEA method to estimate the Färe-Primont productivity index and decompose it into measures of technology, technical efficiency, scale efficiency and mix efficiency for an input orientation. Based on the production function analysis, this is relevant to the Vietnamese context, where HEIs need to efficiently use input resources to obtain the objective outputs, following the government's regulations relating to the ratio of students to teaching staff and floor area per student.

The variable returns-to-scale production technology is illustrated in terms of aggregate inputs and outputs. Let $x = (x_1, \dots, x_M)' \in \Re_+^M$ and $q = (q_1, \dots, q_N)' \in \Re_+^N$ represent vectors of input and output quantities. The production possibilities set available to HEI in period t denotes

$$T(t) = \{(x, q): x \; can \; produce \; q \; in \; period \; t\}.$$

The following standard conditions are assumed (O'Donnell, 2012b; 2014):

A1: $(x, 0) \in T(t) \text{for all } x \in \Re_+^M$ (zero output is feasible)(inactivity);

A2: If $(x, q) \in T(t)$ and $x^1 \leq x$ then $(x^1, q) \in T(t)$(strong disposability of inputs);

A3: If $q \geq 0$ then $(0, q) \notin T(t)$(weak essentiality);

A4: $P(x, t) = \{q: (x, q) \in T(t)\}$ is bounded for all $x \in \Re_+^M$;

For the multiple-output, multiple-input case, TFP of an HEI is defined as the ratio of an aggregate output to an aggregate input: $TFP_{it} = \frac{Q_{it}}{X_{it}}$

where $Q_{it} = Q(q_{it})$ is an aggregate output, $q_{it} = (q_{1it}, \dots, q_{Jit})'$ is the output quantity vector of HEI i in the period *t*. Similarly, $X_{it} = X(x_{it})$ is an aggregate input, $x_{it} = (x_{1it}, \dots, x_{Kit})'$. In addition, $Q(.)$ and $X(.)$ are nonnegative, nondecreasing and linearly homogeneous aggregator functions (O'Donnell, 2010, 2012a, 2012b, 2014).

Using DPIN version 3.1 (O'Donnell, 2011), the Färe-Primont index is decomposed into input-orientated efficiency indicators of HEI *i* in period *t* and are defined by:

$$ITE_{it} = \frac{\bar{X}_{it}}{X_{it}} \qquad \text{Input-orientated technical efficiency;}$$

$$ISE_{it} = \frac{Q_{it}/\bar{X}_{it}}{\tilde{Q}_{it}/\tilde{X}_{it}} \qquad \text{Input-orientated scale efficiency;}$$

$$IME_{it} = \frac{\hat{X}_{it}}{\bar{X}_{it}} \qquad \text{Input-orientated mix efficiency}$$

$\bar{X}_{it} \equiv X_{it}/D_I(x_{it}, q_{it}, t)$ is the minimum aggregate input possible using a scalar multiple of x_{it} to produce q_{it}; $\hat{X}_{it} = argmin_{x>0}\{X(x): (x, q_t) \in T^t\}$.; $\tilde{Q}_{it}$ *and* $\tilde{X}_{it}$ denote the aggregate output and input quantities at the point of mix-invariant optimal scale.

It is widely recognised that input mix efficiency is built on the basis of the DEA deterministic frontier method without accounting for random noise in the data-generating process (DGP). Thus, the results can be sensitive to outliers. Hence, we endeavoured to identify such outliers before implementing the performance analysis of HEIs. Using the concept of super efficiency introduced by Andersen and Petersen (1993) and adopting the procedure of identifying outliers used by Thanassoulis (1999), we first identified HEIs with exceptional achievement relative to the efficient boundary drawn on the remaining HEIs. Then, based on the super-efficiency measure, we assessed how far these HEIs were from the rest of the colleges and decided whether they should be treated as outliers or not. Following Thanassoulis (1999), a threshold difference of super-efficiency of 10 percentage points is applied to identify outliers. Accordingly, a subset of HEIs that had super-efficiency over 100 per cent and were separate from other inefficient colleges by a gap of at least 10 percentage points were identified as outliers. After outliers were identified, they were removed. Then, the super-efficiency measure was implemented again on the new subset of data to detect whether outliers existed in our sample. This process was repeated until there was no gap of 10 percentage points in super efficiency in our sample. This means no HEI in the final dataset was more than 10 percentage points in efficiency further away than other units. It should be noted that this procedure was conducted separately for universities and colleges. As a result, we identified 16 university outliers and nine college outliers. Following the suggestions of Thanassoulis et al. (2011), after the outliers were identified, we did not allow them to affect the position of the efficiency boundary but held them with their data adjusted to sit on the boundary drawn on non-outlier HEIs.

4.2 The impacts of contextual factors on input mix efficiency

The choice of the regression model for the second-stage of DEA analysis has attracted much concern of scholars and researchers. The ordinary least-squares (OLS) model is generally inappropriate in the second stage because the predicted values of the dependent variable may be outside the unit interval. Using a two-limit Tobit model with limits at zero and unity to model DEA scores is moot as well. The reason for this is that the accumulation of observations at unity is a product of the way DEA scores are defined rather than the result of censoring. Furthermore, DEA efficiency scores of zero are not observed; thus the domain of the two-limit is different from that of the DEA scores (Ramalho, Ramalho, and Henriques, 2010; Simar and Wilson, 2007). By contrast, Hoff (2007) and McDonald (2009) suggested the use of the simpler linear regression model, though McDonald (2009) recognised the advantages of the Papke and Wooldridge (1996) model to obtain a more refined analysis.

It is widely known that, in the second stage of the DEA, the scores can be treated like any other dependent variable in regression analysis. Hence, a coherent DGP for DEA scores is essential to select a suitable functional form for the regression model that relates these scores to the environmental variables. Simar and Wilson (2007) were the first to describe such a DGP and to develop appropriate estimation procedures for the second-stage DEA analysis. They provided a set of assumptions in which the use of estimates rather than true efficiency scores does not affect the consistency of the second-stage regression parameters. On the other hand, Banker and Natarajan (2008) proposed a formal statistical foundation for the two-stage DEA analysis to generate consistent estimators in the second stage. A linear relationship between the logarithm of the efficiency scores and the contextual factors in one of their specifications implied that using the OLS can yield consistency of the parameters in the second-stage regression model. However, their DGP is less restrictive than that of Simar and Wilson, and the distributional assumptions about the error term of the second stage are required to re-estimate efficiency scores because the dependent variable is the logarithm, rather than the level, of the DEA scores.

Ramalho, Ramalho, and Henriques (2010) proposed several alternative regression models of efficiency scores in the second stage using fractional regression models and tests of the specification chosen for the regression model using simple statistical tests. For simplicity, they treated the DEA scores as observed measures of technical efficiency, rather than estimated values. They suggested that the two-part fractional regression model may be useful when the percentage of unity values is large. That is, we can test the external effects on both inefficient distances and on the frontier if the proportion of the frontier values (equal to one) is sufficiently large. In addition, the regression analysis with the robust variances is a valid inference in their framework.

In this study, we adopt the Ramalho, Ramalho, and Henriques (2010) model for the second-stage DEA-based efficiency analysis to examine the determinant impacts on input mix efficiency of HEIs. We choose this model because it allows us to examine the impacts of contextual factors on both HEI inefficiency and HEI frontier efficiency by using the two-part fractional models if the alternative hypothesis test, that the two-part fractional model is appropriate, is accepted. Otherwise, the standard (one-part) fractional model can be used. In addition, the input mix efficiency scores, bounded between zero and one, obtained from the DEA approach by decomposing the Färe-Primont productivity index, can be applied directly to this model without converting to Shephard distance function scores (greater than one) as in the Simar and Wilson (2007) model.

The general model for dealing with fractional response variables only requires the assumption of a functional form for y that imposes the desired constraints on the conditional mean of the dependent variable:

$$E(y|x) = G(x\theta)$$

where $G(.)$ is a known nonlinear function satisfying $0 < G(.) \leq 1$. Details of this model in terms of one-part or two-part models are not presented here, but are available in Ramalho, Ramalho, and Henriques (2010). It should be noted that the hypothesis test that the two-part fractional regression model is true needs investigation. If the null hypothesis is rejected, the two-part fractional model is used. Otherwise the one-part fractional regression model to estimate the effects of contextual factors on input mix efficiency scores of HEIs can be used.

4.3 Dataset and variables

We use the compiled data for the period of three years from 2011 to 2013. Data sources came from MOET. The number of universities and colleges are 112 and 141, respectively, in a balanced panel, accounting for 60 per cent of all HEIs in Viet Nam. These are HEIs that complied with the regulations to submit their annual reports to MOET, thus their performance indicators were sufficiently recorded for the purpose of research analysis. Although a longer span of data would have been desirable, at this stage, our available dataset for the period of three years is expected to provide useful information about input mix efficiency of HEIs in Viet Nam.

Under the chosen input-orientated model, the outputs of HEIs are the number of graduates, number of students enrolled, and research income. The number of graduates refers to students who leave with completed degrees at the end of each year. Students enrolled refer to the number of students enrolled in a given year. They are considered as input resource users of HEIs embodied in the process of teaching and research. Carrington, Coelli, and Rao (2005) argued that certain students require more resources to teach than others. For example, postgraduate students can require more resources than undergraduate students. Thus, separate output measures were developed for postgraduates and undergraduates. Sullivan et al. (2012) asserted that both enrolments and completions have been shown to be important in labour market studies and, thus, only using one of them may miss a critical output dimension. Such outputs have been used in recent studies, such as those of Abbott and Doucouliagos (2003, 2009), Castano and Cabanda (2007a, 2007b), Guzman and Cabanda (2009), Daghbashyan (2011), de Franca, de Figueiredo, and Lapa (2010), Fernando and Cabanda (2007), Miranda, Gramani, and Andrade (2012), Martin (2006), Tajnikar and Debevec (2008), and Thanassoulis et al. (2011). Regarding research output, some studies have selected number of journal publications to control for research output. However, the research output of HEIs may include conference papers, book reviews, and patents. Thus, by choosing only one of them, the empirical results may be biased. The choice of research funding, proposed by Robst (2001), and Abbott and Doucouliagos (2003), has been used as a research output. In our study, due to limited data, research output was measured by income from research-related activities, excluding tuition fees and government funding.

The inputs used in this study included the total number of academic staff, the total number of non-academic staff, floor area for academic spaces, and operating costs. While most academics participate in teaching and research activities, non-academics are involved with administering students and other academic stuff, and generally facilitating the teaching and research process. Floor area for academic spaces is one of the mandatory requirements to expand new enrolment quotas as regulated by the government. Operating expenditures were used for annual operations of HEIs.

Along with the key input and output variables discussed above some determinants including age of HEI, location (city or non-city), type of HEI (public or private), and financial capacity (revenues) of HEIs as a proxy for an indirect impact of the tuition policy, Decree 49/2010/ND-CP, were examined to see if they had any impacts on input mix efficiency of HEIs.

5. Empirical findings

In this section, we present the findings of the efficiency decomposition for each year and the whole study period and impacts of determinants on input mix efficiency of HEIs. Two separate models for universities and colleges are illustrated to provide appropriate measures of efficiency relative to their own cohorts.

5.1 Efficiency decomposition of HEIs

5.1.1 University model

Table 1 presents the mean and standard deviations of the indexes of input-orientated measures of technical, scale, and mix efficiencies for the universities for the three years involved. As can be seen, input-orientated measures of technical and scale efficiencies (ITE and ISE) of universities are less than one, indicating that, on average, universities in the sample have used the aggregate inputs more than the minimum aggregate inputs to produce the given output levels. In other words, the universities in our sample were not fully efficient in using input factors to obtain the given output levels. The mean input-orientated mix efficiency (IME) for the universities involved over the three years is 0.829. This shows that universities have not been flexible in mixing and adjusting the various input levels to the volatility in the quantities of outputs. However, ITE and ISE show a decreasing trend in the three years involved, whereas the input mix efficiency of universities only decreases in 2012 and trivially increases in 2013.

Table 1: Input efficiencies of universities for 2011–2013

Year		ITE	ISE	IME
2011	Mean	0.841	0.885	0.841
	Standard deviation	0.183	0.158	0.157
2012	Mean	0.775	0.867	0.823
	Standard deviation	0.200	0.165	0.135
2013	Mean	0.737	0.845	0.824
	Standard deviation	0.207	0.186	0.151
All years	Mean	0.784	0.866	0.829
	Standard deviation	0.201	0.170	0.148

Table 2 demonstrates input efficiencies classified by ownership. It can be observed that all indexes, input-orientated technical, scale, and mix efficiencies are less than one for both public and private universities. It can be seen that public universities have input indexes higher than those of private universities. Except for ITE, input indexes between public and private universities are significantly different from zero at the 1% significance level.

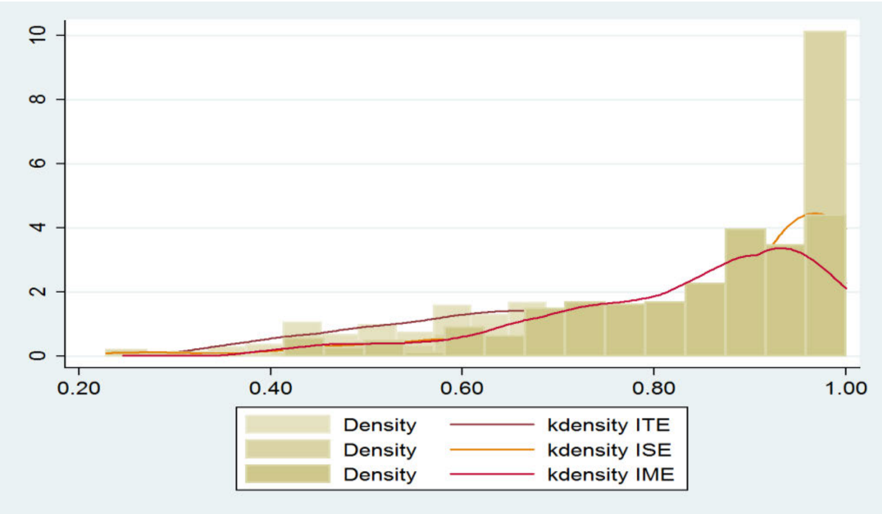
Table 2: Input efficiencies classified by ownership

	Public universities				Private universities				Z-test
	2011	2012	2013	Overall	2011	2012	2013	Overall	
ITE	0.850	0.782	0.727	0.786	0.818	0.756	0.762	0.779	-0.29
ISE	0.907	0.901	0.884	0.897	0.827	0.772	0.739	0.779	-5.3***
IME	0.854	0.861	0.853	0.856	0.807	0.720	0.745	0.757	-5.02***

Note: Z-values obtained from Wilcoxon rank-sum test for equal means between overall scores of public and private universities; *** denotes significance at the 1% level.

Public universities are inclined to be more efficient in saving inputs and using input mix to produce a given output as well as in optimising operational scale in the years involved. Figure 1 illustrates that the empirical densities of ITE, ISE, and IME of universities are left-skewed, moving to unity. The distribution of IME of universities is quite smooth, whereas that of ISE is unimodal at one.

Figure 1: Histogram and kernel densities of input efficiencies of universities



5.1.2 College model

The findings shown in Table 3 indicate that all input efficiency indexes are less than the full frontier efficiency of one, indicating that colleges could potentially further improve their input efficiency. In addition, it can be observed that the average input mix efficiency of colleges is higher than the average input technical and scale efficiencies for the years involved, 0.842 as compared with 0.703 and 0.796, respectively. This implies that colleges are using input mix relatively well to obtain the existing outputs.

Table 3: Input efficiencies of colleges for 2011–2013

Year		ITE	ISE	IME
2011	Mean	0.728	0.804	0.850
	Standard deviation	0.197	0.232	0.128
2012	Mean	0.686	0.790	0.847
	Standard deviation	0.200	0.232	0.125
2013	Mean	0.694	0.793	0.830
	Standard deviation	0.184	0.195	0.124
All years	Mean	0.703	0.796	0.842
	Standard deviation	0.194	0.220	0.126

The results shown in Table 4 indicate that both public and private colleges have not obtained the full frontier efficiency of unity in all indexes, although private colleges are more efficient than public ones in saving inputs to produce the given outputs and tend to obtain the optimal scale (ITE and ISE). This difference is statistically significant at the 1% level. In contrast, public colleges are more dynamic in mixing and adjusting their inputs to produce the existing outputs. The mean input mix efficiency (IME) score of public colleges is 0.847, whereas that of private ones is 0.803. The Wilcoxon test indicates that this difference is statistically significant at the 5% level.

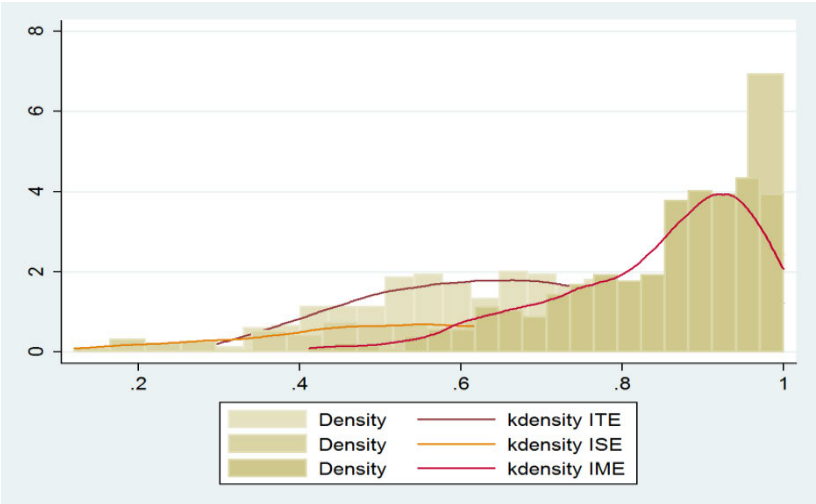
Table 4: Input of efficiencies of colleges classified by ownership

	Public colleges				Private colleges				
	2011	2012	2013	Overall	2011	2012	2013	Overall	Z-test
ITE	0.715	0.674	0.680	0.690	0.828	0.776	0.803	0.802	3.85***
ISE	0.793	0.778	0.790	0.787	0.889	0.886	0.816	0.864	2.59***
IME	0.849	0.854	0.838	0.847	0.852	0.791	0.766	0.803	-1.99**

Note: Z-values obtained from Wilcoxon rank-sum test for equal means between overall scores of public and private HEIs; **, *** denote significance at the 5% and 1% levels, respectively.

Figure 2 demonstrates the distribution densities of the input efficiency components of colleges in which IME is right-skewed towards the value of unity and has higher values than the two other input indexes. In short, these findings provide useful evidence that Vietnamese HEIs in our sample were not fully efficient in mix efficiency of inputs over the period 2011–2013. Although HEIs themselves may be self-motivated to seek better strategies to improve their performance, the government may need to give them some support in terms of a more flexible management mechanism to improve input efficiency.

Figure 2: Histogram and kernel densities of input efficiencies of colleges



5.2. Effects of contextual factors on input mix efficiency

We examined the effects of contextual factors on input mix efficiency (IME) of universities and colleges, respectively, using the fractional regression model. This model allowed us to investigate the impacts of contextual factors on both the frontier efficiency and inefficiency of HEIs if the proportion of the values of unity was sufficiently large. In doing so, we first test the null hypothesis that the standard or one-part fractional regression model is appropriate.

The dependent variable in the fractional models is IME only because of our main interest in input mix efficiency. These models were scrutinized for universities and colleges separately.

5.2.1 University model

In the case of the university model, the null hypothesis that the standard fractional regression was adequate was rejected with *p*-value of 0.0066. Hence, we conducted the two-part fractional regression model on the input mix efficiency scores of universities. The findings of this model and the average marginal effects of explanatory variables are presented in Tables 5 and 6.

It can be seen from Table 5 that the estimated parameters of the fractional component model are significant at the 1% level, whereas those of the binary component model are not statistically significant. This implies that the effects of contextual factors should be explained by the factional component of the two-part model.

Table 5: Two-part fractional regression results on input mix efficiency of universities

Variables	Binary component of two-part model				Fractional component of two-part model			
	Coefficient	EIM Std error	z	*p*>|z|	Coefficient	Robust Std. error	z	*p*>|z|
Location	0.62	0.41	1.50	0.13	-0.29	0.12	-2.50	0.013
Type	0.65	0.48	1.37	0.17	0.58	0.10	5.61	0.000
Ln(Age)	-0.05	0.33	-0.14	0.89	0.232	0.095	2.44	0.015
Ln(financial capacity)	0.08	0.19	0.43	0.67	-0.192	0.064	-3.01	0.003
Constant	-3.21	0.92	-3.5	0.00	1.42	0.26	5.50	0.000

The average marginal effects shown in Table 6 demonstrate influential levels of contextual factors on input mix efficiency of universities. Expectedly, location, type, age, and financial capacity affected positively and significantly input mix efficiency of universities. The coefficient of type indicates that public universities are more efficient in using input mix to produce a diversity of outputs. This is an expected result because, thanks to substantial government support, the majority of public universities are likely to have sufficient financial and human resources to respond to changes of environments to improve their performance.

The location variable has different impacts on HEI efficiency and inefficiency in terms of the binary and fractional components of the two-part model. However, on average, it has a positive effect on input mix efficiency of HEIs. This suggests that HEIs which are located in main cities have more opportunities to use input mix of capital and labour in the years involved. This result was predictable since HEIs located in metropolitan areas can find it easier to alter input resources to meet demands of learners and employers, for example, recruiting highly-qualified teaching staff with higher salaries or investing in modern learning facilities.

Similar to the parameters of age and financial capacity, although their average marginal effects have positive signs, these values are small. This means that an increase in age or revenue contributes trivially to an increase in input mix efficiency of universities, in general. In the Vietnamese context, the financial capacity of HEIs is the main concern of policymakers as it is expected to significantly impact on education quality and student attainment (Chau and Tran, 2015; Trinh, 2012). Our result indeed reflects that the financial capacity of HEIs in the sample involved positively affect the capacity of using flexibly input resources of HEIs in response to the demands of the educational market. However, these positive influences can be varied greatly depending on the proportion of inefficient HEIs in the sample. Thus, a larger sample size of universities is desirable to confirm the influences of these variables.

Table 6: Average marginal effects of contextual factors on input mix efficiency of universities

Variables	E(dy/dx)
Location	0.044
Type	0.062
Ln(Age)	0.00028
Ln(financial capacity)	0.0033

5.2.2 College model

In the case of colleges, the null hypothesis that the standard fractional regression model is appropriate could not be rejected with a *p*-value of 0.25. Hence, the standard fractional regression model was used to examine the impacts of contextual factors on input mix efficiency of colleges. The findings in Tables 7 and 8 indicate that the age variable has significantly positive effects on input mix efficiency of colleges. This suggests that older colleges may have more managerial experience to improve input mix efficiency. In addition, the financial capacity contributes positively to input mix efficiency at the 5% significance level. Similar to the university case, the better financial capacity can help to improve input mix efficiencies of colleges because they can easily use financial resources to adjust input resources in response to changes in the legal environment and demands of the educational markets. On the other hand, location and type are not significantly related to input mix efficiency of colleges.

Table 7: Standard fractional regression results on input mix efficiency of colleges

Variables	Coefficient	Robust Std. error	z	P>|z|	[95% Conf. Interval]	
Location	0.03	0.12	0.23	0.820	-0.21	0.27
Type	0.15	0.16	0.98	0.328	-0.15	0.46
Ln(Age)	0.260	0.097	2.68	0.007	0.07	0.45
Ln(financial capacity)	0.180	0.080	2.25	0.024	0.02	0.34
Constant	0.41	0.27	1.49	0.137	-0.13	0.95

Table 8: Average marginal effects of contextual factors on input mix efficiency of colleges

Variables	E(dy/dx)	Standard error	z	P>|z|	[95% Conf. Interval]	
Location	0.0037	0.0160	0.23	0.819	-0.028	0.035
Type	0.0201	0.0205	0.98	0.327	-0.020	0.060
Ln(Age)	0.0344	0.0129	2.67	0.008	0.009	0.060
Ln(financial capacity)	0.0238	0.0106	2.25	0.024	0.003	0.044

These results reflect the fact that besides inherent sources causing mix input inefficiency, as discussed before, contextual factors are likely to significantly influence input mix efficiency of HEIs. These findings indicate that although some contextual factors could contribute positively to input mix efficiency of HEIs in the reported periods, operating under the rigid governance system and inadequate legal policies, HEIs still found it difficult to respond to changes in external environments and adopt to new teaching technology, and thus could not fully reach technical and input mix efficiencies as expected.

6. Discussion and Conclusions

This paper provides useful information about the input mix inefficiency of Vietnamese HEIs over the three years, 2011–2013. The fractional regression model in the second stage was used to filter out the impacts of contextual factors on input mix efficiency measurement. Input mix inefficiency which is referred to as productivity shortfall, was recorded in the performance of Vietnamese HEIs in the years involved. In the context of an intricate governance system and volatile legal policies, measuring the performance of Vietnamese HEIs should focus on the nature of the inefficiency, particularly input mix inefficiency, besides technical inefficiency or scale inefficiency. This is useful in providing better understanding about the performance of HEIs in response to changes in education circumstances, and, thus, to design more appropriate policies for improving the performance of HEIs.

Our paper uses the advanced DEA method to compute the Färe-Primont productivity index and decomposes this index into efficiency components of technical, scale, and mix efficiency for an input orientation, and proposes the second-stage fractional regression analysis to examine the effects of contextual factors on input mix efficiency of HEIs. For the university model, the empirical findings reveal that the input technical (0.784), scale (0.866), and mix efficiencies (0.842) are less than one. This implies that universities could potentially improve their efficiencies by better use of available input resources, by diversifying inputs and by increasing the scale efficiency if they can operate at the optimal size. Moreover, public universities are more efficient than their private counterparts in efficiently using input mix, although they have not obtained the technical efficiency of one. The results from the fractional regression analysis indicate that the position of a university far away from the frontier is not entirely a result of managerial inefficiency. Instead, some contextual variables including location, ownership, age, and financial capacity are factors affecting the usage of input mix of universities

For the college model, the input technical, scale, and mix efficiency scores of 0.703, 0.796, and 0.842, respectively, indicate that colleges need to further improve their performance in using their input resources to maintain the existing outputs. In the years involved, the colleges involved had better success in mixing their inputs than in saving inputs or maximising their optimal size of operations. The input mix efficiency index is higher for public colleges than for private ones at the 1% significance level. Similar to the university case, public colleges find it easier to select the appropriate mix of available inputs than their private counterparts. The input mix efficiency scores of colleges associated with the standard fractional regression model were used in the second stage to estimate influences of contextual factors. The findings reveal that financial capacity and age play crucial roles in input mix efficiency of colleges, whereas location and ownership are not statistically significant.

From the above results, it can be seen that HEIs in Viet Nam were not only not fully technical and scale efficient but were input mix inefficient as well in the years involved. Hence, the implication for policymakers and educational managers is that they need to be wary of making attempts to reduce technical inefficiency by saving inputs or scale inefficiency by optimising operational scale, and also need to heed the presence of input mix inefficiency. Two solutions are likely to yield benefits for HEIs: allowing them to be more flexible to deal with changes in educational environments, and making greater interdisciplinary efforts to remove “rigidity” from the existing teaching technology. The former is much related to the complicated governance system that has confined HEIs to an inadequate legal framework. While HEIs tried to understand and cope with the intricateness of current policies, they seemed not to respond to the changes in the external educational environment. As a consequence, productivity shortfalls and stagnant education quality were inevitable. If the government policy can provide real autonomy to HEIs, for example, by removing restrictions on revenues and on enrolments, this would give HEIs stronger incentive to improve input mix efficiency. An improvement in education quality refers to management practice skills that may be demanding for institutional managers to adopt the advanced teaching technology and reduce overspecialisation to explore potentials of their input resources to improve their performance.

Our paper has made empirically important empirical contributions to the literature. (a) It provides useful findings about the input mix efficiency of Vietnamese higher education that has not been presented before in the higher education efficiency literature. More importantly, besides technical and scale inefficiencies, the nature of the inefficiency in the higher education sector, specifically input mix inefficiency, needs attention. This reflects the flexibility of HEIs to cope with changes in education circumstances. (b) It allows us to use fractional regression model with DEA approach examine the effects of contextual factors on the performance of individual HEIs.

However, some cautionary comments on our analysis should be addressed. First, because the influences of contextual variables on input mix efficiency of both efficient and inefficient HEIs are varied in the fractional regression model, a larger sample size should be used to confirm these effects. Second, more inputs and outputs should be added to our models; for example, the quality of students, the proportion of employment after graduation, their average salary paid by employer, or the annual number of publications. Future studies are encouraged to consider these possibilities to enrich our findings. Finally, the direct impacts of the policies on input mix efficiency of HEIs have not been tested in our study because this would require a richer dataset to capture longitudinal changes in input mix efficiency of HEIs before and after a policy is imposed. In the current context of Viet Nam, many policies are issued and then varied quickly to meet the current demands. Hence, it would not be easy to capture the influences of a unique policy in an unstable scenario. However, research on this issue is promising and recommended for further studies.

Chapter 7: Technological heterogeneity and efficiencies of Vietnamese higher education institutions: A metafrontier directional distance function approach

Abstract

Using the metafrontier directional distance function approach, we estimate both the group frontier and metafrontier efficiencies for 112 universities and 141 colleges in Viet Nam for 2011–2013 and compute their metatechnology ratios under the unrestricted technology. Our findings indicate that the mean individual and metafrontier efficiencies of universities are 0.837 and 0.773, whereas those of colleges are 0.774 and 0.732, respectively. The metatechnology ratios suggest that using the combined teaching technology instead of their own teaching technologies, universities and colleges could potentially increase their performance by 7.8 and 5.0 per cent, respectively, to obtain the full technical efficiency. This implies that universities and colleges are operating comparatively well under their individual teaching technology according to the metafrontier framework. Our results highlight the need for more appropriate government policies that will assist universities and colleges to explore their full potential to enhance the performance.

Key words: Data envelopment analysis, directional distance, higher education institutions, metatechnology ratio, metafrontier, technological heterogeneity.

1. Introduction

Research on efficiency of higher education has been increasingly acknowledged in the literature because of its importance in socio-economic development. Performance of the higher education sector is a crucial indicator for enhancing the competitive ability of a nation (Schwab, 2013). For a developing country such as Viet Nam, enhancing efficiency of the higher education sector is very important to improve the competitive capacity of the nation, in general, and rankings of its higher education institutions (HEIs), in particular.

The Vietnamese higher education system currently includes universities and colleges. Although universities and colleges are categorised as HEIs following the 2012 *Law of Higher Education*, they are operating under relatively different environments. Specifically, undergraduates at universities are trained for a period of four years (bachelor degree), whereas those in colleges are trained for only three years (associate bachelor degree). Only universities offer postgraduate programs. In addition, research outputs of universities focus on academic research but those of colleges are primarily related to projects of technological transfer and consultancy services. Moreover, colleges are inclined to train students with more practical skills, whereas universities teach students research skills. College students who want to get a degree need to study for a further one to one and a half years to fill a gap in curricula between universities and colleges. From these differences, the teaching technologies of universities and colleges are clearly distinct in their nature, and, thus, the performance of universities and colleges should be evaluated and compared within their own cohorts.

According to the Ministry of Education and Training (MOET), Viet Nam has a total of 421HEIs, of which 83 are private including 54 private universities and 29 private colleges (MOET, 2013). Among 338 public HEIs, there are 153 public universities. Recently, more colleges have applied for an upgrade to university status because this was believed to be more advantageous for them in increasing the number of new enrolments and developing new specialisations to meet the demands of learners. However, policymakers argued that both universities and colleges play crucial roles in the national education system to provide knowledge for learners and meet the requirements of socio-economic development (Hoang, 2013b; Pham, 2013). The main aim of the government is to have an efficient higher education system, in which universities and colleges can deliver their respective programs in their own respective teaching environments. In the current context, the sector may have some challenges in achieving their full potential as a result of some constraints imposed by restrictions on resources, regulations, and contextual factors. Understanding the technological heterogeneity and the operational efficiencies of HEIs and identifying potential bottlenecks would be helpful to orient education policies in the right direction and, thus, allow the policymakers to act on the specific needs required to improve the performance of HEIs.

In this paper, we aim to investigate the gap in teaching technology and in the efficiencies of universities and colleges over the period 2011–2013. This gap is not only due to the nature of universities and colleges themselves but the policy environment as well. In many cases, the government has issued separate regulations for universities and colleges. Any regulation that was issued for both would have different indicators required for universities and colleges. Given the mandate provided to each of these sectors, it is imperative to examine the efficiencies of universities and colleges with respect to their own teaching technologies and that of the whole industry. In doing so, we integrate the data envelopment analysis (DEA) metafrontier framework into the directional distance function in a conventional efficiency analysis to develop a methodological approach for assessing differences in teaching technology and efficiencies between the two groups, namely universities and colleges. The directional distance approach is more flexible than traditional input or output distance function because it allows one to seek for simultaneously expanding outputs and contracting input resources. Integrating the directional distance function (Chambers, Chung and Färe, 1998) into DEA metafrontier framework (O'Donnell, Rao, and Battese, 2008), the operational efficiencies of universities and colleges are estimated in terms of their respective frontier and metafrontier teaching technology. The metatechnology ratio is referred to as a distance in the efficiencies between their own frontier and metafrontier teaching technology. This ratio allows assessment of how well universities and colleges operate using their respective teaching technology under a general scenario represented by the metafrontier.

Our paper is the first to apply the metafrontier directional distance function approach to the higher education sector to better understand how well different groups, universities and colleges, operate under the unrestricted teaching technology represented by the metafrontier. In addition, we also calculate the capacity utilisation of floor area for academic spaces as a surrogate of the quasi-fixed inputs that cannot be easily adjusted in a short time to obtain full technical efficiency. The structure of this paper is organised as follows. Section 2 briefly presents a review on the use of the directional distance function and the metafrontier framework in recent years. Section 3 introduces the methodology developed in this paper including the directional distance function approach in a metafrontier framework and measuring the capacity utilisation of the quasi-fixed inputs. This is followed in Section 4 with its application in Vietnamese higher education including discussion of the dataset, the variables, and the empirical results. Section 5 includes implications and conclusions of our empirical findings.

2. Review of studies on directional distance functions and the metafrontier approach

Measuring efficiency of the higher education sector has recently attracted much attention of researchers. Given that the higher education sector not only uses multiple inputs to produce a diversity of outputs, but it also has differences in production technology, undertaking empirical analyses of efficiency and productivity is often difficult and complicated (Carrington, Coelli and Rao, 2005; Emrouznejad and Thanassoulis, 2005). The recent empirical studies using DEA to assess efficiencies of HEIs have mostly assumed that all decision making units (DMUs) share the same technology. However, this supposition may be inappropriate when different groups of HEIs face heterogeneous technological limitations (Beltrán-Esteve et al., 2014; Chiu et al., 2013). Efficiency under technological heterogeneity has been studied in the higher education sector by assessing heterogeneous technological frontiers for different groups of HEIs. Nevertheless, with this method the efficiency scores cannot be directly comparable across groups because they are calculated against different technological frontiers. The metafrontier approach considers an unconstrained technology being available to all groups, which overcomes this problem and allows the assessment of technological differences across groups of HEIs regarding their operational efficiency.

Recently, the metafrontier framework and the directional distance function approach have been used to analyse productivity differences. The directional distance functions, developed by Chambers, Chung, and Färe (1998) provides an additive measure of technical efficiency that allows one to seek to simultaneously expand output quantities and reduce input quantities. The Shephard distance function is a special case of the directional distance function (Cross et al., 2013). Many studies have used the directional distance function to estimate the technical and environmental efficiencies of polluting firms including Färe et al. (2005), Kumar and Managi (2009), Marklund and Samakovlis, (2007), Serra, Lansink, and Stefanou (2010), and Yang and Pollitt (2010). The metaproduction function was originally proposed by Hayami (1969) and Hayami and Ruttan (1970) to illustrate the relationship between inputs and outputs of agricultural production units. Battese and Rao (2002) and Battese, Rao, and O'Donnell (2004) introduced it the estimation of a stochastic frontier framework. O'Donnell, Rao, and Battese (2008) proposed the metafrontier framework using DEA as an alternative to stochastic frontier analysis for estimating group frontiers and metatechnology ratios. This approach has been increasingly applied in analysing efficiency in different sectors such as hospitality, industry, and environment (Beltrán-Esteve et al., 2014; Chiu et al., 2013; Hsiao, Chern, and Yu, 2012; Yu and Choi, 2014).

Integrating the directional distance function with the metafrontier framework has been implemented in recent studies to measure technological differences in the efficiencies of different groups. Hsiao, Chen, and Yu (2012) used the DEA directional distance function and a metafrontier approach to evaluate the efficiency of integrated circuit design firms with differences between technology groups. They adopted the theory of Chung, Färe, and Grosskopf (1997) and Färe and Grosskopf (2004) for the directional distance function and calculated the technological gap by the difference between the group frontier and the whole sample, which was different from the method of O'Donnell, Rao, and Battese (2008). Lin, Chen, and Chen (2013) estimated and analysed the differences in environmental efficiencies across country groups for four income levels using the directional output distance function and the metafrontier approach (Battese, Rao, and O'Donnell, 2004) to provide a measure of environmental efficiency.

Similarly, Chiu et al. (2013) used the DEA directional metafrontier distance function to evaluate the impacts of quasi-fixed inputs on hospitality. They used the network DEA in two stages where the immediate output in the first stage became an input in the second stage. In their model, quasi-fixed inputs and intermediate outputs were not adjusted, whereas other inputs and final outputs were adjusted using a directional vector of variables. The technological gap was estimated by the difference between the directional distance function of the group frontiers and that of the whole sample. Beltrán-Esteve et al. (2014) used the DEA directional distance function and the metafrontier approach to assess technological heterogeneity in eco-efficiency between groups of producers. They adopted the directional distance functions proposed by Chambers, Chung, and Färe (1998) and the metafrontier approach suggested by O'Donnell, Rao, and Battese (2008). They proposed seven different models with pressure reduction objectives on natural resources such as land erosion, carbon dioxide emissions, agricultural practices, and pesticide risk and one model for an increase in total value added but maintaining environmental pressures.

Most recently, Munisamy and Arabi (2015) used a slacks-based DEA measure to compute the metafrontier Malmquist-Luenberger productivity index for 48 Iranian thermal power plants during the period 2003–2010.Three different technologies—steam, gas and combined cycle—are assessed over an eight-year period of restructuring the power industry. The results showed that the last years of the restructuring period witnessed a greater rate of productivity growth compared to the initial years, and that there was evidence of significant eco-efficiency improvement over the period in all the three types of the thermal power plants. These findings provided useful information for policymakers and power-industry regulators in developing sustainable policies towards environmental protection and planning power plant operations. However, due to the small sample size of the three types of power plants, 18, 17 and 10 for steam, gas and combine cycle, respectively, therefore the efficiency discrimination of the DEA model is not as strong as expected.

In the context of higher education, to our knowledge, no studies have applied the directional distance function under the metafrontier framework to estimate the efficiencies of HEIs in terms of different sub-technology groups. More importantly, the capacity utilisation of some quasi-fixed inputs that are employed in the production process of higher education has not been examined in recent studies. Managers of HEIs often deal with some inputs, such as floor area for academic spaces, the numbers of classrooms, laboratories and workshops, which they cannot increase or decrease in a short period. In reality, managers of HEIs find it difficult to reduce these inputs if they are exogenously fixed (Banker and Morey, 1986; Coelli et al., 2005). In some cases, HEIs used too many of these quasi-fixed inputs; however, contraction or expansion of these inputs is not easily implemented in the short run. Färe and Grosskopf (2000b) developed a new measure to calculate the capacity utilisation of these inputs based on the DEA directional distance function. This allows one to estimate the capacity utilisation of quasi-fixed inputs in practice.

3. Methodology

We employ the directional distance function and metafrontier approach in an integrated framework. The directional distance function can be estimated in at least two ways, DEA and stochastic frontier analysis. In this study, the DEA approach is adopted to estimate technical efficiencies of DMUs under the group frontiers and the metafrontier using the directional distance function for the following reasons. First, in the current context of Vietnamese higher education, the information about input prices of HEIs have not often been sufficiently recorded and made publicly available.

Second, the Vietnamese higher education system is still in the restructuring process with many new policies and regulations that are promulgated simultaneously and then varied quickly, and this may affect the performance of HEIs in different ways. Finally, no implicit assumption regarding the functional relationship between the multiple inputs and outputs is made.

In this section, we outline the methodological approach by integrating the directional distance function into the DEA metafrontier framework to measure teaching technology gaps between the different groups of HEIs, and using the DEA directional distance function to measure the capacity utilisation of floor area for academic spaces as a surrogate of quasi-fixed inputs for these groups.

3.1 The DEA metafrontier directional distance function and metatechnology ratios

Let $x \in \Re_+^N$ and $y \in \Re_+^M$ denote the vectors of N inputs and M outputs, respectively. Assume that there are $K(> 1)$ clusters of HEIs, each operating under different group-specific technologies and using N inputs to produce M outputs. The metafrontier is identified as the common frontier that envelops the group frontiers of all HEI groups. As indicated in O'Donnell, Rao, and Battese (2008), the overarching metatechnology set contains all input and output combinations that are technologically feasible and can be defined as:

$$T = \left\{ \begin{array}{c} (x, y): x \geq 0 \in L^k(y); y \geq 0 \in P^k(x); \\ x \ can\ produce\ y\ in\ at\ least\ one\ group\ technology\ set\ T^k, k = 1, \ldots, K \end{array} \right\} \tag{1}$$

where $L(y)$ and $P(x)$ are the desirable feasible input and output sets associated with the metafrontier technology set T. The input set $L(y)$ and output set $P(x)$ can be identified by using the directional distance function that simultaneously seeks to expand outputs and contract inputs. The boundary of this set is referred to as the directional metadistance function. Following Chambers, Chung, and Färe (1998), let $g = (g_x, g_y) \in T$, where $g_x \in \Re_+^N$ and $g_y \in \Re_+^M$, the directional technology distance function defined on the technology T is introduced as:

$$\vec{D}_T(x, y; g_x, g_y) = sup\{\beta: (x - \beta g_x, y + \beta g_y \in T\} \tag{2}$$

This projects the input-output vector $(x, y) \in \Re^{N+M}$ onto the technology frontier in the $g = (-g_x, g_y)$ direction, where $(g_x, g_y) \in \Re_+^{N+M}$. Chambers, Chung, and Färe (1998) indicated that, in a few special cases of $\vec{D}_T(x, y; g_x, g_y)$ that are of interest, the directional technology distance function collapses to the input or output distance functions.

For the choice of a direction, Färe et al. (2008,) suggested the range of different choices for the direction vectors. For this study, the directional vector of $(g_x, g_y) = (x, y)$ was chosen because first, HEIs are assumed to manage to simultaneously expand outputs and save inputs to obtain the frontier efficiency even though output expansion has to be in the confines of meeting the government's requirements. Second, the operating scope and scale of HEIs are relatively different, thus, they have different ways to expand outputs and contract inputs. Accordingly, choosing the direction vector of x and y is feasible. It can be seen that using the direction vector of (x, y) allows two targets to be obtained: reflecting the real nature of academic operations of HEIs, and demonstrating the spirit of the Farrell measures and the Shephard distance functions (Färe and Grosskopf, 2000b).

We suppose that HEIs are separated into $K(> 1)$ groups because of the presence of sub-technology sets that characterise production possibilities of HEI clusters. Restricted by resources, regulation or other external influences, HEIs in specific groups may be prohibited from selecting from the complete range of technologically feasible input-output coordination in the metatechnology framework. Hence, the combinations of inputs and outputs available to HEIs in the k^{th} group are defined as follows:

$$T^k = \left\{ \begin{matrix} (x, y): x \geq 0 \in L^k(y); y \geq 0 \in P^k(x); \\ x \text{ can be used by HEIs in group } k \text{ to produce } y \end{matrix} \right\} \tag{3}$$

where $L^k(y)$ is the feasible input set for the output set $P^k(x)$ associated with the k^{th} group's technology set. The K group-specific technologies can be represented by the following directional distance function:

$$\vec{D}^k(x, y; -g_x, g_y,) = sup\{\beta \in \Re: (x - \beta g_x, y + \beta g_y) \in T^k\} \tag{4}$$

The boundaries of the group-specific technology sets are referred to as the group frontiers.

Under the DEA approach, the piecewise reference directional metadistance technology of T with variable returns to scale (VRS) is estimated by:

$$\vec{D}(x, y; g_x, g_y) = max_{\beta,\lambda}\, \beta \tag{5}$$

subject to

$$\sum_{i=1}^{n} \lambda_i y_i \geq y + \beta g_y$$

$$\sum_{i=1}^{n} \lambda_i x_i \geq x - \beta g_x$$

$$\lambda_i \geq 0, \quad i = 1, \ldots n$$

where β is a scalar and λ_i is the intensity variable to contract or expand the observed operations of HEI i $(i = 1, \ldots, N)$ for the purpose of constructing convex combinations of the observed inputs (x_i) and outputs (y_i).

For the group-k frontier, the DEA VRS directional distance technology is defined as:

$$\vec{D}^k\left(x, y; g_x, g_y\right) = max_{\beta,\lambda}\, \beta \tag{6}$$

subject to

$$\sum_{i=1}^{n} \lambda_{ik} y_{ik} \geq y + \beta g_y$$

$$\sum_{i=1}^{n} \lambda_{ik} x_{ik} \geq x - \beta g_x$$

$$\lambda_{ik} \geq 0, \quad i = 1, \ldots n; \quad k = 1, \ldots, K,$$

where k is the number of HEI groups.

It is observed that the directional metadistance function in (5) and (6) is always equal or greater than zero (Chambers, Chung, and Färe, 1996, 1998; Beltrán-Esteve et al., 2014). That means that a score of zero denotes full efficiency, otherwise there is the presence of inefficiency. The greater the metadistance function, the lower the technical efficiency. It is noted that the Farrell efficiency is calculated from (5) and (6) by the formula:

$$TE_{Farrell} = 1 - \vec{D}\left(x, y; g_x, g_y\right) \tag{7}$$

Following the standard regularity properties as identified in O'Donnell, Rao, and Battese (2008, p. 235), the DEA directional metatechnology ratio for the k^{th} group of HEIs is defined as:

$$MTR^k = \frac{1 - \vec{D}\left(x, y; g_x, g_y\right)}{1 - \vec{D}^k\left(x, y; g_x, g_y\right)} \tag{8}$$

where MTR^k is interpreted as the Farrell efficiency score that is bounded by zero and one. With $MTR^k = 1$, HEIs have fully technical efficiency, otherwise they have some inefficiency.

3.2 Capacity utilisation of quasi-fixed inputs

Färe and Grosskopf (2000b) proposed the method of measuring the capacity utilisation of non-discretionary inputs using a direction distance function and DEA techniques. In this research, we adopt this approach to compute the capacity utilisation of floor area for academic spaces that is considered as a quasi-fixed input, not easily contracted or expanded in a short time.

Following Färe and Grosskopf (2000b), the input vector is partitioned into two sub-vectors $x = (x_{v,} x_f)$ where x_v is the sub-vector of variable factors and x_f is the sub-vector of quasi-fixed factors, for example, floor area for academic spaces including classrooms, libraries, workshops, laboratories, and dormitories for students.

Assuming that the variable inputs are unrestricted and the fixed inputs may be employed too much and need to be contracted, the directional distance function is defined as in equation (2) above. In terms of variable inputs x_v and fixed inputs x_f, we define the directional distance function when the variable inputs are unconstrained as follows:

$$\widehat{D}_T\left(x_f, y; -g_{x_f}\right) = sup\left\{\beta : \left(x_f - \beta g_{x_f}, x_v, y\right) \in T, x_v \geq 0\right\} \tag{9}$$

Thus, the capacity utilisation measure is defined as:

$$CU = \frac{\vec{D}_T(x, y; -g_x, g_y) + 1}{\widehat{D}_T\left(x_f, y; -g_{x_f}, g_y\right) + 1} \tag{10}$$

Equation (10) is extended further from the Färe and Grosskopf (2000) method to calculate the capacity utilisation under Farrell efficiencies, where the efficiencies are estimated using the DEA approach as defined by equations (5) and (6).

It is generally argued that DEA results can be sensitive to outliers. Hence, we endeavoured to identify the outliers, if any, before implementing the efficiency analysis of HEIs. Following the procedure of identifying outliers used by Thanassoulis (1999) and the concept of super-efficiency introduced by Andersen and Petersen (1993), we identified institution outliers in our sample. As suggested by Thanassoulis (1999), a threshold difference of super-efficiency of 10 percentage points can be applied to identify outliers. Accordingly, a subset of HEIs that had super-efficiency over 100 per cent and were separated from other inefficient colleges by a gap of 10 percentage points were identified as outliers. After the outliers were identified, they were removed. Then, the super-efficiency measure was implemented again on the new subset of data to detect whether outliers existed in our sample. This process was repeated until there was no gap of 10 percentage points in super-efficiency in our sample. This means no HEI in the final dataset lay more than 10 percentage points in efficiency further away than any other units. Consequently, 16 university outliers and 9 college outliers were identified. Following the suggestions of Thanassoulis et al. (2011), after the outliers were identified, we did not allow them to affect the position of the efficiency boundary but held them with their data adjusted to sit on the boundary drawn on non-outlier HEIs.

4. Application to Vietnamese higher education institutions

The approaches outlined above are applied to a sample of 253 Vietnamese HEIs comprising 112 universities and 141 colleges in a balanced panel. Data were obtained from MOET over the period 2011–2013. The sampled HEIs were the ones that complied with the government regulations to submit their annual reports to MOET for all three years. The number of HEIs in our sample represents 60 per cent of the total number of institutions currently in Viet Nam. Although a longer span of data would have been desirable, our available dataset for the three years is expected to provide useful information about the technological differences and efficiencies of the two groups of institutions, universities and colleges, in Viet Nam.

4.1 Input and output variables

The inputs used in this study included the total number of academic staff, the total number of non-academic staff, floor area for academic spaces, and operating costs of the institutions. Most academics participate in teaching and research activities, whereas non-academics are involved with administering students and other academic staff, generally facilitating the teaching and research processes. Floor area for academic spaces is one of the important reporting requirements for HEIs to obtain annual enrolment quotas as regulated by the government. Operating expenditures are used for annual operations of HEIs including teaching staff wages, student allowances, learning facilities purchases, and other related academic costs.

We use three outputs for both universities and colleges: number of graduates, number of students enrolled, and research income. The number of graduates refers to students who leave with completed degrees at the end of each year. Students enrolled refer to the number of students enrolled in a given year. Under the production function, they are considered as input resource users of HEIs embodied in the process of teaching and research. Sullivan et al. (2012) asserted that enrolments and completions have been shown to be important in labour market studies and thus only using one of them can miss a critical output dimension. Such outputs have been used in recent studies, such as those of Abbott and Doucouliagos (2003; 2009), Castano and Cabanda (2007a; 2007b), Guzman and Cabanda (2009), Daghbashyan (2011), de Franca et al. (2010), Fernando and Cabanda (2007), Miranda, Gramani, and Andrade (2012), Martin (2006), Tajnikar and Debevec

(2008) and Thanassoulis et al. (2011). It is noted that in the universities' case, numbers of postgraduates are converted to numbers of undergraduates by a coefficient regulated by the government.[7] Doing this allowed us to obtain consistency in the number of outputs of universities and colleges when placing them all in a common context. Regarding research output, some studies have selected the number of journal publications to control for research outputs. However, the research output of HEIs may include conference papers, book reviews and patents. Research funding proposed by Robst (2001) and Abbott and Doucouliagos (2003) has been used as a research output. In our study, due to limited data, research output is measured by incomes from research-related activities, excluding tuition fees and government funding.

The summary statistics of inputs and outputs is presented in Table 1.

Table 1: Summary statistics on input and output variables

	Unit	Mean	Standard deviation	Max	Min
Universities					
Inputs					
Floor area	1,000 m^2	28	32	326	1.59
Academic staff	Person	375	307	2,123	44
Non-academic staff	Person	154	125	718	35
Operating cost	Billion VND	80	79	528.98	0.31
Outputs					
Total students enrolled	Person	9,842	9,622	46,264	65
Graduates	Person	2,010	2,152	18,126	0
Research income	Billion VND	16	36	344.54	0
Colleges					
Inputs					
Floor area	1,000 m^2	13.3	9.2	89.312	0.981
Academic staff	Person	129	70	494	30
Non-academic staff	Person	54	21	167	17
Operating cost	Billion VND	18	14	125.14	0.69
Outputs					
Total students enrolled	Person	2113	1553	7872	67
Graduates	Person	554	448	2220	0
Research income	Billion VND	3.6	9.9	144.76	0

4.2 Efficiencies of HEIs relative to group frontiers and the metafrontier

This section presents separately the empirical results of technical efficiencies of the two groups of HEIs, universities and colleges, with respect to specific-group technology and metatechnology for

[7] Document 1325/2007/BGDDT-KHTC was issued by MOET on instructions on identifying the imputed coefficients for students and teachers in higher education.

each HEI in the sample. The metafrontier technology ratios provide more insights on the production capacity of HEIs when placing them in the unrestricted technology. In addition, the capacity utilisation of floor area for academic spaces as a surrogate of the quasi-fixed inputs is also computed to provide more information for HEIs to develop better strategies to efficiently use this input. It noted that the efficiency scores obtained from the directional distance function measures have been transferred to Farrell efficiency measures for ease of interpretation and computing the metatechnology ratios.

4.2.1 Universities model

Table 2 presents efficiency scores of universities in terms of group frontiers and the metafrontier, together with the metatechnology ratios for the three years considered.

Table 2: Technical efficiencies and metatechnology ratio of universities

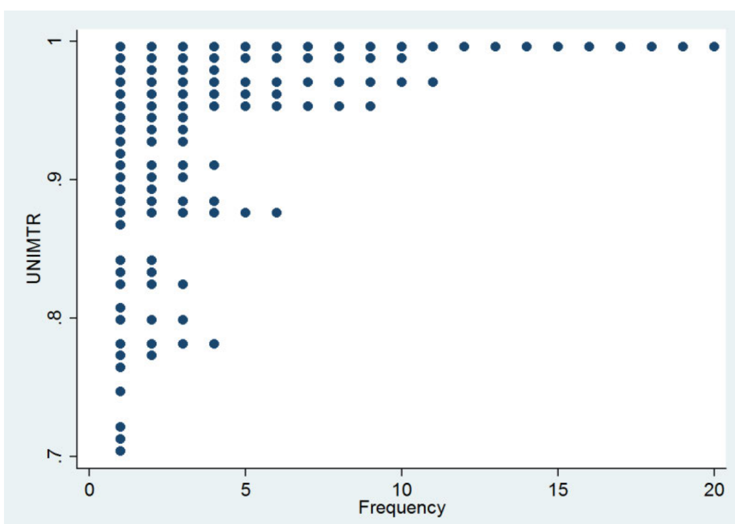
Year	2011	2012	2013	Overall
Technical efficiencies in terms of group frontiers				
Mean	0.867	0.816	0.827	0.837
Standard deviation	0.143	0.153	0.137	0.124
Min	0.424	0.362	0.376	0.387
Max	1	1	1	1
Efficient universities	36	19	17	5
Hotelling's test [a] (F value)				13.35***
Technical efficiencies in terms of the metafrontier				
Mean	0.813	0.745	0.761	0.773
Standard deviation	0.163	0.166	0.149	0.136
Min	0.350	0.257	0.304	0.303
Max	1	1	1	1
Efficient universities	21	13	11	3
Hotelling's test (F value)				18.95***
Metatechnology ratios				
Mean	0.935	0.912	0.920	0.922
Standard deviation	0.084	0.096	0.086	0.078
Min	0.637	0.651	0.624	0.700
Max	1	1	1	1
Efficient universities	31	22	15	8
Hotelling's test (F value)				5.46***

Note: [a] Hotelling's statistic tests for equal means among the three years;
*** denotes significance at the 1% level.

It can be observed that, when compared with the best-practice HEIs within their own group, universities could potentially improve their efficiencies, on average, by 16.3 per cent. Hotelling's test indicates that variations in efficiencies of each group over the three years are statistically significant at the one per cent significance level. The number of efficient universities varies across the three years. On average, the university group has five efficient HEIs. Under the unrestricted metatechnology, the mean technical efficiencies of the universities decreases from 0.813 in 2011 to 0.745 in 2012, and then slightly increases in 2013 to 0.761 and obtain a mean of 0.773 over the three years. The numbers of efficient universities relative to the metafrontier decreased sharply relative to their group frontiers. Only three universities were operating efficiently at the metafrontier over the three years.

The average DEA metatechnology ratio for universities model in Table 2 is about 0.922. This means that the universities could potentially increase their efficiency by about 7.8 per cent with the teaching technology available to them to obtain the full efficiency of one under the unrestricted teaching technology. There are eight universities with metatechnology ratios of one. These universities efficiently used the input-output combinations that placed them at the point of tangency between their group frontiers and the metafrontier technology. Figure 1 demonstrates the distribution plots of metatechnology ratios of universities across the three years. These distributions are quite dense towards to the value of one.

Figure 1: Distribution plots of metatechnology ratios of universities



In Table 3, the technical efficiencies and metatechnology ratios of universities classified by their ownership are presented. In the Vietnamese higher education system, HEIs are categorised as private and public depending on terms of their operating environments. Therefore, it is worth examining the technical efficiencies and metatechnology ratios of these two ownerships relative to the same production technology. Public universities appear to be more efficient than their private counterparts in terms of their group frontiers and the metafrontier. However, this difference is not statistically significant using the Kruskal-Wallis test.

However, the metatechnology ratios reveal that public universities tend to be more efficient than private ones in using the inputs to produce the outputs under the metatechnology. For example, the average metatechnological ratios of 0.925 and 0.914 for public and private universities, respectively, suggest that public universities could potentially increase their efficiencies by about 7.5 per cent using the metatechnology, whereas private ones could potentially improve their efficiency by about 8.6 per cent under the same metafrontier technology. The difference in the metatechnology ratio between public and private universities is statistically significant at the 10 per cent level. These findings were expected because public universities have the advantage of being able to use available input resources to maximise their benefits.

Table 3: Efficiencies and metatechnological ratio of universities classified by ownership

	2011	2012	2013	Overall
Technical efficiencies relative to group frontiers				
Public	0.873	0.827	0.823	0.841
Private	0.851	0.786	0.835	0.824
χ^2 test[a]				0.364
Technical efficiencies relative to the metafrontier				
Public	0.823	0.759	0.760	0.781
Private	0.786	0.707	0.764	0.752
χ^2 test				2.01
Metatechnology ratio				
Public	0.940	0.914	0.922	0.925
Private	0.922	0.907	0.914	0.914
χ^2 test				2.87*

Note: [a] The Kruskal-Wallis nonparametric rank test equality of populations; * and ** denote significance at the 10% and 5% levels, respectively.

4.2.2 Colleges model

Regarding the colleges model, with respect to their own group frontier, colleges could potentially improve their efficiencies, on average, by 22.6 per cent. Hotelling's test revealed that variations in their efficiencies over the three years are statistically significant at the one per cent level. The number of efficient colleges fluctuated across the three years. On average, there were 11 efficient colleges in the reported period. However, under the unrestricted metatechnology, the technical efficiencies of colleges have slight downward trends over the three years. The numbers of efficient colleges relative to the metafrontier decreased sharply relative to the group frontier. Only three colleges were operating efficiently at the metafrontier over the three years.

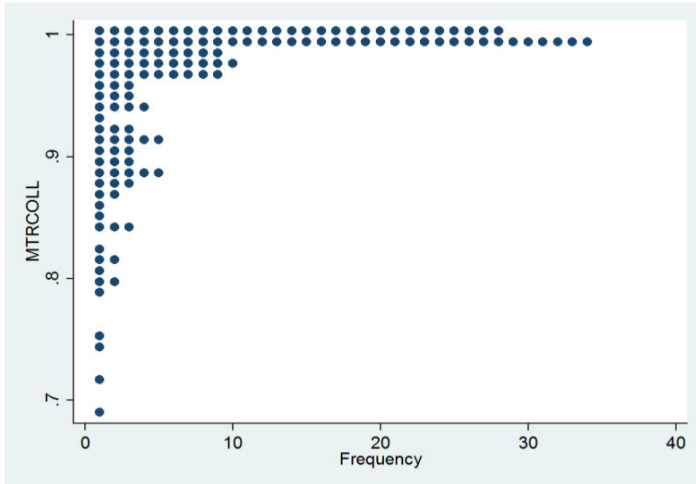
The average DEA metatechnology ratio of colleges in Table 4 is about 0.95. This means that colleges could potentially improve their efficiency by five per cent under the unrestricted teaching technology to obtain full technical efficiency. Although the college group, in reality, is operating under conditions that are more constrained than the university group, this group has a metatechnology ratio that is relatively good under the overarching teaching technology.

Table 4: Efficiencies and metatechnology ratio of colleges

	2011	2012	2013	Overall
Technical efficiencies in terms of group frontiers				
Mean	0.791	0.759	0.773	0.774
Standard deviation	0.159	0.170	0.160	0.146
Min	0.399	0.362	0.389	0.410
Max	1	1	1	1
Efficient colleges	25	17	18	11
Hotelling's test [a] (F value)				7.54***
Technical efficiencies in terms of the metafrontier				
Mean	0.757	0.721	0.719	0.732
Standard deviation	0.155	0.161	0.147	0.140
Min	0.399	0.360	0.389	0.409
Max	1	1	1	1
Efficient colleges	14	7	8	3
Hotelling's test (F value)				11.05***
Metatechnology ratios				
Mean	0.959	0.953	0.936	0.950
Standard deviation	0.061	0.067	0.091	0.068
Min	0.678	0.639	0.610	0.687
Max	1	1	1	1
Efficient colleges	50	42	48	22
Hotelling's test (F value)				9.92***

Note: [a] Hotelling's statistic tests for equal means among the three years;
*** denotes significance at the 1% level.

Figure 2: Distribution plots of metatechnology ratios of colleges



As can be seen, there are 22 colleges with the metatechnology ratio of one. These colleges efficiently used the input-output combinations that positioned them at the point of tangency between their group frontiers and the metafrontier technology. Figure 2 demonstrates the distribution plots of metatechnology ratios of colleges across the three years. These distributions are quite dense and focus near the value of one.

Table 5: Efficiencies and metatechnology ratio of colleges classified by ownership

	2011	2012	2013	Overall
Technical efficiencies relative to the group frontier				
Public	0.781	0.749	0.761	0.764
Private	0.869	0.833	0.864	0.856
χ^2 test [a]				13.47***
Technical efficiencies relative to the metafrontier				
Public	0.747	0.714	0.710	0.724
Private	0.831	0.772	0.782	0.795
χ^2 test				8.33***
Metatechnology ratio				
Public	0.960	0.957	0.940	0.953
Private	0.948	0.924	0.907	0.927
χ^2 test				0.737

Note: [a] The Kruskal-Wallis nonparametric rank test equality of populations; *** denotes significance level at 1%.

Table 5 presents the technical efficiencies and metatechnology ratio of colleges classified by their ownership. It is surprising to see that private colleges are significantly more efficient than public ones relative to the group frontier in all three years at the one per cent significance level using the Kruskal-Wallis test. Relative to the metafrontier technology, this difference is also statistically significant at the one per cent level. By contrast, the metatechnology ratios illustrate that public colleges tend to be more efficient than private ones in using the inputs to produce the outputs under the metatechnology. For instance, the average metatechnological ratios of 0.953 and 0.927 for public and private colleges, respectively, suggest that public colleges could potentially improve their efficiency by 4.7 per cent using the metatechnology, whereas private ones could potentially increase their efficiency by about 7.3 per cent under the same metafrontier technology. However, the difference in efficiencies of public and private colleges is not statistically significant.

4.3 Capacity utilisation of floor area proxied as the quasi-fixed input

This section presents results of the capacity utilisation of floor area for academic spaces as a surrogate of the quasi-fixed inputs of HEIs. As regulated by the government, this input is one of the obligatory reporting requirements used to evaluate the performance of HEIs and determine whether they are eligible to increase their annual enrolment quotas. Some HEIs can expand their floor area to enhance their performance whereas the others have not had the conditions to do so due to different reasons such as financial pressures, restrictions to regulations, and other external impacts. Thus, in the context of scarce resources for higher education, investigating the capacity utilisation of floor area is imperative to provide information for educational leaders and policymakers that will enable them to better explore possible ways for improving the performance of HEIs.

Using the directional distance function approach, we examine separately the university and college models to provide a clearer picture of the efficiency of floor area for academic spaces contributing to the efficiencies of universities and colleges, and the capacity utilisation of this input with respect to the individual groups. The findings of the directional distance efficiency of all used inputs, of the quasi-fixed floor area, and the capacity utilisation of this input are shown separately for universities and colleges.

4.3.1 Universities model

Table 6 reveals that efficiency of floor area of universities without other inputs is relatively low, on average, 0.565. This shows that the quasi-fixed floor area was underutilised in the years involved. Improvements in the technical efficiency of this input could potentially be increased by 43.5 per cent. When compared with the efficiency in terms of all inputs used to produce the outputs, the capacity utilisation of floor area is 0.826. This suggests that universities could potentially increase the usage efficiency of this input in combination with other inputs by about 17.4 per cent. In the higher education sector, the quasi-fixed input resources are generally scarce and not easy to be changed in the short term; thus, it is useful for universities to be able to increase their annual enrolment quotas efficiently using these inputs, and, thereby, improve their operational efficiencies. Accordingly, the policy on enrolment quotas should be removed. Our empirical findings reveal that there was only one university that fully efficiently utilised the quasi-fixed floor area for academic spaces in combination with other inputs to produce the output levels.

Table 6: Capacity utilisation of floor area of universities

	2011	2012	2013	Overall
Technical efficiencies in terms of all inputs				
Mean	0.867	0.816	0.827	0.837
Standard deviation	0.143	0.153	0.137	0.124
Min	0.424	0.362	0.376	0.387
Max	1	1	1	1
Efficient universities	36	19	17	5
Hotelling's test[a] (F value)				7.54***
Technical efficiencies of floor area				
Mean	0.612	0.532	0.551	0.565
Standard deviation	0.246	0.246	0.243	0.215
Min	0.044	0.060	0.075	0.060
Max	1	1	1	1
Efficient universities	7	8	8	1
Hotelling's test (F value)[a]				11.6***
Capacity utilisation of floor area				
Mean	0.833	0.820	0.824	0.826
Standard deviation	0.121	0.114	0.112	0.103
Min	0.539	0.553	0.529	0.605
Max	1	1	1	1
Efficient universities	9	9	8	1
Hotelling's test (F value)				1.28

Note: [a]Hotelling's test for equal means among the three years; *** denotes significance level at the 1% level.

Table 7: Capacity utilisation of floor area of universities classified by ownership

	2011	2012	2013	Overall
Technical efficiencies in terms of all inputs				
Public universities	0.873	0.827	0.823	0.841
Private universities	0.851	0.786	0.835	0.824
χ^2 test[a]				0.364
Technical efficiencies with floor area				
Public universities	0.621	0.547	0.542	0.570
Private universities	0.588	0.488	0.575	0.550
χ^2 test				0.558
Capacity utilisation of floor area				
Public universities	0.834	0.820	0.821	0.825
Private universities	0.830	0.819	0.833	0.827
χ^2 test				0.126

Note: [a] The Kruskal-Wallis nonparametric rank test equality of populations

Table 7 provides more details of the capacity utilisation of the quasi-fixed floor area of universities classified by their ownership. The findings show that public universities tend to use this input more efficiently than private ones. However, the Kruskal-Wallis test indicates that these differences are not statistically significant. However, for the capacity utilisation of this input, improvements in technical efficiency could be potentially increased by 17.5 and 17.3 per cent for public and private universities, respectively, in combination with other inputs to produce the outputs.

4.3.2 Colleges model

Technical efficiencies and capacity utilisation of floor area for academic spaces of colleges are presented in Table 8. As can be seen, colleges underused the quasi-fixed floor area in the reported period with the low mean technical efficiency of 0.464. This means that on average, colleges could potentially increase technical efficiency with respect to using this input by 53.6 per cent to obtain the full efficiency of one. When compared with the efficiency in terms of all inputs used to produce the outputs, the capacity utilisation of floor area of colleges was 0.811. This implies that colleges could potentially increase the usage efficiency of this input in combination with other inputs by about 18.9 per cent. Our empirical findings showed that there was no college that fully efficiently utilised the quasi-fixed floor area for academic spaces in combination with other inputs to produce the output levels during the considered period.

Table 8: Capacity utilisation of floor area of colleges

	2011	2012	2013	Overall
Technical efficiencies in terms of all inputs				
Mean	0.791	0.759	0.773	0.774
Standard deviation	0.159	0.170	0.160	0.146
Min	0.399	0.362	0.389	0.410
Max	1	1	1	1
Efficient universities	25	17	18	11
Hotelling's test (F value)				7.54***
Technical efficiencies in terms of floor area				
Mean	0.458	0.452	0.482	0.464
Standard deviation	0.260	0.257	0.272	0.241
Min	0.055	0.073	0.090	0.089
Max	1	1	1	0.996
Efficient universities	6	3	9	0
Hotelling's test (F value)				2.67*
Capacity utilisation of floor area				
Mean	0.796	0.813	0.823	0.811
Standard deviation	0.103	0.098	0.105	0.091
Min	0.552	0.541	0.555	0.563
Max	1	1	1	0.996
Efficient universities	6	6	11	0
Hotelling's test (F value)				5.23***

Note: [a] Hotelling's test for equal means among the three years;
*, *** denote significance at 10% and 1%, respectively

Table 9: Capacity utilisation of floor area classified by ownership

	2011	2012	2013	Overall
Technical efficiencies in terms of all inputs				
Public colleges	0.781	0.749	0.761	0.764
Private colleges	0.869	0.833	0.864	0.856
χ^2 test[a]				13.47***
Technical efficiencies with floor area				
Public colleges	0.445	0.441	0.470	0.452
Private colleges	0.561	0.536	0.572	0.556
χ^2 test				8.67***
Capacity utilisation of floor area				
Public colleges	0.796	0.813	0.824	0.811
Private colleges	0.802	0.812	0.812	0.809
χ^2 test				0.001

Note: [a] The Kruskal-Wallis nonparametric rank test equality of populations; *** denotes significance at 1%.

Table 9 illustrates more details of the capacity utilisation of the quasi-fixed floor area for academic spaces of colleges classified by their ownership. It is interesting to see that private colleges are more efficient than public ones in using this quasi-fixed input. The Kruskal-Wallis test indicates that this difference is significant at the one per cent level. This may reflect the fact that because private colleges must use their own capital to invest in floor area for academic spaces, they use this quasi-fixed input efficiently. However, when comparing with technical efficiency in terms of using all inputs, the capacity utilisation of this input by public colleges is better than for private ones. However, this distinction is not statistically significant.

On average, the capacity utilisation of the quasi-fixed floor area for academic spaces of public colleges could be potentially increased by 18.9 per cent, whereas that of private ones could be potentially increased by 19.1 per cent in combination with other inputs to produce the output level. In general, in both models, for an input-output combination, public HEIs are more efficient and have the advantage of being able to maximise the capacity utilisation of the quasi-fixed floor area for academic spaces for output expansion.

5. Discussion and Conclusions

This paper provides insights about technological heterogeneity and the efficiencies of the Vietnamese universities and colleges under the overarching teaching technology for the three years, 2011–2013. The DEA metafrontier directional distance function approach (Chambers, Chung, and Färe, 1998; Färe and Grosskopf, 2000b; O'Donnell, Rao and Battese, 2008) is used to analyse technical efficiencies of HEIs relative to the group frontiers and the metafrontier of the separate groups. This approach is also used to compute the capacity utilisation of the quasi-fixed floor area for academic spaces. Reporting of floor area for academic spaces is one of the requirements of the government and essential if HEIs wish to increase their outputs. This method itself has made a methodological contribution to this field of higher education research because it discovers technological heterogeneity that would remain veiled using orthodox approaches based on proportional measures of the efficiencies of HEIs.

Our empirical findings yielded fruitful information for educational leaders and policymakers concerning the metatechnological efficiencies of the two categories of tertiary institutions in Viet Nam, namely universities and colleges. The fact that the higher education sector plays a crucial role in enhancing the economic competitiveness of the nation supports the practical relevance of evaluating the operational efficiencies of universities and colleges. In addition, the findings are helpful in reducing asymmetric information when comparing the efficiencies of universities and colleges, and, thus, can provide more insights for the government to accurately assess the role of universities and colleges, which operate under different teaching technologies, in the national higher education system.

Regarding metafrontier technical efficiencies of each HEI group, there is room for HEIs to improve their performance. Under the unrestricted and own teaching technologies, on average, the university group could potentially increase its efficiency by 22.7 and 16.3 per cent, respectively. The metatechnology ratios reveal that the management of inputs is related to technical inefficiencies of universities in the production of the outputs under the teaching technology represented by the metafrontier. This suggests that the university group could potentially increase its technical efficiencies by 7.8 per cent to obtain the metafrontier full efficiency. It is also worth highlighting that, under the unrestricted teaching technology, public universities are more efficient than private ones using the same teaching technology.

The college group could potentially increase its efficiency under the metafrontier and individual frontier by 26.8 and 22.6 per cent, respectively. It is interesting to see that the average metatechnology ratio of the college group is relatively sound at 0.95. This means colleges could potentially improve their efficiencies by five per cent to obtain the full efficiency of one, using their individual teaching technology represented by the metafrontier. Under the common teaching technology used by the colleges group, private colleges are more efficient, in general. However, regarding the management of input resources to produce outputs measured by the metatechnology ratios, public colleges are inclined to be more technically efficient.

Under the pressure of scarce resources such as land, estimating the capacity utilisation of such quasi-fixed inputs provides useful information for HEIs to have better strategies in the utilisation of these inputs that cannot be quickly adjusted to maximise their outputs. This is appropriate for the Vietnamese situation in which the government asks HEIs to meet the standards of floor area for academic spaces as regulated if they want to increase their annual enrolment quotas. Our empirical findings reveal that the capacity utilisation of the quasi-fixed floor area for academic spaces of Vietnamese HEIs was underutilised in the years considered. This means that both universities and colleges were not efficient in using the quasi-fixed floor area for academic spaces to improve their performance, assuming that they could make decisions to simultaneously expand their outputs and contract their input resources. Regarding the ownership, there was insignificant difference between public and private HEIs in the capacity utilisation of the quasi-fixed floor area for academic spaces, although their capacity utilisation of this input was less than full technical efficiency of unity.

The above results are relevant when it comes to the managerial implications. First, both universities and colleges are not efficient in terms of their own teaching technologies. Under the metafrontier framework, universities are more efficient than colleges at the five percent significance level ($p=0.019$). However, the metatechnology ratios show that the gap between their own frontiers and metafrontier technologies is 0.078 and 0.05 for universities and colleges, respectively, implying that both groups, using their individual teaching technology, are operating comparatively well. This result suggests that it is not necessary for colleges to upgrade to universities because they are relatively efficient in their own technology. Accordingly, the government should confirm the role of each group in terms of their operational efficiencies in the national higher education system and have appropriate policies to improve their performance and education quality.

Second, floor area for academic spaces is referred to as the quasi-fixed input that cannot be expanded or contracted in the short run. This input of HEIs is currently underutilised. As for the efficiency in the input-output combinations, it may be impossible for HEIs to better use this input if they are unlikely to expand their output levels. This suggests that the government should have more relevant policies, for example, have fair access in the land usage policy for public and private HEIs and remove restrictions on enrolments to motivate them to increase their outputs. Hence, HEIs could better use their available input resources to produce their outputs at the optimal level. However, note that HEIs should use their own input resources wisely and be proactive in making their decisions to improve their performance, rather than depend mainly on support and preferential treatment from the government.

Finally, it is important for policymakers and education leaders to be aware of the fact that actions aimed at upgrading some colleges to universities may motivate the efforts of those colleges in particular, but would inevitably reduce the efficiency of the university group and the education system in general.

This paper applied the metafrontier directional distance function approach to analyse the efficiencies of universities and colleges in the higher education sector in Viet Nam. However, some limitations should be addressed. First, we used panel data over a short period of three years; thus, changes in the technical efficiencies of HEIs over multiple periods could not be observed to provide a general picture of the performance of HEIs. In this sense, a longer span of data would be preferable to paint a clearer picture. Second, we assumed that, under the same legal environment, there was no difference between public and private own-teaching technology and management structure. In addition, we assumed that there was no difference in the locations of HEIs. However, in reality these exogenous factors can affect the performance of HEIs to some extent, and, thus, they should be directly included in a metafrontier framework as sub-frontiers. This may lead to a new direction in metafrontier methodology. Finally, the robustness of the estimation procedures should be taken into account by investigating confidence intervals of the directional distance efficiency estimates by bootstrap methods.

Chapter 8: Financial efficiencies of Vietnamese public universities: A dynamic network DEA approach

Abstract

This paper estimates the financial efficiencies and their correlation with the academic and overall efficiencies of 82 Vietnamese public universities in an organisational structure for the period 2011–2013. A dynamic network data envelopment analysis (DEA) is employed in the analysis. This method is a combination between the dynamic and network models that make it possible to simultaneously estimate the divisional efficiencies and dynamic changes across the multiple periods. The results indicate that in a network structure, the average estimated efficiency of the financial operations is 0.826, whereas that of the academic division is 0.782. The correlation between the efficiencies of financial and academic divisions is not particularly strong, being 0.495. The empirical findings also show that the mean of the overall dynamic network efficiencies of public universities is 0.804 and strongly correlated with the efficiency of the academic division rather than that of the financial division. These findings suggest that public universities need to further improve the efficiencies in their financial operations by implementing various solutions such as balancing input usages and output production, paying more attention to managerial skills, and lobbying the government to increase financial support for universities by removing the tuition cap and enrolment quotas.

Key words: Dynamic network, data envelopment analysis, financial efficiencies, dynamic change, higher education institutions.

1. Introduction

The higher education sector is a perennial matter of interest to both economists and policymakers because of its crucial role in socio-economic development. It is widely recognised that the difficult public funding situation and the demanding requirements for better use of scarce resources by higher education institutions (HEIs) have made the assessment of the efficiencies of HEIs pivotal and imperative in several different nations. In Western countries, public HEIs cannot escape political and taxpayers' scrutiny of their activities (Agasisti and Pohl, 2012; Sav, 2012). Therefore, studies on measuring the efficiencies of HEIs remain an important issue in times of financial challenges. In developing countries, such studies are crucial for re-evaluating the government reform policies, and increasing financial accountability to the society (Castano and Cabanda, 2007a; Hayden, 2012). Viet Nam is not an exceptional case, and the higher education system faces challenges in providing sufficient financial resources for the development of HEIs.

Public universities are of great importance in the Vietnamese higher education system. Among 338 public HEIs, 153 are public universities, accounting for 36 per cent of the total number of HEIs in Viet Nam. In 2012/13, the total number of students in public institutions was 1.86 million, with 68.4 per cent of this number coming from public universities. Public universities employed nearly 50 thousand academic staff, more than four times that of private ones (Ministry of Education and Training (MOET), 2013). Public universities have received much more attention from the government in terms of favourable policies and funding for their operations. This is because they are expected to take leading roles in teaching and research activities to boost their ranking and be rated amongst the world's best universities.

In this sense, public universities are often expected to demonstrate a higher level in their operational efficiencies, which are considered as one of the important stimuli to increase the quality of education and research as well as the competitiveness capacity of the nation's economy (Nazarko and Saparauskas, 2014; Kabok, et al., 2013). However, the practical performance of public HEIs, especially public universities, has not confirmed their role as a main driver in the Vietnamese higher education sector. Specifically, the higher education competitive capacity index in 2013/14 was relatively low, ranked 95th among the 148 nations involved (Schwab, 2013). In addition, no Vietnamese university has been in the list of the top 400 universities of the world (Thanh, 2012). A question arises as to whether public universities have sufficient financial resources to improve the quality of education or whether the financial management and distribution system is adequate at the national and institutional levels.

Although public universities were allowed to increase tuition fees during 2010–2014 following Decree 49/2010/ND–CP of the government, the increases were not sufficient for the operations of HEIs because they not been computed on the basis of the real demands of HEIs (Hayden, 2012). Indeed, tuition fees of public HEIs are currently very low, but, adding state budget aid to this, the public expenditure per student accounts for 39.8% of GDP per capita, which is not really low in comparison with some Asian nations such as Cambodia (27.8%), Indonesia (24.2%), Myanmar (11.8%), Philippines (9.7%) and Thailand (19.5%) (Economic and Social Commission for Asia and the Pacific, 2014). Chau and Tran (2015) pointed out that increasing tuition fees can be an appropriate solution, but more important is the improvement of financial performance. According to Duong (2013), Vietnamese public HEIs rely heavily on public funding, which is distributed by the top-down mechanism annually. Additionally, they have not asked to be assessed publicly for whether or not these financial resources have been used efficiently. Therefore, public HEIs seem to lack self-motivation to improve efficiencies in their financial and academic operations.

Financial efficiency is defined as divisional efficiency of the financial department, the so-called supporting unit that provides financial resources for the academic division, thus contributing to the overall efficiency of public universities. The financial divisions are expected to provide useful advice to the boards of management on how to efficiently use HEIs' revenues including public funding, tuition fees, and others. In this sense, the main objective of this paper is to measure, using the dynamic network DEA model, the financial efficiencies and their relationship with the academic and overall efficiencies of public universities, a key driver of the Vietnamese higher education system in a network structure. This model not only looks inside the university, allowing greater insights to the sources of organisational inefficiency, but also captures the dynamic changes of multiple activities via different divisions, such as finance and teaching, over multiple periods. Using this approach also allows us to investigate the correlation between efficiencies of financial operations and those of the overall operations of public universities, as a whole. In addition, the overall dynamic efficiencies of universities measured by the efficiencies of different divisions in a unified framework is then compared with the overall efficiencies of the standard "black-box" DEA model for further analysis.

The structure of our paper consists of the following sections: Section 2 presents a brief review of the DEA approach with the dynamic change and network structure. Section 3 illustrates the empirical model applied in the Vietnamese context. Section 4 presents the empirical dynamic network model for the analysis. Section 5 presents and discusses the empirical results of financial efficiencies in a network structure. The last section will be implications and conclusions.

2. Higher education in Viet Nam: A brief review

The reform process of higher education, which started in 1986, has a strong link to the nationwide economic reform. Vietnamese higher education has experienced significant growth in the numbers of institutions and enrolments, and research activities. Since 1997, when Resolution 90/1997/NQ–CP of the government on socialisation policy of education, health, and culture was introduced, followed by Decree 73/1999/ND–CP, the higher education sector has witnessed great changes in numbers of HEIs and in numbers of enrolments. Following this, several policies were issued to favour the operating environments of HEIs, especially Resolution 14/2005/CP on comprehensive reform of Vietnamese higher education, the so-called Higher Education Reform Agenda, which made significant contributions to the productivity growth of the higher education system.

Viet Nam has currently a total of 421 HEIs, including universities and colleges, of which there are 207 universities. The number of public universities accounts for 73.9 per cent of the total number of universities. Regarding academic staff, the number of lecturers rose remarkably to more than 87,000 academic staff in 2012/13, being 2.5 times greater than that in 1999/2000 (MOET, 2013). The number of articles by Vietnamese researchers published in international journals has shown an increasing trend over the period 2008–2012, going from 955 to 1,731 articles, mainly from a few large universities. However, this number of articles was quite low relative compared with other Asian countries such as Singapore, Malaysia and Thailand (Hien, 2010; Hoang, 2013a; Thanh, 2012). Progress has also been made in the curricula framework and MOET is cooperating with foreign universities to compose 23 advanced curricula at 17 chosen universities. These programs use English as the medium of teaching and learning and are assessed against the educational standards of foreign universities (Vu, 2012).

Universities and colleges are classified as HEIs following the 2012 *Law of Higher Education*. However, their operating environments are relatively heterogeneous in terms of training programs, curricula, teaching staff, and scientific research. Accordingly, universities and colleges are governed by different regulations. In many cases, the government issued separate regulations for universities and colleges. If an issued regulation is used for both types of institutions, there would be different indicators required for them. This implies that the government assesses the performance of universities and colleges using different criteria. Hence, evaluating the performance of universities should be surveyed independently to provide better analysis of their own cohorts.

The role and position of universities is of great concern to policymakers, researchers, and the community because of its importance in training a highly-qualified labour force for society. The aim of the government is that, by 2020, at least one Vietnamese university is ranked in the top 200 universities of the world. This has increased the importance of the role of universities and concerns about their performance.

Table 1, which illustrates the growth in numbers and enrolments of universities over different periods, shows that public universities occupy an important place in the national higher education system with respect to the numbers of institutions and enrolments. In the academic year 2012/13, public universities accounted for nearly 58.6 per cent of total national university enrolments, equivalent to 71.2 per cent of total enrolments in public higher education. This provides evidence of the crucial role of public universities in the higher education system. Hence, research on their performance should be of much more interest as appropriate solutions are sought in their endeavour to attain the high international standards in higher education.

Table 1: Institutions and enrolments of universities over recent years

	1999-2000	2005-2006	2012-2013
Institutions	69	125	207
Public	52	100	153
Private	17	25	54
Enrolments	719,842	1,046,291	1,453,067
Public	624,423	933,352	1,275,608
Private	95,419	112,939	177,459
Share of total enrolment	80.5%	75.4%	66.7%
Public	69.9%	67.3%	58.6%
Private	10.7%	8.1%	8.2%

Source: MOET (2013)

It is observed that public universities get benefits via public funding and the tuition fee policy. In 2010, the government issued Decree 49/2010/ND–CP on tuition fees that allowed public HEIs to increase the tuition fees over the period 2010/11–2014/15 within the regulated ceiling tuition framework. This Decree gives more autonomy to public HEIs regarding tuition fees. However, public HEIs are not permitted to charge students above the allowed ceiling tuition levels for each group of study fields. As instructed by Joint Circular 20/2014/TTLT–BGDDT–BTC–BLDTBXH, the government provides state funding to public universities based on the difference between total budget estimates approved for their annual operating expenses and total revenues from tuition fees of students. That is, if public universities obtain higher revenues from tuition fees, the government distributes less state funds for their operations and vice versa. It can be seen that this policy ensures public universities have enough expenditure costs to maintain their operations. However, it may make them less dynamic in improving the efficiencies in their operations.

Kent (2005) argued that the government incentives via the budget are useful tools for policy implementation in higher education. However, these incentives should prove their validity and enhance performance of public HEIs. A recent study of restructuring higher education via the public budget conducted by Trinh (2012) indicated that the policy and mechanism of distributing public funding in Viet Nam were improper and ineffective. Hayden (2012) argued that, although the government has provided a schedule of imposing tuition fees for public HEIs, the fee rate seems not to be sufficient for their operations and is not computed based on their real demands. In this context, it is imperative to discover what the efficiencies are of financial operations in connection with the academic and overall operations of public universities. These efficiencies can be considered as one of the important stimuli to increase the quality of education as well as the competitiveness capacity of the nation's economy (Nazarko and Saparauskas, 2014; Kabok et al., 2013).

3. Data envelopment analysis (DEA) with the dynamic change and network structure

The traditional DEA model is a well-known nonparametric method widely used in operations research to measure the efficiencies of firms. The greatest advantage of this method is its ability to use multi- inputs and multi-outputs without assuming the relationship between variables and without asking price information. However, the standard DEA does not take into account the internal structure of firms and is referred to as the black-box model. Most previous studies in the higher education sector have used the standard DEA to assess the efficiencies of HEIs and neglected the internal structures of HEIs in their production process.

The network DEA was developed by Färe and Grosskopf (1996a, 1996b, 2000a). Their models have been extended by several studies to investigate the (in)efficiency of immediate steps to seek more specific and better solutions for efficiency improvement of firms in different fields. Such studies include those of Lewis and Sexton (2004), Yu and Lin (2008), Tone and Tsutsui (2009), Chen and Yan (2011), Rostamy-Malkhlifeh et al. (2013), and Matthews (2013).

In the context of higher education, it is widely recognised that measuring efficiency is difficult because of its diversity and multi-faceted nature (Carrington, Coelli, and Rao, 2005; Emrouznejad and Thanassoulis, 2005). HEIs have multiple missions including teaching, research, and knowledge transfer via training services and project consultancy; thus, using multi-inputs to produce multi-outputs. Like other sectors, it is assumed that HEIs may face some intervening steps or linking activities, for example, academic (teaching, research), administrative, and financial operations in the production process, that the standard DEA model may neglect (Tone and Tsutsui, 2009). Arguably, the network DEA can provide a methodology capable of assessing efficiencies of internal activities and overall efficiencies of HEIs in a unified framework.

To our knowledge, only two studies into higher education have applied the network DEA to the internal structure of the production process of HEIs. Johnes (2013) used the Tone and Tsutsui (2009) model to construct two nodes, namely, teaching and student's employability, in a network DEA framework for 94 English HEIs in the 2011/12 academic year. His findings revealed that there are differences in efficiency of each node and the overall evaluation in the network DEA. In addition, most of the efficiency scores of the network DEA are less than those of the standard DEA model. It is clear that the network DEA model has provided more specific details about (in)efficiency of each node that is useful for educational managers when formulating appropriate strategies for the development of their HEIs. Monfared and Safi (2013) applied the network DEA model with two nodes, teaching and research, to analyse academic performance. These authors only considered nine academic colleges of Alzahra University in Iran based on the availability of data. Their findings showed that overall teaching quality of Alzhra University was better than its research productivity and suggested an improvement for research activities. It should be noted that due to the small sample size relative to the number of inputs and outputs, the discriminating power of analysis in their work was limited.

On the other hand, capturing the dynamic change over periods has attracted much attention in DEA research. Whereas the traditional DEA method only focuses on a single period, the dynamic DEA model can measure the intertemporal efficiency change using carry-over variables. The first approach for this purpose was proposed by Klopp (1985) for the window analysis. Färe, Grosskopf, Norris, and Zhang (1994) proposed the Malmquist index in the DEA framework based on the work of Malmquist (1953). Then, the dynamic DEA model formally suggested by Färe and Grosskopf (1996) was the first innovative method to cope with the linking activities. Later, Tone and Tsutsui (2010) extended their model by using the slacks-based measurement proposed by Tone (1999) and Pastor, Ruiz, and Sirvent (1999). The Tone and Tsutsui (2010) model is non-radial and thus can be used with inputs/outputs individually with non-uniform input/output factor efficiency, whereas the radial approaches assume proportional changes in inputs/outputs and provide only uniform input/output. In this model, weights to input/output items can be set according to their importance.

The dynamic network DEA model is a combination of the dynamic and network models proposed by Tone and Tsutsui (2014). This model accounts for internal heterogeneous divisions of firms. These divisions are linked together by the connecting variables and internal products. The dynamic network model can provide the overall efficiency over the whole years involved and the dynamic changes in both the period efficiency and the divisional efficiency. To our knowledge, exploring this model in empirical studies in higher education is still limited. Our study fills this gap in the literature by (a) explore in-depth the organisational dynamic efficiency obtained from intervening activities of different divisions in a unified framework; (b) estimating the efficiency of financial operations in public universities that has not been conducted in the higher education sector; and (c) examining how much financial efficiencies do contribute to the academic and overall efficiencies to offer possible solutions for public universities to improve their performance.

4. The empirical model with dynamic network DEA approach

In this part, we discuss the empirical model using the dynamic network DEA approach to measure financial efficiencies of 82 Vietnamese public universities in the period of 2011–2013. Universities in our sample account for 54 per cent of the total number of public universities in Viet Nam (MOET, 2013). We only focus on two main divisions, financial and academic, as they are indispensable to the operational process of each public university, whereas other divisions can be widely varied depending on their real demands. In Viet Nam, public universities must observe the regulation framework for all financial operations because they receive public funding from the government. Hence, the financial division plays an important role in consulting with the institutional board of directors to adequately use financial resources as regulated by law. In this sense, the major objective of the financial division is to help the institutional board of directors manage a healthy financial situation based on available labour and capital inputs. Additionally, this division is considered as the supporting unit for the academic division via providing financial resources. However, the main target of the academic division is to provide the educational services using operating expenditures that are maintained by the financial division. The two divisions are reciprocal and occupy crucial places in the production process, and influence the overall efficiencies of public universities as a whole.

Following Tone and Tsutsui (2014), the dynamic network slacks-based measure approach is defined by the following mathematical programming formulae.

Assume that n HEIs $(j = 1, \dots, 82)$ consist of K divisions $(k = 1,2)$ over T time periods $(t = 1,2,3)$. Public universities in our sample are considered as homogeneous under the same legal environment for their academic operations. Let m_k and r_k be the numbers of inputs and outputs to division k, respectively. The link leading from division k to division h is denoted by $(kh)_i$ and the set of links by L_{kh}. The inputs, outputs, and linking and carry-over variables are described as follows:

$x_{ijk}^{t} \in R_{+}$ $(i = 1, \dots, m_k; j = 1, .., n; t = 1, \dots, T)$ is the input resource i to HEI_j for division k in period t.

$y_{rjk}^{t} \in R_{+}$ $(r = 1, \dots, r_k; j = 1, \dots, n; t = 1, \dots, T)$ is the output product r from HEI_j, division k, in period t.

Specifically, for the financial division, one labour input and two capital inputs are adopted at this division. The financial division does not directly provide educational services to learners. Instead, it takes charge of providing the operating expenditures to the academic division and keeps the financial status sound as regulated by law. Thus, administrative staff are used for these activities. As for capital inputs, we use tuition fees and public funding as income sources of universities to cover a part of their operating expenditures. All capital inputs are adjusted by the annual inflation rate to provide real values of these inputs.

For the academic division, two labour inputs are used, namely, academic staff and non-academic staff. Most academics participate in teaching and research activities, whereas non-academic staff undertake tasks of administering students, teaching and research staff, and generally facilitating the academic process. We use two outputs for this division: graduates and students enrolled. The number of graduates refers to students who leave with completed degrees at the end of each year. Students enrolled refers to the number of students enrolled in a given year. Sullivan et al. (2012) asserted that both enrolments and graduates have been shown to be important in labour market studies and thus only using one of them can miss a critical output dimension. Under the production function, students enrolled are considered as input resource users of HEIs embodied in the process of teaching and research. Carrington, Coelli, and Rao (2005) argued that certain students require more resources to teach than others. For example, postgraduate students require more resources than undergraduate students. Thus, separate output measures are developed for postgraduates and undergraduates. Such outputs have been used in recent studies, such as those of Abbott and Doucouliagos (2003; 2009), Castano and Cabanda (2007a; 2007b), Guzman and Cabanda (2009), Daghbashyan (2011), De Franca et al. (2010), Fernando and Cabanda (2007), Miranda, Gramani, and Andrade (2012), Martin (2006), Tajnikar and Debevec (2008) and Thanassoulis et al. (2011).

$z^{t}_{j(kh)_l} \in R_+$ $(j = 1, \dots, m_k; l = 1, \dots, L_{kh}; t = 1, \dots, T)$ is linking intermediate products of HEI_j from division k to division h in period t, where L_{kh} is the number of items in links from k to h.

The linking variable acts as an intermediate product which makes a major difference between the dynamic network DEA model and the traditional DEA model. This variable is simultaneously an output from the financial division and an input to the academic division. Using an intermediate product, the multiple production stages are estimated among divisions in one university.

$z^{(t,t+1)}_{jk_l} \in R_+$ $(j = 1, \dots, m_k; l = 1, \dots, L_k; k = 1, \dots, K; t = 1, \dots, T-1)$ is carry-over of HEI_j, at division k, from period t to period $t+1$, where L_k is the number of items in the carry-over from division k.

The carry-over variable is one of advantages of the dynamic network DEA model. It is widely recognised that each university operates continuously over several terms and its efficiency could be affected by intertemporal factors. The carry-over variable can enable us to take into account the effects of the linking activities between sequential periods. In this paper, we set the research income as an undesirable carry-over for the financial division, rather than using it as a research output in the academic division. This is because research outputs estimated by the numbers of journal publications, conference papers, book reviews, patents, etc., are not available and are difficult to obtain in the Vietnamese context. Hence, for specific objectives of this study, the research income is used as a carry-over because its source comes from research projects that may be undertaken over some years. Thus, universities use it as a net income surplus and carry it over to the next period. In the academic division, we use the academic area as an undesirable carry-over. This variable is chosen because it seems to be a quasi-fixed input which is not only used in the current period but also carried over to the next period. In addition, universities are required to efficiently use their property assets.

Let the production possibility set $P^t = \left\{ (x_k^t, y_k^t, z_{(kh)}^t, z_{ik}^{(t,t+1)}) \right\}$ $(t = 1, \dots, T)$ be defined by

$$x_k^t \geq \sum_{j=1}^{n} x_{jk}^t \lambda_{jk}^t \;\; (\forall k, \forall t)$$

$$y_k^t \leq \sum_{j=1}^{n} y_{jk}^t \lambda_{jk}^t \;\; (\forall k, \forall t)$$

$$z_{(kh)_t}^t = \sum_{j=1}^{n} z_{j(kh)_t}^t \lambda_{jk}^t \;\; (\forall \mathrm{l}, \forall (kh)_l, \forall t)(as\ outputs\ from\ k\ in\ period\ t)$$

$$z_{(kh)_t}^t = \sum_{j=1}^{n} z_{j(kh)_t}^t \lambda_{jh}^t \;\; (\forall \mathrm{l}, \forall (kh)_l, \forall t)(as\ inputs\ from\ h\ in\ period\ t)$$

$$z_{k_l}^{t(t+1)} = \sum_{j=1}^{n} z_{jk_l}^{t(t+1)} \lambda_{jk}^t \;\; (\forall \mathrm{l}, \forall (kh)_l, \forall t)(as\ carry-over\ from\ period\ t)$$

$$z_{k_l}^{t(t+1)} = \sum_{j=1}^{n} z_{jk_l}^{t(t+1)} \lambda_{jk}^{t+1} \;\; (\forall \mathrm{l}, \forall (kh)_l, \forall t)(as\ carry-over\ to\ period\ t+1)$$

$$\sum_{j=1}^{n} \lambda_{jk}^t = 1 \; (\forall k, \forall t), \lambda_{jk}^t \geq 0 \; (\forall j, \forall k, \forall t)$$

where $\lambda_k^t = \left\{ \lambda_{jk}^t \right\} \in R_+^n$ is the intensity vector corresponding to division $k, \forall k$ at $t, \forall t$

It is assumed that at the initial period 1, there are no linking inputs and no carry-over from the previous period and, at the terminal term T, there are no linking outputs from terminal division and no carry-over to the next period.

- *Input output constraints*

For firm$_o$ $(o = 1, \dots, n \in \mathrm{P}^t$, input and output constraints can be expressed by

$$x_{ok}^t = X_k^t \lambda_k^t + s_{ko}^{t-} \; (\forall k, \forall t)$$

$$y_{ok}^t = Y_k^t \lambda_k^t - s_{ko}^{t+} \; (\forall k, \forall t)$$

$$e\lambda_k^t = 1 \ (\forall k, \forall t)$$

$$\lambda_k^t \geq 0, s_{ko}^{t-} \geq 0, s_{ko}^{t+} \geq 0 \ (\forall k, \forall t)$$

where $$X_k^t = (x_{1k}^t, \dots, x_{nk}^t) \in R^{m_k \times n}$$

$$Y_k^t = (y_{1k}^t, \dots, y_{nk}^t) \in R^{r_k \times n}$$

are input and output matrices, and $s_{ko}^{t-}$and s_{ko}^{t+} are, respectively, input and output slacks.

- *The linking constraints*

With regard to the linking constraints, the as-input link value case is used in this paper. This implies that the linking activities are treated as input to the succeeding division and excesses are accounted for in the input inefficiency. The linking constraint is shown as

$$z_{o(kh)in}^t = Z_{(kh)in}^t \lambda_k^t + s_{o(kh)in}^t ((kh)in = 1, \dots, linkin_k)$$

where $s_{o(kh)in}^t \in R^{L_{(kh)in}}$ is slacks and non-negative, and $linkin_k$ is the number of as-input links from division k.

It is noted that there are four possible cases for the linking values as described by Tone and Tsutsui (2009, 2014). For instance, the free link value case implies that the linking variables are freely determined while keeping continuity between input and output. In our model, we set the operating expenditure as a linking variable from the financial division to the academic division. It is assumed that the financial division is in charge of maintaining a sound financial status and providing the operating expenses for academic operations. The academic division uses its operating expenses and delivers the educational services to learners. We accept a discretionary free link, where the linking activity can increase or decrease in each period. The reason for this is that it would be likely for the academic division to discuss with the financial division any changes to the operating expenditures based on the number of students.

- *The carry-over linking constraints*

The formula for the carry-over linking constraints is generally expressed as

$$\sum_{j=1}^{n} z_{jk_l\alpha}^{t(t+1)} \lambda_{jk}^t = \sum_{j=1}^{n} z_{jk_l\alpha}^{t(t+1)} \lambda_{jk}^{t+1} \ (\forall k;\ \forall k_l; t = 1, \dots, T-1)$$

where α denotes good, bad, free or fixed variables as described by Tone and Tsutsui (2014)

Tone and Tsutsui (2014) classified the carry-over activities into four categories. For example, the undesirable (not good) carry-over variables are treated as inputs and comparative excess is attributed to inefficiency. In our study, research income and floor area for academic spaces as carry-overs should be theoretically considered as the desirable (good) variable and treated as outputs. However, in the case of the capital asset, it is usually treated as a capital input as in the input model (Tone and Tsutsui, 2010). This is totally relevant to the Vietnamese context where, in any case, universities should reduce their inputs to obtain the optimal outputs. Thus, we adopt the undesirable carry-overs in our model for the linking activity from the period t to period t+1 and treat them as inputs.

In this case, the equation for the carry-over constraints is specifically illustrated as

$$z_{ok_l carry}^{t(t+1)} = \sum_{j=1}^{n} z_{jk_l carry}^{t(t+1)} \lambda_{jk}^{t} + s_{ok_l carry}^{t(t+1)} (k_l = 1, \ldots, ncarry_k, \forall \mathrm{k}, \forall t)$$

- *The objective function*

The DEA input-orientated measure is chosen to measure the efficiency of universities. This is because, in Viet Nam, enrolment quotas are limited within the confines of regulations to ensure the education quality. In addition, external influences, such as imperfect competition, government regulations, and constraints on finance, may cause a university to be operating at a less than optimal scale. Thus, we chose the variable-returns-to-scale specification in the public universities' case.

The overall-, period- and divisional-efficiencies are depicted by the following formulae:

Period efficiency

$$\tau_0^{t*} = \sum_{k=1}^{K} w^k \left[1 - \frac{1}{m_k + linkin_k + ncarry_k} \left(\sum_{i=1}^{m_k} \frac{s_{iok}^{t-}}{x_{iok}^{t}} + \sum_{kh_t=1}^{linkin_k} \frac{s_{o(kh)_i in}^{t}}{z_{o(kh)_i in}^{t}} + \sum_{k_t=1}^{ncarry_k} \frac{s_{ok_i carry}^{t(t+1)}}{z_{ok_i carry}^{t(t+1)}} \right) \right]$$

Divisional efficiency

$$\delta_0^{t*} = \sum_{t=1}^{T} W^t \left[1 - \frac{1}{m_k + linkin_k + ncarry_k} \left(\sum_{i=1}^{m_k} \frac{s_{iok}^{t-}}{x_{iok}^{t}} + \sum_{kh_t=1}^{linkin_k} \frac{s_{o(kh)_i in}^{t}}{z_{o(kh)_i in}^{t}} + \sum_{k_t=1}^{ncarry_k} \frac{s_{ok_i carry}^{t(t+1)}}{z_{ok_i carry}^{t(t+1)}} \right) \right]$$

Period-divisional efficiency

$$\rho_0^{t*} = 1 - \frac{1}{m_k + linkin_k + ncarry_k} \left(\sum_{i=1}^{m_k} \frac{s_{iok}^{t-}}{x_{iok}^{t}} + \sum_{kh_t=1}^{linkin_k} \frac{s_{o(kh)_i in}^{t}}{z_{o(kh)_i in}^{t}} + \sum_{k_t=1}^{ncarry_k} \frac{s_{ok_i carry}^{t(t+1)}}{z_{ok_i carry}^{t(t+1)}} \right)$$

Overall efficiency

$$\theta_o^{*} = min \sum_{t=1}^{T} W^t \left[\sum_{k=1}^{K} w^k \left[1 - \frac{1}{m_k + linkin_k + ncarry_k} \left(\sum_{i=1}^{m_k} \frac{s_{iok}^{t-}}{x_{iok}^{t}} + \sum_{kh_t=1}^{linkin_k} \frac{s_{o(kh)_i in}^{t}}{z_{o(kh)_i in}^{t}} + \sum_{k_t=1}^{ncarry_k} \frac{s_{ok_i carry}^{t(t+1)}}{z_{ok_i carry}^{t(t+1)}} \right) \right] \right]$$

It should be noted that in the input-orientated model, the overall efficiency is the weighted arithmetic mean of the period-efficiencies. The weighted parameters for period efficiency should be chosen to ensure the uniqueness issue in efficiency. Tone and Tsutsui (2014) suggested that the last period T has the top priority and those of previous periods decrease in order. Under this principle, the uniqueness issue can be accommodated.

In the Vietnamese context, the government allowed public universities to increase tuition fees in the regulated framework from 2010/11 to 2014/15. This means that tuition fees of the following year would be set at a higher level than the level of the current year. In other words, the last period, 3, has the top priority and those of the periods 2 and 1 decrease in this order. For division, the importance of financial management and academic operations is currently equal in the Vietnamese context. The reason for this is that in the context of facing financial difficulties, universities should simultaneously manage their financial resources well and carry out academic operations efficiently. Weights for periods and division are presented in Table 2. Figure 1 presents the empirical framework for measuring the dynamic change of efficiencies of public universities and Table 3 describes in detail variables used in this model.

Table 2: Weights for periods and divisions

	Weight
Periods	
Year 2011	0.15
Year 2012	0.30
Year 2013	0.55
Divisions	
Finance	0.5
Academic	0.5

Figure 1: Empirical framework for measuring the dynamic change of period efficiencies

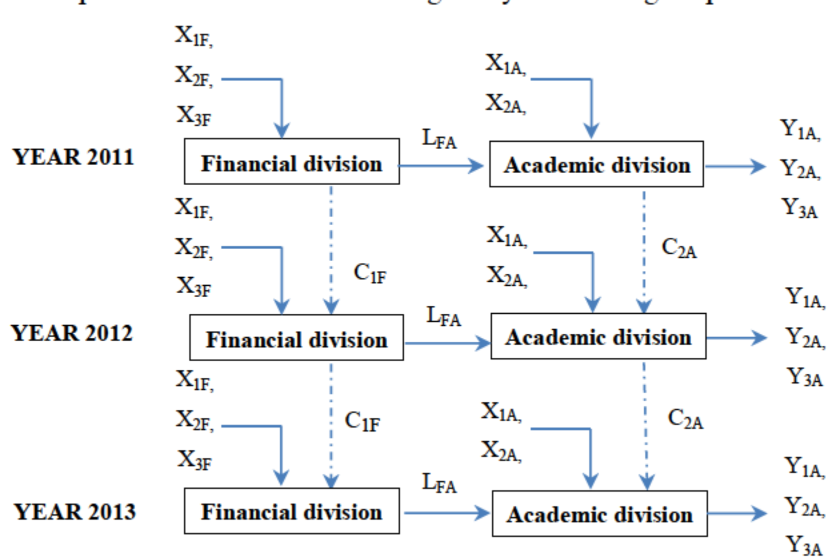
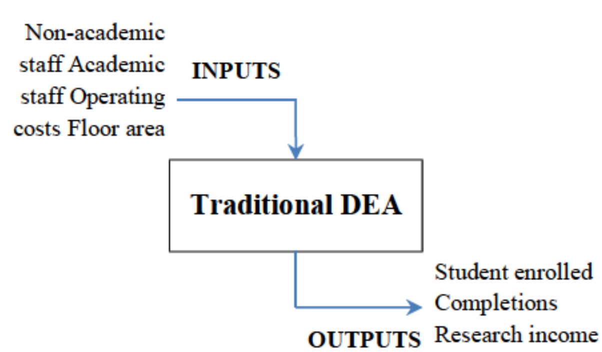


Table 3: Description of variables used in the empirical dynamic network model

Variables	Categories	Description
Financial division		
X_{1F}	Input	The number of non-academic staff working for financial division
X_{2F}	Input	The tuition fees
X_{3F}	Input	The government funding
L_{FA}	Link	The operating expenditure
C_{1F}	Carry-over	Research incomes from academic research and consultancy services
Academic division		
X_{1A}	Input	The number of non-academic staff serving the academic operations
X_{2A}	Input	The number of academic staff
Y_{1A}	Output	The number of undergraduates enrolled
Y_{2A}	Output	The number of postgraduates enrolled
Y_{3A}	Output	The number of graduates (completions)
C_{2A}	Carry-over	Floor area for academic spaces

Figure 2 illustrates the traditional "black-box" DEA model including inputs and outputs used in this model. It is noted that inputs and outputs of the standard DEA model are integrated based on the operating context of HEIs. For this model, inputs include non-academic staff, academic staff, operating costs and the area for academic spaces. Floor area for academic spaces is a compulsory condition for each university as regulated by the government. Outputs consist of the numbers of full-time equivalent students, graduates, and research income. Due to insufficient data and being beyond our objectives, we do not account for output quality such as the percentage of graduates who find employment. Research income is used in this model to control for research output.

Figure 2: The traditional "black-box" DEA model



The statistical summary for variables used in the dynamic network and traditional DEA models is presented in Table A1 in the Appendix. It is widely recognised that DEA results can be sensitive to outliers. Hence, before implementing the performance analysis of HEIs, we endeavoured to identify these outliers. We adopted the procedure of identifying outliers used by Thanassoulis (1999) and used the concept of super-efficiency introduced by Andersen and Petersen (1993) to identify university outliers. Following Thanassoulis (1999), a threshold difference of super-efficiency of 10 percentage points can be applied to identify outliers. Accordingly, a subset of HEIs that had super-efficiency over 100 per cent and were parted from other inefficient colleges by a gap of 10 percentage points were identified as outliers. After outliers were identified, they were removed. Then, the super-efficiency measure was implemented again on the new subset of data to detect whether outliers existed in our sample. This process was repeated until there was not a gap of 10 percentage points in super-efficiency in our sample. This means no HEI in the final dataset was more than 10 percentage points in efficiency further away than any other units. Consequently, 18 university outliers were identified. Following the suggestions of Thanassoulis et al. (2011), after the outliers were identified, we did not allow them to affect the position of the efficiency boundary but held them with their data adjusted to sit on the boundary drawn on non-outlier HEIs.

5. Empirical findings

This part presents results of the dynamic network model for Vietnamese public universities across the period 2011–2013. Then, the overall efficiencies of this model are compared with those of the traditional DEA model for further analysis. Table 4 presents efficiency scores of universities from the dynamic network DEA model.

It is recognised that the greatest advantage of the network structure in the dynamic network model is that it allows us to observe the efficiency change independently for different internal structures. Findings reveal that the average level of estimated period-divisional efficiency of the financial division for the dynamic model increased from 0.739 in 2011 to 0.867 in 2012, then declined to 0.827 in 2013, resulting in a mean of 0.826 for the whole period. This implies that public universities are currently inefficient in their financial operations. In the financial division, there are 12 universities which obtained full efficiency of one. For the academic division, the period-divisional efficiency of universities fluctuated slightly across the three years, rising from 0.778 in 2011 to 0.868 in 2012 and then decreasing to 0.736 in 2013. Its average efficiency reached

0.782, less than that of the financial division for the three-year period. Hotelling's test indicated that changes in efficiency scores of financial and academic divisions across the three years are significant to the one per cent significance level.

Table 4: Dynamic network DEA efficiencies

Division	Year	2011	2012	2013	Overall
Dynamic Network	Mean	0.758	0.868	0.782	0.804
	Standard deviation	0.166	0.125	0.164	0.134
	Max	1	1	1	1
	Min	0.461	0.609	0.492	0.568
	Efficient universities	14	29	20	6
	Hotelling's test (F value)				45.70^{***}
Finance	Mean	0.739	0.867	0.827	0.826
	Standard deviation	0.194	0.150	0.175	0.136
	Max	1	1	1	1
	Min	0.404	0.550	0.473	0.581
	Efficient universities	20	42	33	12
	Hotelling's test (F value)				21.34^{***}
Academic	Mean	0.778	0.868	0.736	0.782
	Standard deviation	0.219	0.174	0.213	0.173
	Max	1	1	1	1
	Min	0.336	0.417	0.384	0.429
	Efficient universities	33	48	29	19
	Hotelling's test [a] (F value)				25.45^{***}

Note: *** denotes the significance level at 1%; [a] Hotelling's test for equal means among efficiency scores of three years.

With respect to the above analysis, it can be seen that in the years following Decree 49/2010/ND-CP of the government on tuition fees, efficiencies of public universities grew but suddenly decreased in 2013. In fact, in 2013, MOET officially suggested universities and colleges reduce the enrolment quotas for some fields of study, such as economics, finance, accounting, and education, because the unemployment rate of graduates of these fields of study had been mounting and had caused an imbalance in the labour force. Consequently, HEIs witnessed a sharp decrease in the enrolment quotas for these study areas in 2013. This might have influenced the financial resources of public universities via tuition fees in that year. It is evident that there was a decrease in the efficiencies of the financial and academic operations in 2013. However, whether this decrease can be attributed to the influence of the policy intervention is beyond our study because deterministic and causal relationships in this context are difficult to identify.

Table 4 indicates that the average overall efficiency obtained from the dynamic network model is 0.804. This suggests that, on average, public universities can potentially increase their efficiency by approximately 19.6 per cent. It is observed that the dynamic change in overall efficiency scores of universities as determined by the dynamic network model varies across terms, increasing slightly in 2012 before marginally declining in 2013. This fluctuation was caused by the divisional efficiencies of financial and academic operations across years.

Table 5: Spearman's rank correlation tests for universities

	OFD	OAD	ODN
Overall financial division (OFD)	1		
Overall academic division (OAD)	0.495***	1	
Overall dynamic network (ODN)	0.824***	0.892***	1

Table 5 presents Spearman's rank correlation coefficient among the period-divisional efficiencies of the financial and academic operations and the overall efficiency for the three-year period. The findings show that there is a significant association between efficiencies of the financial and academic divisions. However, this relationship is quite weak with the coefficient of 0.495 at the one per cent significance level. This may indicate that the linkage between financial and academic operations via the operating expenditure is not sufficiently strong to increase the efficiency of academic operations. In addition, the overall dynamic network efficiency is strongly correlated to the efficiency of the academic division rather than that of the financial division, 0.892 versus 0.824, respectively, at the one per cent significance level. This implies that the academic efficiency does indeed play a more dominant role in operations of public universities.

Figure 3: Scatter plots of the dynamic network efficiencies

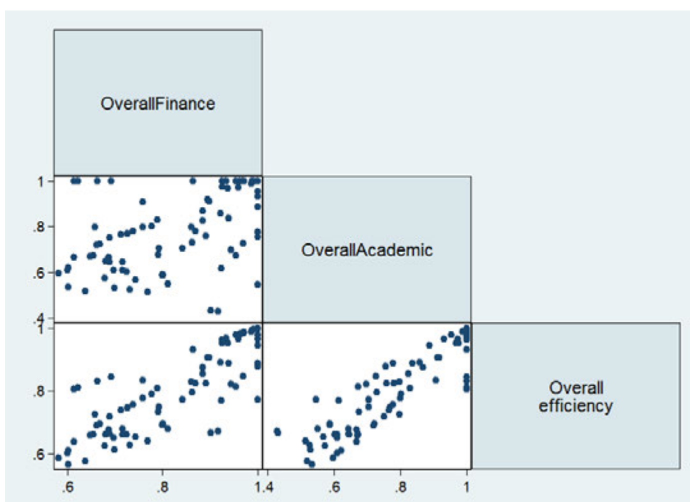


Figure 3 illustrates the efficiency distribution of public universities based on the dynamic network DEA model for each division and the overall organisation. It can be seen that efficiency of the financial division is distributed more discretely than that of the academic division. On the other hand, the overall efficiency of public universities is quite closely and densely distributed. This suggests the importance of both divisions in the operational efficiencies of public universities, although both divisions need to improve their performance to obtain the full frontier efficiency of one.

Regarding a further analysis of the overall efficiencies between the two models, the dynamic network and traditional DEA models, Table 6 shows that the efficiencies of public universities obtained from the traditional DEA model decreased across three years involved. On average, public universities could potentially improve their performance by 26.4 per cent. The number of efficient public universities in the traditional DEA model was quite high, 12, whereas the findings of the dynamic network model in Table 6 indicate that only 6 public universities showed full technical efficiency, accounting for 7.3 per cent of the total number of public universities in the reported sample. This implies that the dynamic network model provides stricter evaluation by screening universities that obtain full efficiency from financial and academic divisions. Based on this comparison, it is widely recognised that the dynamic network DEA model not only uncovers the efficiencies of multiple activities via different divisions that would have been hidden using the "black-box" traditional DEA, but explores the dynamic changes of the divisional and overall efficiencies across multiple periods as well.

Table 6: Traditional DEA efficiency scores

	2011	2012	2013	Overall
Mean	0.796	0.720	0.692	0.736
Standard deviation	0.210	0.226	0.211	0.185
Max	1	1	1	1
Min	0.407	0.346	0.342	0.428
Efficient units	34	27	19	12

We further investigated the differences in the efficiencies of public universities located inside and outside central cities. It is generally supposed that the metropolitan universities have an advantage as they can diversify outputs and efficiently use inputs because they have more chances to access advanced learning resources and different facilities for the learning process of students. As a result, they can increase financial resources via increased enrolments and improve their academic efficiency. Table 7 illustrates the efficiencies from the dynamic network model of public universities classified by their location.

Table 7: Efficiencies of public universities by location

Efficiency	In-city	Out-city	Z-value
Financial	0.846	0.790	-1.909*
Academic	0.810	0.734	-1.986**
Overall	0.828	0.762	-2.065**
Efficient units	5	1	
No. of universities	52	30	

Note: *** and ** denote significance at 1% and 5%, respectively.
Z-value is the Wilcoxon rank sum test

The results show that the metropolitan universities are more efficient than others in all cases, as expected. The distinction of efficiencies of the academic division between the in-city and out-city colleges is statistically significantly different to zero. The efficient public universities located in the city are higher in number than those outside the city, five and one, respectively.

6. Implications and conclusions

This paper provides insights about the financial efficiencies and their association with the academic and overall efficiencies of Vietnamese public universities across the three years, 2011–2013. The dynamic network DEA model is used to analyse the internal structure of each university and capture the dynamic changes of two divisions, financial and academic, that are linked together in universities' operations across multiple periods. Our findings contribute to the efficiency literature in higher education by exploring in-depth the organisational inefficiency via linking activities in the production process and by offering a better understanding about the financial efficiency of public universities under the current policies and regulations. This detailed information is useful for the government and educational leaders to reformulate policies for enhancing the operational efficiencies of public universities.

Despite the fact that the organisational structure of each university is diversified, the financial division is considered as one of the most important divisions in maintaining educational operations of the whole system. The financial division is responsible for assisting the board of institutional directors in maintaining a sound financial status as regulated by law and providing sufficient financial capacity to the academic division. In a network structure, the efficiencies of financial and academic operations establish the overall efficiencies of each university. Thus, they occupy important places in the whole production process of universities. Estimating the efficiency of each division and examining their correlations with each other and with the overall efficiency of universities is useful, especially in the context of financial difficulties.

Using the dynamic network approach, we reach the following important findings. First, the dynamic change in overall efficiency score of public universities varied across the period 2011–2013. Hotelling's test indicated that this variation is significant at the one per cent level. A closer look at the internal structure revealed that the period-divisional efficiency of the financial division decreased over three years ($p < 0.001$). This implies that Vietnamese public universities are inefficient in their financial operations, given the policies and regulations which were in effect at the time of the research. As can be seen, the financial efficiency of public universities showed an increasing trend in the years that followed Decree 49/2010/ND-CP on tuition fees. On the other hand, also following suggestions of MOET to limit the enrolment quotas to some indicated fields of study in 2013, levels of the financial and academic efficiencies of public universities decreased in that year. We have not attributed these changes to the influence of the policies because the complex nature of casual correlation in the context is not easy to identify. However, this may lead us to the managerial implication that the variations in the policy environment may inevitably influence the performance of universities to some extent.

Second, the overall dynamic efficiencies are linked to the academic efficiencies more strongly than to the financial efficiencies, 0.824 and 0.892, respectively. In addition, the relationship in efficiencies between financial and academic divisions is not particularly strong, being 0.495. Taking a closer look at individual public universities in the sample, we found that some universities were fully efficient in the financial division but they were inefficient in the academic division and vice versa. As a result, only six public universities were efficient for the whole period. Financial inefficiency of public universities can result from insufficient financial resources (Hayden, 2012) or from managerial financial inefficiency (Chau and Tran, 2015; Duong, 2013; Trinh, 2012). From institutional perspectives, HEIs may need to be aware that they obtain full overall efficiency only when they are efficient in both financial and academic operations. This means that HEIs should have a specific strategy for each division to reduce technical inefficiency in its divisional operations. Specifically, to obtain full efficiency, public universities should implement the strategy of output expansion and/or input saving for individual inputs, assuming that these inputs are purely disposable (see Table A2 of the Appendix for more detail). From policy perspectives, the top-down public budget distribution is not efficient because it has not created strong incentives for HEIs to better use their financial resources and, thus, there is a lack of innovation in teaching and research that inevitably leads to poorer education quality.

Finally, we examined differences in the efficiencies of public universities located inside and outside central cities. It was observed that the metropolitan public universities were more efficient than others. Likewise, the number of efficient universities in the city was greater than that of non-metropolitan universities. Building the network of HEIs in the provinces of Vietnam is an appropriate strategy to reinforce local socio-economic development via training and providing a highly-qualified labour force for the local economy (Pham, 2015a). However, to enable HEIs to keep abreast of the rapidly changing educational environment, the government and policymakers should put more favourable policies in place to enhance their performance.

Compared with the traditional DEA model, the dynamic network model provides a better understanding about efficiencies of universities via investigating in-depth the operational efficiency of each division in a unified framework. Hence, this helps managers of HEIs to design appropriate solutions for each division to improve the overall performance of institutions. Findings indicate that the dynamic network model provides a stricter assessment than the traditional DEA model. As a result of using the dynamic network model, only six universities were found to be efficient, whereas using the traditional DEA model, 12 were regarded as efficient. This reflects the fact that the dynamic network model is an appropriate model and should be chosen to explore the network structure with multiple divisions and multiple missions in a production process such as higher education.

However, further studies should be undertaken to supplement our empirical findings. First, more divisions such as research, administration, and student employability, should be investigated in a network structure to evaluate in more detail the efficiencies of each division. Second, differences in characteristics of universities such as reputation, location, specialised training programs, leadership skills, and other external factors should also be taken into account to assess the performance of public universities. Third, because the reporting system of the Vietnamese higher education system has not been adequate, some variables, for example, percentage of students of graduates who gain employment or the number of publications, were not included in our study. Therefore, it is desirable to have more variables to make more thorough evaluations.

Appendix

Table A1: Summary statistics of variables used in dynamic network DEA model of public universities

	Unit	Mean	SD	Min	Max
Inputs					
Non-academic staff	Person	175	14	42	718
For financial division	Person	58	43	14	239
For academic division	Person	117	93	28	479
Academic staff	Person	414	328	62	2123
Tuition fees	Billion VND	50	60	0.13	330.7
Government funding	Billion VND	39	35	0.10	167.56
Linking/carry-over variables					
Operating cost	Billion VND	71	61	0.67	279.50
Research income	Billion VND	20	41	0.001	344.54
Floor area for academic spaces	1,000 m^2	31	36	2.49	32.60
Outputs					
Postgraduates	Student	791	1,178	0	5,964.4
Undergraduates	Student	10,204	9,255	406	46,172
Graduates	Student	2,245	2,261	67	18,126

Table A2: Target inputs and outputs of public universities

Division	Unit	Variables	Current	Target	Saving	Expansion
Financial division						
Non-academic	Person	Input	58	44	14	
Tuition fees	Billion VND	Input	50	47	3	
State funding	Billion VND	Input	39	34	5	
Research income	Billion VND	Input	20 2	17.8	2.4	
Operating costs	Billion VND	Output	70 9	70.9		0
Academic division						
Operating cost	Billion VND	Input	70 9	58.9	12.0	
Non-academic	Person	Input	116	88	28	
Academics	Person	Input	413	316	97	
Floor area	1,000 m^2	Input	31.6	28.6	3.0	
Postgraduates	Student	Output	834	941		107
Undergraduates	Student	Output	10,394	10,657		263
Completions	Student	Output	2328	2484		156

Notes:

- Current quantities are the existing levels of inputs and outputs being used by HEIs
- Target quantities are the levels of inputs and outputs suggested to obtain the full efficiency
- Saving or expanding quantities are the levels of inputs and outputs that should be saved or expanded to reach the full efficiency.

Chapter 9: Measuring efficiency of Vietnamese public colleges: An application of the DEA-based dynamic network approach [8]

Abstract

Public colleges play a crucial role in shaping the socioeconomic and educational development strategies in Viet Nam and provide a skilled labour force needed in the country's market-oriented economy. Using balanced panel data for 2011–2013, we employ the integrated DEA-based dynamic network model to examine dynamic changes in efficiencies of public colleges in the sector. This model allows simultaneously estimating efficiencies of financial and academic operations and the overall dynamic changes of colleges in a network structure. Our findings indicate that the overall efficiencies of colleges are, on average, 0.741, whereas the average efficiencies of the financial and academic operations are 0.722 and 0.760, respectively. Further, the in-city colleges are more efficient than others, 0.776 and 0.728, respectively.

Key words: Data envelopment analysis, dynamic network efficiency, public colleges, Viet Nam

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1. Introduction

Higher education is considered one of the crucial organs of a nation's socioeconomic system because it plays an important role in the development of human resources and is an efficiency enhancer for national competitiveness beyond simple production processes (Schwab, 2013). In today's global trends, financial challenges and the demands for more efficiently using the scarce resources of higher education institutions (HEIs) have made the efficiency assessment of HEIs become crucial for the government and educational leaders to better understand about performance of HEIs. Thereby, more appropriate polices can be designed to enhance the operations of HEIs.

Public higher education plays a dominant role in the Vietnamese higher education system. According to the Ministry of Education and Training ([MOET], 2013), the number of public HEIs, comprising universities and colleges, is 338, and accounts for 80 per cent of the total number of HEIs in Viet Nam. Of the 338 public institutions, 185 are colleges and 153 are universities. During 2005–2012, the numbers of college enrolments and graduates increased, respectively, by 142 per cent and 160 per cent, whereas university enrolments and graduates increased by only 42 per cent and 74 per cent, respectively (MOET, 2013). This illustrates the significant role of colleges in providing the labour force for the national economy. However, the importance of colleges has not received as much attention as universities. Perhaps policymakers and researchers are inclined to emphasise the performance of universities in order to get at least one university among the world's top 200 by 2020, as planned by the government. Previous studies have mainly focused on exploring and analysing impacts of government policies on universities rather than colleges (Hayden and Lam, 2007; Vallely and Wilkinson, 2008; Postiglione, 2011; Hayden, 2012; Pham, 2012).

Our study examines the performance of public colleges in Viet Nam for two main reasons. First, public colleges are very important in the national education system because of the large number of institutions and their enrolments. Currently, 86.5 per cent of all colleges in Viet Nam are publicly owned and their enrolments accounted for 81.3 per cent of total college enrolments in 2012/2013 (MOET, 2013). Second, regardless of revenues from tuition fees, the operations of public colleges mainly rely on public funding, and its distribution has been based on the difference between the budget estimates approved for their annual operations and revenues from tuition fees. Duong (2013) argued that with such a top–down budget distribution mechanism, public HEIs seem to lack self-motivation to improve their performance with respect to financial and academic operations. In this sense, it is imperative to examine whether public colleges are operating efficiently in the current financial mechanism and whether the financial operations are favouring the academic operations, and the performance of public colleges as a whole.

Using the advanced dynamic network data envelopment analysis (DEA) model, we measure dynamic change in efficiencies of public colleges in a network structure for 2011–2013. This method allows us to capture the dynamic changes of multiple activities via different divisions, for example, finance and teaching, over multiple terms and to examine the correlation in efficiencies of financial operations with those of the overall operations of public colleges. We expect results of our study to provide a better understanding of the performance of public colleges for policymakers and educational leaders for seeking possible ways to move Vietnamese higher education forward.

The structure of our paper consists of the following sections: Section 2 presents the general context of higher education in Viet Nam. Section 3 presents a brief review of the DEA studies in higher education. Section 4 illustrates the theoretical method of dynamic network DEA. The empirical model applied for Vietnamese public colleges is presented in Section 5. Section 6 provides the empirical results of efficiencies of public colleges in a network structure before presenting conclusions in Section 7.

2. The general context of higher education in Viet Nam

The economic reform of Viet Nam, known as *Doi Moi* (reform) policy, which started in 1986, is strongly linked to education reform. However, not until 1995 did the Vietnamese economy really permit foreign direct investment to enhance its economic growth. Subsequently, Viet Nam became one of the fastest growing economies in the world with its GDP growing by an average of seven per cent per annum during the period 1989–2010 (World Bank, 2011). This created a strong impetus for Viet Nam to reform its higher education system. The year 1997 was a turning-point for Vietnamese higher education when Resolution 90/1997/NQ–CP, dealing with education, health and culture, was introduced, private education for officially encouraging. Following this, several policies have been promulgated to favour the operating environment of the higher education sector, especially Resolution 14/2005/NQ–CP on comprehensively reforming Vietnamese higher education. This is the so-called "Higher Education Reform Agenda", which has been considered the landmark guidelines for the reform of Vietnamese higher education.

After nearly 20 years since the initiation of the reform process in 1997, Vietnamese higher education has achieved significant growth in the numbers of institutions, enrolments, and research activities. In 2012/13, Viet Nam had a total of 421 HEIs comprising universities and colleges, of which 214 were colleges. The number of private HEIs accounts for 19.7 per cent of the current total number of HEIs, with 83 private HEIs. The number of academic staff increased remarkably to more than 87,000 in 2012/2013, which is 2.5 times greater than the number in 1999/2000 (MOET, 2013). Regarding academic research, the number of articles by Vietnamese researchers published in international journals shows an increasing trend over the period 2008–2012, with an increase from 955 to 1731 articles, mainly from a few large universities. However, this number of articles was quite low relative to other Asian countries such as Singapore, Malaysia, and Thailand (Hien, 2010; Thanh, 2012; Hoang, 2013). In addition, MOET initiated co-operation with foreign universities to develop 23 advanced curricula at 17 selected universities. These programmes use English as the medium of teaching and learning, and are assessed against the educational standards of foreign universities (Vu, 2012).

The Vietnamese higher education system includes two main kinds of institutions: universities (including research institutes) and colleges. According to the 2012 *Law of Higher Education*, although universities and colleges are categorised as HEIs, they operate under relatively heterogeneous environments. Specifically, universities train students for a period of four years (bachelor degrees), whereas colleges train students for only three years (associate bachelor degrees). Only universities offer postgraduate programs. In addition, research outputs of universities focus on academic research but those of colleges are primarily related to projects of technological transfers and consultancy services. Moreover, colleges tend to train students with more practical skills, whereas universities are inclined to teach students research skills. The teaching technologies and outputs of universities and colleges are relatively distinct in nature. Furthermore, universities and colleges are governed by different regulations. In many cases, the government has issued separate regulations for universities and colleges. Any regulation issued for both types of institutions would have different indicators required for universities and colleges. In general, the government has had different requirements for assessing the performance of universities and colleges.

Although the role and position of universities has stimulated much concern among policymakers, researchers, and the community, colleges seem to be neglected. In fact, colleges make significant contributions to tertiary education by providing a highly technical labour force to the economy. Table 1 illustrates the growth in numbers and enrolments of colleges over different periods.

Table 1: Growth of institutions and enrolments of colleges over years

	1999–2000	2005–06	2012–13
Institutions			
Public	79	142	185
Private	5	12	29
Total	84	154	214
Enrolments			
Public	161,793	277,176	589,039
Private	12,119	22,118	135,193
Total	173,912	299,294	724,232
Share of total national enrolment			
Public (%)	18.1	20.0	27.1
Private (%)	1.4	1.6	6.2
Total (%)	19.5	21.6	33.3

Source: MOET (2013)

It can be seen that public colleges occupy an important place in the college groups with respect to the number of institutions and enrolments. In the academic year 2012/2013, public colleges accounted for 33 per cent of the total national enrolments, equivalent to 46 per cent of the total enrolments in public higher education. The substantial contribution of public colleges is worth recognising. Hence, research on the performance of public colleges should be of interest along with the performance of public universities.

Like public universities, public colleges benefit from public funding and the tuition fee policy. In 2010, the government issued Decree 49/2010/ND–CP on tuition fees allowing public HEIs to increase the tuition fees for 2010/11–2014/15 within the regulated ceiling tuition framework. It should be noted that public HEIs are not permitted to charge students fees exceeding the allowed ceiling tuition levels for each group in different fields of study. Public colleges are only allowed to charge students 80 per cent of the ceiling tuition levels. As instructed in the Joint Circular 20/2014/TTLT–BGDDT–BTC–BLDTBXH, the government provides state funding to public colleges based on the difference between the total budget estimates approved for their annual operating expenses and total revenues from tuition fees of students. That is, if public colleges receive higher revenues from tuition fees, the government would provide less state funds for their operations and vice versa.

With this government support, public colleges are expected to demonstrate a higher level of efficiency in their operations, which would be considered as one of the important stimuli to increase the quality of education, as well as the competitiveness capacity of the nation's economy (Kabok, et al., 2013; Nazarko and Saparauskas, 2014). However, the performance of public colleges has not been investigated to see whether this financial resource has been used efficiently and contributed well to the academic operations. Hence, it is timely and fitting to undertake research on these matters, the results of which will provide useful information for public colleges to improve their performance.

3. Using DEA to measure efficiency in higher education: A brief review

DEA is a well-known nonparametric method widely applied in operations research to estimate the efficiency of firms. Handling multiple outputs as well as multiple inputs without specifying the relationship between variables and without requiring price information is an advantage of this method. The majority of studies in the higher education sector have used the standard DEA to assess efficiencies of HEIs, such as Abbott and Doucouliagos (2003, 2009), Agasisti et al. (2012), Agasisti and Pohl (2012), Castano and Cabanda (2007a, 2007b), Fu and Huang (2009), Johnes (2006), Johnes and Johnes (2009), and Kuah and Wong (2011, 2013). However, measuring efficiency in the higher education sector is complicated as this is a diverse and multi-faceted sector (Carrington et al., 2005; Emrouznejad and Thanassoulis, 2005). Higher education not only uses multiple inputs to produce a diversity of outputs, but has multiple divisions as well. Hence, using the standard DEA, referred to as the "black-box" model does not take into account the internal structure of HEIs that links multiple activities from different divisions in the production process.

It is widely recognised that HEIs have multiple missions, including teaching, research, and knowledge transfer, via training services and project consultancies, thus using multi-inputs to produce multiple outputs. In addition, like other sectors, HEIs face some intervening steps or linking activities, for example, academic (teaching, research), administrative, and financial operations, in the production process. This suggests that to obtain the overall full efficiency, each division should be efficient. However, the standard DEA model fails to estimate divisional efficiency.

To address this problem, the network DEA model was proposed by Färe and Grosskopf (1996a, 1996b, 2000a). Their models have been extended by several studies to investigate the (in)efficiency of intermediate steps to seek more specific and better solutions for efficiency improvement of firms in different fields. Such studies include those of Lewis and Sexton (2004), Yu and Lin (2008), Tone and Tsutsui (2009), Chen and Yan (2011), Rostamy-Malkhlifeh et al. (2013), and Matthews (2013). Also, the network DEA can provide a methodology capable of assessing efficiencies of internal activities and overall efficiencies of HEIs in a unified framework.

In higher education, to our knowledge, two studies applied the network DEA to the internal structure of the production process of HEIs. The first study (Johnes, 2013) applied the Tone and Tsutsui (2009) model to construct a two-node (teaching and students' employability) network DEA framework for 94 English HEIs in the 2011/12 year. The findings revealed differences in efficiencies of each node and the overall evaluation in the network DEA. In addition, most of the efficiency scores of the network DEA were less than the standard DEA model. It is clear that the network DEA model has provided more specific details about the (in)efficiency of each node, which can be useful for educational managers to formulate appropriate strategies for the development of their institutions. The second study (Monfared and Safi, 2013) applied the network DEA model with two nodes, teaching and research, to analyse the academic performance of nine academic colleges of Alzahra University in Iran. Their findings showed that the overall teaching quality of Alzhra University was better than its research productivity. However, as the number of observations in this study was small relative to the number of inputs and outputs, the discriminating power of the analysis may be limited.

Capturing the dynamic change-over periods has attracted much concern in recent DEA research. Whereas the traditional DEA method only focuses on a single period, the dynamic DEA model can measure the inter-temporal efficiency change using carry-over variables. The first approach for this purpose was proposed by Klopp (1985) for the window analysis. Färe et al. (1994) proposed the Malmquist index in the DEA framework based on the work of Malmquist (1953). Then, the dynamic DEA model formally suggested by Färe and Grosskopf (1996a) was the first innovative method to cope with the linking activities. Furthermore, Tone and Tsutsui (2010) extended their model using slacks-based measurement proposed by Tone (1999) and Pastor et al. (1999). The Tone and Tsutsui model is non-radial and thus can be used with inputs/outputs individually with non-uniform input/output factor efficiency, whereas the radial approaches assume the proportional changes in inputs/outputs and provide only uniform input/output. With this model, weights to input/output items can be set according to their importance.

A combination of the dynamic and network models was proposed by Tone and Tsutsui (2014)–the so-called "dynamic network DEA model"–to account for internal heterogeneous divisions of firms. These divisions are linked together by the connecting variables and internal products. The dynamic network model can provide estimates for the overall efficiency over the whole surveyed period, and the dynamic changes in both the period efficiency and the divisional efficiency. To our knowledge, exploring this model in empirical studies in higher education is still limited; thus, this establishes the basis of our paper, which makes the following empirical contributions. First, this is the first study to apply the DEA-based dynamic network model to higher education, particularly in Viet Nam, to explore in-depth the organisational dynamic efficiency obtained from intervening activities of different divisions in a unified framework. Second, this is also the first study of financial and academic divisions in a network structure to be explored in higher education, which allows the separate estimation of the efficiency of financial and academic operations of colleges. Finally, we examine how strongly divisional efficiencies are correlated to the overall efficiencies and also compare the dynamic network efficiency with the overall efficiency obtained from the traditional DEA model.

4. Methodology

In this section, we present the theoretical method of the dynamic DEA model with network structure before presenting the empirical model applied to Vietnamese public colleges in the next section.

Following Tone and Tsutsui (2014), the dynamic network slacks-based approach is defined by the following mathematical programming formulae.

Assume that n HEIs $(j = 1, \dots, n)$ consist of K divisions $(k = 1, \dots, K)$ over T time periods $(t = 1, \dots, T)$. Let m_k and r_k be the numbers of inputs and outputs to division k, respectively. The link leading from division k to division h is denoted by $(kh)_i$ and the set of links by L_{kh}. The inputs, outputs, linking, and carry-over variables are described as follows:

$x_{ijk}^{t} \in R_{+}$ $(i = 1, \dots, m_k; j = 1, \dots, K; t = 1, \dots, T)$ is the input resource i to HEI_j for division k in period t;

$y_{rjk}^{t} \in R_{+}$ $(r = 1, \dots, r_k; j = 1, \dots, K; t = 1, \dots, T)$ is the output product r from HEI_j, division k, in period t;

$z^t_{j(kh)_l} \in R_+$ $(j = 1, \dots, m_k; l = 1, \dots, L_{kh}; t = 1, \dots, T)$ is the linking intermediate products of HEI_j from division k to division h in period t, where L_{kh} is the number of items in the link from k to h; and

$z^{(t,t+1)}_{jk_l} \in R_+$ $(j = 1, \dots, m_k; l = 1, \dots, L_k; k = 1, \dots, K; t = 1, \dots, T-1)$ is the carry-over of HEI_j, at division k, from period t to period $t+1$, where L_k is the number of items in the carry-over from division k.

Let the production possibility set $P^t = \left\{(x^t_k, y^t_k, z^t_{(kh)}, z^{(t,t+1)}_{ik})\right\}$ $(t = 1, \dots, T)$ be defined by

$$x^t_k \geq \sum_{j=1}^{n} x^t_{jk}\lambda^t_{jk} \ \ (\forall k, \forall t)$$

$$y^t_k \leq \sum_{j=1}^{n} y^t_{jk}\lambda^t_{jk} \ \ (\forall k, \forall t)$$

$$z^t_{(kh)_t} = \sum_{j=1}^{n} z^t_{j(kh)_t}\lambda^t_{jk} \ \ (\forall \mathrm{l}, \forall (kh)_l, \forall t)(as\ outputs\ from\ k\ in\ period\ t)$$

$$z^t_{(kh)_t} = \sum_{j=1}^{n} z^t_{j(kh)_t}\lambda^t_{jh} \ \ (\forall \mathrm{l}, \forall (kh)_l, \forall t)(as\ inputs\ from\ h\ in\ period\ t)$$

$$z^{t(t+1)}_{k_l} = \sum_{j=1}^{n} z^{t(t+1)}_{jk_l}\lambda^t_{jk} \ \ (\forall \mathrm{l}, \forall (kh)_l, \forall t)(as\ carry-over\ from\ period\ t)$$

$$z^{t(t+1)}_{k_l} = \sum_{j=1}^{n} z^{t(t+1)}_{jk_l}\lambda^{t+1}_{jk} \ \ (\forall \mathrm{l}, \forall (kh)_l, \forall t)(as\ carry-over\ to\ period\ t+1)$$

$$\sum_{j=1}^{n} \lambda^t_{jk} = 1\ (\forall k, \forall t), \lambda^t_{jk} \geq 0\ (\forall j, \forall k, \forall t)$$

where $\lambda^t_k = \left\{\lambda^t_{jk}\right\} \in R^n_+$ is the intensity vector corresponding to division $k, \forall k$ at $t, \forall t$.

It is assumed that at the initial period 1, there are no linking inputs and no carry-over from the previous period and, at the terminal period, T, there are no linking outputs from the terminal division and no carry-over to the next period.

- *Input-output constraints*

For firm$_o$ $(o = 1, \dots, n \in \mathrm{P}^t)$, input and output constraints can be expressed by

$$x^t_{ok} = X^t_k\lambda^t_k + s^{t-}_{ko}\ (\forall k, \forall t)$$

$$y_{ok}^{t} = Y_k^t \lambda_k^t - s_{ko}^{t+} \ (\forall k, \forall t)$$

$$e\lambda_k^t = 1 \ (\forall k, \forall t)$$

$$\lambda_k^t \geq 0, s_{ko}^{t-} \geq 0, s_{ko}^{t+} \geq 0 \ (\forall k, \forall t)$$

where

$$X_k^t = (x_{1k}^t, \ldots, x_{nk}^t) \in R^{m_k \times n}$$

$$Y_k^t = (y_{1k}^t, \ldots, y_{nk}^t) \in R^{r_k \times n}$$

are input and output matrices, and $s_{ko}^{t-}$and s_{ko}^{t+} are, respectively, input and output slacks.

- *The linking constraints*

With regard to the linking constraints, the as-input link value case is used in this paper. This implies that the linking activities are treated as input to the succeeding division and excesses are accounted for in the input inefficiency. The linking constraint is shown as:

$$z_{o(kh)in}^{t} = Z_{(kh)in}^{t} \lambda_k^t + s_{o(kh)in}^{t} ((kh)in = 1, \ldots, linkin_k)$$

where $s_{o(kh)in}^{t} \in R^{L_{(kh)in}}$ are slacks and non-negative, and $linkin_k$ is the number of as-input links from division k.

- *The carry-over linking constraints*

The formula for the carry-over linking constraints is generally expressed as follows:

$$\sum_{j=1}^{n} z_{jk_l\alpha}^{t(t+1)} \lambda_{jk}^{t} = \sum_{j=1}^{n} z_{jk_l\alpha}^{t(t+1)} \lambda_{jk}^{t+1} \ (\forall \text{k}; \ \forall k_l; t = 1, \ldots, T-1)$$

where α denotes good, bad, free or fixed variables as described by Tone and Tsutsui (2014).

As for carry-over activities, the assets including capital and property are utilised as carried-over link variables in two nodes of financial management and academic operations. Based on the categories proposed by Tone and Tsutsui (2010; 2014), the assets in our model were treated as "capital inputs" as in the as-input model above. In the Vietnamese context, colleges should use and manage capital assets efficiently. Likewise, floor area for academic spaces should be used in the best way.

In this case, the equation for the carry-over constraints is specifically illustrated as follows:

$$z_{ok_l carry}^{t(t+1)} = \sum_{j=1}^{n} z_{jk_l carry}^{t(t+1)} \lambda_{jk}^{t} + s_{ok_l carry}^{t(t+1)} (k_l = 1, \ldots, ncarry_k, \forall \text{k}, \forall t)$$

- *The objective function*

We used the input-oriented approach to measure efficiencies of colleges in Viet Nam. The overall-, period- and divisional-efficiencies are depicted by the following formulae:

Period efficiency

$$\tau_0^{t*} = \sum_{k=1}^{K} w^k \left[1 - \frac{1}{m_k + linkin_k + ncarry_k} \left(\sum_{i=1}^{m_k} \frac{s_{iok}^{t-}}{x_{iok}^{t}} + \sum_{kh_t=1}^{linkin_k} \frac{s_{o(kh)_i in}^{t}}{z_{o(kh)_i in}^{t}} + \sum_{k_t=1}^{ncarry_k} \frac{s_{ok_i carry}^{t(t+1)}}{z_{ok_i carry}^{t(t+1)}} \right) \right]$$

Divisional efficiency

$$\delta_0^{t*} = \sum_{t=1}^{T} W^t \left[1 - \frac{1}{m_k + linkin_k + ncarry_k} \left(\sum_{i=1}^{m_k} \frac{s_{iok}^{t-}}{x_{iok}^{t}} + \sum_{kh_t=1}^{linkin_k} \frac{s_{o(kh)_i in}^{t}}{z_{o(kh)_i in}^{t}} + \sum_{k_t=1}^{ncarry_k} \frac{s_{ok_i carry}^{t(t+1)}}{z_{ok_i carry}^{t(t+1)}} \right) \right]$$

Period-divisional efficiency

$$\rho_0^{t*} = 1 - \frac{1}{m_k + linkin_k + ncarry_k} \left(\sum_{i=1}^{m_k} \frac{s_{iok}^{t-}}{x_{iok}^{t}} + \sum_{kh_t=1}^{linkin_k} \frac{s_{o(kh)_i in}^{t}}{z_{o(kh)_i in}^{t}} + \sum_{k_t=1}^{ncarry_k} \frac{s_{ok_i carry}^{t(t+1)}}{z_{ok_i carry}^{t(t+1)}} \right)$$

Overall efficiency

$$\theta_o^{*} = min \sum_{t=1}^{T} W^t \left[\sum_{k=1}^{K} w^k \left[1 - \frac{1}{m_k + linkin_k + ncarry_k} \left(\sum_{i=1}^{m_k} \frac{s_{iok}^{t-}}{x_{iok}^{t}} + \sum_{kh_t=1}^{linkin_k} \frac{s_{o(kh)_i in}^{t}}{z_{o(kh)_i in}^{t}} + \sum_{k_t=1}^{ncarry_k} \frac{s_{ok_i carry}^{t(t+1)}}{z_{ok_i carry}^{t(t+1)}} \right) \right] \right].$$

It should be noted that in the input-orientated model, the overall efficiency is the weighted arithmetic mean of the period efficiencies. The weighted parameters for period efficiency should be chosen to ensure the uniqueness issue in efficiency. Tone and Tsutsui (2014) suggested that the last period T has the top priority and those of previous periods decrease in order. Under this principle, the uniqueness issue can be accounted for.

5. Application to Vietnamese public colleges

5.1 Empirical model

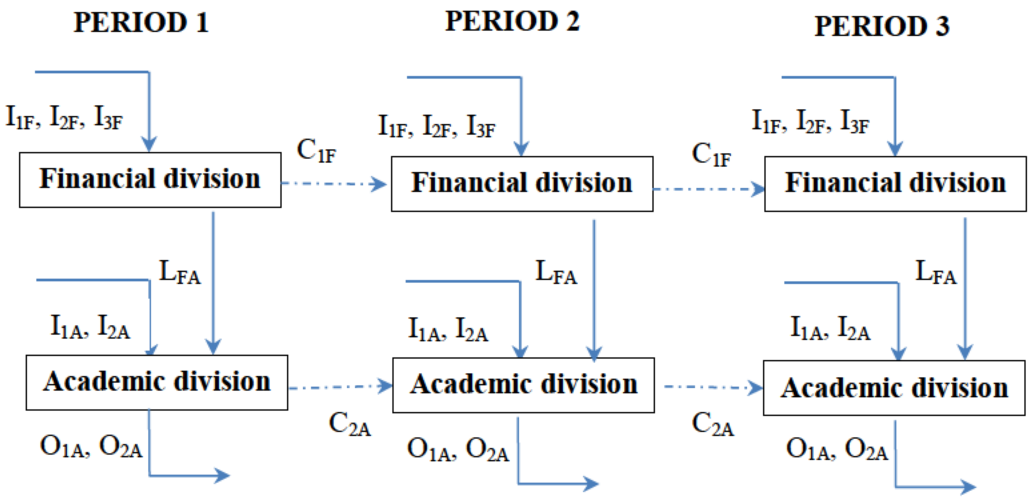
The above-mentioned theoretical model was applied to a dataset of 116 public colleges over the period 2011–2013 in a balanced panel. Of the 185 public colleges, only 125 complied with the government regulations to report fully their performance indicators for 2011-2013 and to send their reports to MOET as required. We obtained reliable data for our analysis from MOET and, after scanning these data, 116 public colleges were included in our empirical study. The number of public colleges in our sample accounted for 63 per cent of the total number of public colleges in Viet Nam.

For a network structure, we focused on two main divisions in the operational process of each public college, financial and academic divisions, without considering more detailed divisions, for example, research and administration (human resources, student support services, etc.). The reasons for this are as follows: (a) the financial and academic divisions are the most important and indispensable in the management structure of any college; and (b) other types of divisions vary widely across colleges depending on their real needs for managerial tasks. In addition, the detailed data to compute the efficiency scores for other types of divisions would have been difficult to obtain in the current context of Viet Nam.

For the two divisions chosen, it is observed that the major objective of the financial division is to assist the institutional board of management to manage a healthy financial situation using labour and capital inputs. This division is considered as the supporting unit for the academic division by providing financial resources. However, the main target of the academic division is to provide the educational services using operating expenditures that are maintained by the financial division. Both divisions occupy crucial places in the production process of colleges. Some previous studies using the standard DEA to measure efficiency of the academic operations have ignored activities of the financial division, by either input or output variables. The dynamic network model enables examination of the activities of both divisions independently and observation of their dynamic changes over the periods of time.

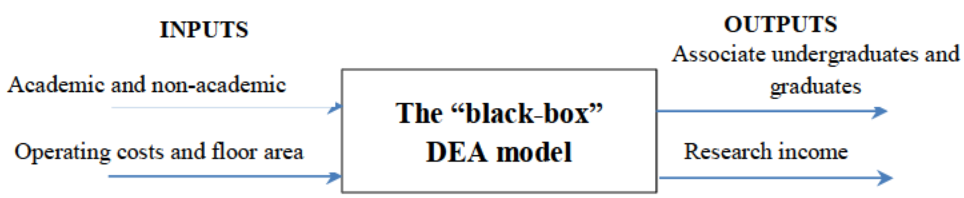
Figures 1 and 2 present the empirical framework for measuring the dynamic change of efficiencies of public colleges and the traditional "black-box" DEA model. It should be noted that inputs and outputs of the standard DEA model are integrated based on the operating context of colleges and as used in recent studies in higher education. For this model, inputs include non-academic staff, academic staff, floor area for academic spaces, and operating costs. Floor area for academic spaces is one of the compulsory conditions for each college to set their own enrolment quotas annually as regulated by the government. Outputs consist of the numbers of associate undergraduate students, graduates, and research income from consultancy services.

Figure 1: Empirical model for the dynamic network model



Source: Authors' own model adapted from Tone and Tsutsui (2014)

Figure 2: The 'black-box' DEA model



Descriptions of the inputs, outputs, links, and carry-overs for this model are presented in Table 2. One labour input and two capital inputs are used for the financial division. The financial division provides the operating expenditures to the academic division and keeps the financial status sound. Thus, administrative staff should be used for managing the financial situation of colleges. For capital inputs, we use tuition fees and the government funding as the main income sources of colleges to cover their operating expenditures. All capital inputs are deflated by the annual inflation rate to provide real values of these inputs for 2011–2013.

Table 2: Description of variables used in the empirical dynamic network model

Variable	Category	Description
Financial division		
I_{1F}	Input	Number of non-academic staff working for the financial division
I_{2F}	Input	Tuition fees
I_{3F}	Input	Government funding
L_{FA}	Link	Operating expenditure
C_{1F}	Carry-over	Research incomes from consultancy services
Academic division		
I_{1A}	Input	Number of academic staff
I_{2A}	Input	Number of non-academic staff serving the academic operations
O_{1A}	Output	Number of full-time equivalent undergraduate students
O_{2A}	Output	Number of graduates (the completed students)
C_{2A}	Carry-over	Floor area for academic spaces

For the academic division, two labour inputs were used including academic staff and non-academic staff. Most academics participate in teaching and research activities, whereas non-academic staff undertake tasks of administering students, teaching staff and research staff, and generally facilitating the academic process. We used the total numbers of graduates and associate undergraduate students as outputs for this division. The number of student enrolled was used as an output, as under the production function they are considered as resource users of colleges. The research output of publications was not included in our model because, unlike universities, colleges are inclined to implement projects of technological transfer and consultancy services rather than focus on international publications, conference papers, book reviews, et cetera. As a result, such research output has rarely been presented in the academic activities of public colleges.

The linking variable acts as an intermediate product which makes a major difference between the dynamic network DEA model and the traditional DEA model. This variable was simultaneously an output from the financial division and an input to the academic division. Using an intermediate product, the multiple production stages were estimated among divisions in a college. In this research, the operating expenditure was used as a linking variable from the financial division to the academic division. We accepted a discretionary-free link, where the linking activity could increase or decrease in each period. The reason for this was that the academic division would likely discuss with the financial division to change the operating expenditures based on the number of students.

The carry-over variable is one of the advantages of the dynamic network DEA model that accounts for the effects of the linking activities between sequential periods. For the financial division, research income was set as an undesirable carry-over because its source comes from research projects that may be undertaken over some years. Thus, colleges use it as a net income surplus and carry it over to the next period. Theoretically, this carry-over should be considered as a desirable (good) variable and treated as an output. However, in the case of the capital asset, it is usually treated as a capital input as in the as-input model (Tone and Tsutsui, 2010). This is totally relevant to the Vietnamese context, where, in any case, colleges should save their inputs to obtain the optimal outputs. Thus, the undesirable carry-over was used as the linking activity from period t to period t+1 and treated as an input.

In the academic division, floor area for academic spaces was chosen as an undesirable carry-over because it was attributed as a quasi-fixed input that was not only used in the current period but also carried over to the next period. Colleges are required to efficiently use their property assets, thus this variable should be treated as a capital input, as in the as-input model to connect activities from periods t to t+1. The statistical summaries for variables used in the dynamic network and traditional DEA models are shown in Table A in the appendix.

Weights for periods and divisions need to be pre-determined in the dynamic network DEA approach. In Viet Nam, the government allowed public colleges to increase their tuition fees in the regulated framework over the period 2010/11–2014/15. This means that tuition fees of the following year would be set at a higher level than the level of the current year. In other words, the last period 3 has the top priority and those of the periods 2 and 1 decrease in this order. Presumably, the two divisions, financial management and academic operations, are of equal importance because, in the context of facing financial difficulties, public colleges should simultaneously manage their financial resources and carry out academic operations efficiently. Details of weights for divisions and periods are presented in Table 3.

Table 3: Weights for periods and divisions

Year	Weight	Division	Weight
2011	0.15	Financial management	0.5
2012	0.30	Academic operations	0.5
2013	0.55		

5.2 Detection of outliers

As DEA is a deterministic frontier method that does not account for random noise in the data-generating process, DEA results can be sensitive to extreme data points. Thanassoulis et al. (2011) argued that such data points can considerably influence the location of the efficient boundary by their isolated positions. Hence, before implementing the performance analysis of the colleges involved, we sought to identify any so-called outliers. We consider these observations as simply those that show exceptionally high efficiencies relative to the rest of the observations in the sample, rather than being outliers in the statistical sense. Thanassoulis et al. (2011) expounded that outliers with poor performance are not of concern in DEA because these outliers do not influence the position of the efficient boundary that, in turn, forms the reference plane for all estimated efficiencies.

In this study, we adopted the procedure of identifying outliers used by Thanassoulis (1999). Using the concept of super-efficiency, introduced by Andersen and Petersen (1993), we first identified the colleges with exceptional achievement relative to the efficient boundary drawn on the remaining colleges. Then, based on the super-efficiency measure, we assessed how far these colleges were from the rest of the colleges and decided whether they were treated as outliers or not. Thanassoulis suggested that a threshold difference of super-efficiency of 10 per cent can be applied to identify outliers. Following this, colleges with super-efficiency over 100 per cent and separated from other inefficient colleges by a gap of 10 per cent were identified as outliers. For the first round, six outlier colleges were identified and removed. Then, we again implemented the super-efficiency measure to detect whether outliers were present in our sample. As a result, three outliers were detected and removed. For the third round, there was no gap of 10 per cent in super-efficiency in our sample. This means that no college in the final dataset was more than 10 per cent in efficiency further away than some other units.

Following the suggestions of Thanassoulis et al. (2011), after the nine outliers were identified, we did not allow them to affect the position of the efficiency boundary but held them with their data adjusted to sit on the boundary drawn on non-outlier colleges.

6. Empirical findings

This section presents results of the dynamic network model for Vietnamese public colleges for 2011–2013. Then, the overall efficiencies of this model are compared with the traditional DEA model for further analysis. In addition, the efficiencies of public colleges in different locations are also examined. Table 4 presents efficiency scores of colleges from the dynamic network DEA model.

Table 4: Dynamic network efficiencies of colleges

Division	Year	2011	2012	2013	Overall
Dynamic network	Mean	0.739	0.773	0.723	0.741
	Standard deviation	0.144	0.152	0.149	0.131
	Min	0.481	0.463	0.451	0.473
	Max	1	1	1	1
	Efficient colleges	10	21	12	4
	Hotelling's test				8.08***
Financial	Mean	0.716	0.756	0.704	0.722
	Standard deviation	0.207	0.207	0.198	0.160
	Min	0.371	0.364	0.378	0.404
	Max	1	1	1	1
	Efficient colleges	29	40	25	9
	Hotelling's test				3.01*
Academic	Mean	0.763	0.790	0.742	0.760
	Standard deviation	0.155	0.184	0.174	0.133
	Min	0.363	0.321	0.435	0.526
	Max	1	1	1	1
	Efficient colleges	19	41	27	8
	Hotelling's test				2.74*

Note: *, *** denote significance at 10% and 1%, respectively.
Hotelling's test for equal means among efficiency scores of three years

The average overall efficiency obtained from the dynamic network model is 0.741. This suggests that, on average, public colleges could potentially increase their efficiency by approximately 25.9 per cent. It is observed that the dynamic change in overall efficiency scores of colleges, as determined by the dynamic network model, varies across years, increasing slightly from 2011 to 2012 before declining in 2013. This fluctuation is affected by the divisional efficiencies of financial and academic operations across years.

Analysis of divisional efficiencies in the dynamic network model allows us to observe the efficiency change independently for different internal structures. Our results show that the average level of estimated divisional efficiency of the financial division for the dynamic network model increased 0.04 (from 0.716 in 2011 to 0.756 in 2012) and then decreased by 0.052 (to 0.704 in 2013), and had a mean of 0.722 for the whole period. On average, public colleges need to improve their financial efficiencies by 27.8 per cent to obtain the full efficiency score.

For the academic division, the period-divisional efficiency of colleges fluctuated slightly across the three years, increasing by 0.027 (from 0.763 in 2011 to 0.790) in 2012 and then decreasing by

0.048 (to 0.742 in 2013). The efficiency of this division moved in the same direction with the financial division, especially in 2013 when the efficiencies of both divisions declined. In fact, in 2013, MOET officially suggested that colleges (and universities) should reduce the enrolment quotas for some fields of study such as economics, finance, accounting, and education because the unemployment rate of graduates in these fields of study had been mounting causing an imbalance in the labour market. As a result, the year 2013 witnessed the quick decline in the enrolment quotas for these fields of study. The number of enrolments in colleges in 2013 may inevitably have been affected by this policy. Accordingly, financial resources of public colleges via tuition fees may have also been affected in that year, although they were allowed to increase their tuition fees higher than previous years, as indicated in the government's Decree 49/2010/ND–CP on tuition fees. These matters might have led to a decrease in the financial and academic efficiencies in 2013. However, whether this decrease can be attributed to the impact of the policy intervention is beyond our consideration because deterministic and causal relationships in this context are difficult to identify.

Apart from this phenomenon, the average efficiency of the academic division reached 0.760, which was greater than that of the financial division for the three-year period. However, the number of efficient colleges in the academic division was less than the financial division, eight versus nine colleges, respectively. The Hotelling's tests indicate that differences in the efficiency scores of the academic and financial divisions across the three years are significant at the 10 per cent significance level.

The Spearman's rank correlation coefficients among the efficiencies of the financial and academic divisions for the three years and the overall efficiency for the three-year period are presented in Table 5. Although there is a significant correlation between the efficiencies of the financial and academic divisions, this correlation is the smallest at 0.572, indicating that the linkage between financial and academic operations via the operating expenditure is not particularly strong. However, the overall dynamic network efficiency is more strongly correlated with efficiency of the financial division rather than with the academic division, 0.908 versus 0.849, but all these sample correlation coefficients are significantly different from zero at the one per cent level. This implies that the financial efficiency plays a more dominant role in operations of public colleges.

Table 5: Spearman's rank correlation tests for colleges

	OFD	OAD	ODN
Overall financial division (OFD)	1.000		
Overall academic division (OAD)	0.572***	1.000	
Overall dynamic network (ODN)	0.908***	0.849***	1.000

Note: *** denotes the significance level at 1%

The distributions of the estimated efficiencies of public colleges based on the dynamic network DEA model for each division and the overall organisations are illustrated in Figure 3. It can be observed that the efficiency of the financial division is more closely related to the overall dynamic efficiency than that of the academic division. This suggests the importance of both divisions in the operational efficiencies of public colleges, although both divisions need to improve their performance to obtain the full frontier efficiency.

Figure 3: Scatter plots of the dynamic network efficiencies

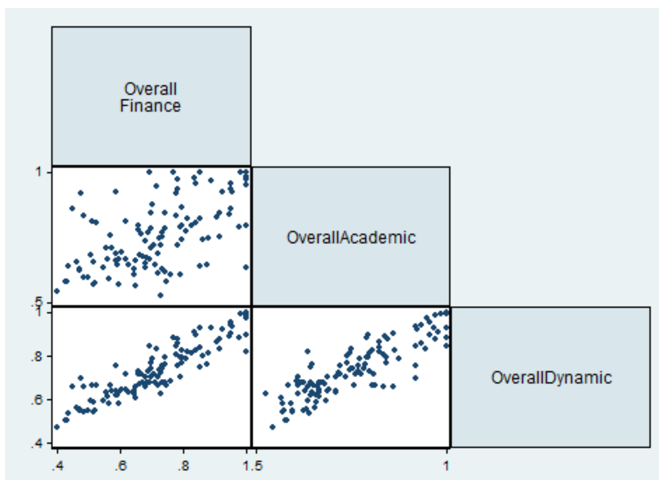


Table 6 shows that the efficiency of public colleges obtained from the traditional DEA model decreases across the three years involved. On average, public colleges could potentially improve their performance by 27.4 per cent. It can be seen that the overall efficiency of the dynamic network model is slightly higher than the traditional DEA model, 0.741 and 0.726, respectively. This is because the overall dynamic network efficiencies are established by a deeper analysis of the efficiency of each division. Furthermore, the number of efficient public colleges in the traditional DEA model is quite high, 21, whereas the findings of the dynamic network model in Table 4 indicate that only four public colleges show full technical efficiency in the whole surveyed period, accounting for 3.5 per cent of the total number of public colleges in the reported sample. This implies that the dynamic network model provides stricter evaluation by screening colleges that obtain full efficiency from both divisions. It is clear that the dynamic network DEA model not only uncovers the efficiencies of multiple activities via different divisions that would have been hidden in the "black-box" traditional DEA, but explores the dynamic changes of the divisional and overall efficiencies across the multiple periods as well.

Table 6: Traditional DEA efficiency scores

Year	2011	2012	2013	Overall
Mean	0.737	0.692	0.750	0.726
Standard deviation	0.221	0.221	0.204	0.187
Min	0.328	0.330	0.372	0.350
Max	1	1	1	1
Efficient colleges	40	31	36	21

We further examined the differences in efficiencies of colleges located inside and outside central cities. It is generally supposed that the in-city colleges have more advantages in diversifying outputs and efficiently using inputs because they have more chances to access advanced learning resources and different facilities for the learning process of students. As a result, they can make an increase in financial resources via increased enrolments and improve their academic efficiency.

Table 7 illustrates the efficiencies from the dynamic network model of public colleges classified by their location. The results show that the in-city colleges are more efficient than the others in all cases, as expected. However, the distinction of efficiencies of the academic division between the in-city colleges and others is not statistically significantly different from zero. It is quite interesting to see that the efficient public colleges are located outside the cities.

Table 7: Efficiencies of public colleges by location

Efficiency	In-city	Others	Z value
Financial	0.785	0.698	-2.668***
Academic	0.768	0.757	-0.59
Overall	0.776	0.728	-2.137**
Efficient colleges	0	4	
No of colleges	31	85	

Note: *** and ** denote significance at 1% and 5%, respectively.
Z value is the Wilcoxon rank sum test

7. Discussions and Conclusions

Using the dynamic network DEA model, our research provides insights into the dynamic change in efficiencies of Vietnamese public colleges across the three years, 2011–2013. This advanced model was explored to analyse the internal structure of each college and to capture the dynamic changes of two divisions, financial and academic, that are linked together in colleges' operations across multiple periods. Our findings make empirical contributions to the efficiency literature in higher education by exploring in-depth the organisational inefficiency via linking various activities in the production process and offer better understanding about the dynamic efficiency of public colleges in a network structure. These results are also useful for the government and educational managers providing them with more adequate information to design more relevant policies for improving the operational efficiencies of public colleges.

We explored a network structure of each college by two typical divisions, financial and academic, that are considered as the two most important divisions in maintaining educational operations of the whole system. The operations of these two divisions are reciprocal. The financial division is responsible for assisting the board of institutional directors in preserving sound financial status and providing sufficient financial capacity to the academic division. In return, the academic division should efficiently use financial resources to provide the best academic services to learners. The efficiencies of both divisions contribute significantly to the overall efficiency of colleges.

Using the dynamic network approach, we obtained the following important results. First, the dynamic change in overall efficiency scores of public colleges varies across the period of 2011–2013. The Hotelling's test indicates that this variation is significant at the one per cent significance level. Generally, public colleges could potentially improve their efficiencies on average by 25.9 per cent. Analysing the internal structure reveals that the efficiency of the financial division varies over the three years. This change is statistically significant at the one per cent level. Findings revealed that public colleges could potentially improve their financial efficiency on average by 27.8 per cent to obtain the full efficiency of one. Similar to the financial division, the levels of academic efficiency of public colleges fluctuated across the three years–increased in 2012, then declined in 2013. On average, public colleges could potentially improve their academic efficiency by 24 per cent to reach full efficiency. As can be seen, the financial efficiency of public colleges was on an increasing trend in the years that followed the issue of Decree 49/2010/ND-CP on tuition fees. On the other hand, following suggestions of MOET to limit the enrolment quotas in some indicated fields of study in 2013, levels of the financial and academic efficiencies of public colleges decreased in that year. To attribute these changes to the influence of the policies is outside our study because the complex nature of causal correlation in the context is not easy to isolate. However, this may lead us to the managerial implication that the variations in the policy environment may influence the performance of colleges to some extent.

Second, the correlation in efficiencies of financial and academic divisions was not very strong, being 0.572. In addition, the overall dynamic efficiency was more strongly correlated with the efficiency of the financial division than with that of the academic division, being 0.908 and 0.849, respectively. Taking a closer look at individual public colleges in the sample, we found that some colleges were fully efficient in their financial division, but they were inefficient in the academic division and vice versa. As a result, only four public colleges were efficient for the whole period. This suggests further consideration by the government and educational leaders to assist public colleges in improving their performance, including financial and academic operations.

Third, we examined differences in efficiencies of public colleges located inside and outside central cities. It was observed that the in-city public colleges were more efficient than others. However, efficient colleges were located outside rather than inside central cities. This finding may attract the concern of policymakers to have more suitable policies for HEIs outside the central cities to enhance their performance.

Finally, as compared to the traditional DEA model, the dynamic network model provides a better understanding about efficiencies of colleges by investigating the operational efficiency of different divisions in a unified framework. Hence, appropriate solutions for each division can be designed to improve the overall performance of institutions. Our findings indicate that the dynamic network model provides a stricter assessment than the traditional DEA model. Colleges are considered as efficient only when they are efficient in both financial and academic operations. As a result, there were only four efficient public colleges according to the dynamic network model, whereas there were 21 efficient ones according to the traditional DEA model. This reflects the fact that the dynamic network model is the more appropriate model and should be used for exploring the network structure with multiple divisions and multiple missions in a production process such as higher education.

Our empirical results are expected to be informative for policymakers and educational leaders in formulating more appropriate policies to improve the operational efficiency of public colleges. Further studies should be conducted to supplement our findings. First, our study focused on two important divisions, financial and academic, in Vietnamese colleges and did not consider other divisions that could contribute significantly to efficiency of HEIs in their operating processes. Thus, more divisions, for example, student employability, should be investigated in a network structure to evaluate in more detail the efficiencies of each division. Second, differences in characteristics of colleges such as reputation, specialised training programs, managerial skills, and other external factors should also be taken into account in the process of assessing the performance of public colleges. Third, because the reporting system of the Vietnamese higher education sector has not been adequate, some quality variables, for example, percentage of students in employment, were not included in our study. Therefore, further studies should add these variables to the analysis to provide more robust evaluations. Finally, a university model should also be implemented to provide a complete picture of the operational efficiencies of Vietnamese HEIs. Hence, policymakers and educational leaders would have additional information for redesigning more appropriate policies for improving the performance of Vietnamese higher education.

Appendix

Table A: Summary statistics of variables used in the dynamic network DEA model of colleges

Variable	Unit	Mean	Standard deviation	Min	Max
Inputs					
Academic staff	Person	128	66	30	473
Non-academic staff	Person	55	21	21	167
For financial division	Person	18.2	7.2	7	56
For academic division	Person	36.5	14.3	14	111
Tuition fees	Billion VND	7.4	7.3	0.035	65.67
Government funding	Billion VND	12.6	10.2	0.001	69.75
Linking/carry-over variables					
Operating cost	Billion VND	16.0	10.9	0.76	63.79
Research income	Billion VND	4.1	10.7	0.001	144.76
Floor area for academic spaces	1,000 m^2	14.0	9.4	0.981	89.31
Outputs					
Associate undergraduates	Person	2,188	1,572	67	7,872
Graduates	Person	571	443	0	2,220

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PART 3: GENERAL CONCLUSIONS AND IMPLICATIONS

This thesis provides empirical evidence about the performance of Vietnamese HEIs in the process of matching the standards for the world's best higher education systems. Empirical papers included in this thesis examine different aspects of the performance of HEIs by using different DEA-based models with cross-sectional and panel data. To our knowledge, the efficiency analyses reported in these papers are the most comprehensive studies for Vietnamese higher education. The empirical results of this thesis provide important information for consideration in the restructuring process of Vietnamese higher education. More importantly, our study contributes significantly to the literature, not only in the context of higher education in developing countries, but in efficiency analysis itself.

This part is presented in a single chapter in which the results from empirical papers are considered and reconciled to come up with a common measure and indicator of the performance of HEIs in Viet Nam.

Chapter 10 includes a brief overview of the study, summary of core findings, contributions to the literature, research implications, and final concluding remarks.

Chapter 10: Summary, implications, and conclusions

1. Introduction

This chapter provides a summary of the main findings, discusses managerial implications and research implications as well as contributions of the thesis. The structure of this chapter is organised as follows. Section 2 presents a brief overview of the thesis, followed by a summary of the major results presented in Section 3. Section 4 discusses policy implications. The main contributions of this thesis are expounded in Section 5. Suggestions for further research are delineated in Section 6. Some concluding comments with regards to the contribution of this study for future direction of Viet Nam's higher education are provided in Section 7.

2. An overview of the study

The study was originally motivated by the fact that education, in general, and higher education, in particular, has a crucial role to play in socio-economic development because of its important role for the nation's human resources, especially because Viet Nam is a developing nation. Higher education is considered an important efficiency enhancer for Viet Nam to improve its competitiveness capacity beyond the simple production process. There is no doubt that the more efficient are higher education institutions (HEIs), the more significantly it will contribute to the nation's economic growth through providing a highly-qualified labour force for different sectors of society. However, it is widely recognised that the higher education system is strong and effective only when HEIs are really efficient in their academic operations. Thus, measuring the performance of individual HEIs is imperative to provide insights to educational leaders and policymakers in their endeavours to design better education policies to improve the performance of HEIs.

In Viet Nam, higher education is one of the focuses of the government's efforts to restructure the economy. Despite the fact that there has been a remarkable growth in the numbers of enrolments and institutions in almost 20 years since the reform policy on higher education was enacted in 1997, Vietnamese higher education still faces challenges resulting from the complex governance system, and the unclear accountability of HEIs and their performance being unassessed. This situation has undermined Viet Nam's higher education system, causing it to lag behind the world's best practice in higher education. The government's policy objective stated that the performance of HEIs needed to be improved so that by 2020 at least one Vietnamese university would be ranked in the world's top 200 universities. Whether or not this objective is achievable, pursuing excellence in higher education in the today's age of globalisation is a worthy aim. In this context, Vietnamese HEIs will be subject to more challenges and need to adapt and respond to changes in educational circumstances.

The themes of operational efficiency and productivity analyses of HEIs have thoroughly been studied in several countries, but rarely in Viet Nam. As is the case in most other developing nations, Viet Nam needs a comprehensive analysis of the performance of HEIs to provide the necessary information to develop a plan to advance its higher education. The majority of previous studies have focused on macro policy aspects of higher education in Viet Nam, but building a complete profile and conducting a performance analysis of HEIs has been neglected. Thus, a more thorough and up-to-date study on exploring different aspects of Vietnamese tertiary education is warranted. A careful consideration of the performance of HEIs based on their operational efficiencies is needed to target educational development and policy interventions.

The main theme of this thesis is to analyse the performance of Viet Nam's HEIs in the current operating environment and to see whether HEIs, as regulated by the uniform legislation, are efficient in operations and in using scarce input resources. This thesis is organised in ten chapters, divided into three parts. The core empirical analyses are presented in empirical paper-based chapters.

Following the overview of higher education in Viet Nam that is presented in Chapter 2, the first empirical analysis uses a standard DEA to investigate the operational efficiencies of HEIs including universities and colleges with cross-sectional and panel data. A DEA with the bootstrap method is employed to obtain measures of operational efficiencies. We measure operational efficiencies for an input orientation, saving inputs to obtain the existing outputs, and bootstrapped 2,000 replications to eliminate biases of serial correlation between inputs and outputs. The results reveal that the universities and colleges were inefficient in their operations during the years 2001–2003 and, thus, could potentially improve their performance. It was found that inefficiencies of HEIs could result from the impacts of contextual factors on input usages, and, thus, a more detailed study is needed to estimate the efficiencies of HEIs by eliminating the impacts on input usages.

As reported in Chapters 3 and 4, measures of inefficiencies of HEIs could be influenced by some contextual variables. Hence, the main purpose of Chapter 5 is to obtain indicators of performance when input variables are adjusted to take into account the possible effects of environmental variables. The process is performed by using a multi-stage DEA approach with the bootstrap procedure. In this chapter, the demand for measuring the performance of Viet Nam's HEIs and the impacts of environmental factors, including age, ownership, national entrance examination marks, and financial capacity, which could all be influential on input usages and, thus, affect the operational efficiencies of HEIs, were discussed. This is followed by the methodological development by proposing a new stage with the bootstrap procedure on the adjusted efficiencies at the final stage to remove biases of unobserved disturbances to generate more robust results. The research context and methodological extension in this study are the first of their kind and make a novel contribution.

In Chapter 6, we analyse input mix inefficiencies in an input-orientation of individual HEIs using the advanced nonparametric DEA proposed by O'Donnell (2008, 2011, 2014). This approach allows the estimation of the Färe-Primont productivity index and its decomposition into measures of technology, technical efficiency, scale efficiency, and mix efficiency. We extended the analysis by integrating the fractional regression model into the second stage to examine impacts of contextual factors on input mix efficiency of HEIs. By using this model, we investigate the impacts of contextual factors on both the fully efficient and inefficient HEIs.

In Chapters 3, 4, 5 and 6, the efficiencies of universities and colleges are examined separately to provide appropriate measures relative to their own cohorts. Given that universities and colleges are both classified as HEIs, the question arises about the efficiencies of universities and colleges using their own teaching technology if both are placed in a common frontier. In this regard, a deeper delineation of technological differences and the efficiencies of these two groups in an unrestricted metafrontier technology provides more insightful information for policy interventions, which is addressed in Chapter 7.

By using a metafrontier directional distance function approach, the technological heterogeneity and efficiencies of universities and colleges are investigated in Chapter 7. The directional distance approach is more flexible than an input or output distance function because it allows one to seek for simultaneously expanding outputs and saving input resources. Integrating the directional distance function (Chambers, Chung, and Färe, 1998) into the DEA metafrontier framework (O'Donnell, Rao, and Battese, 2008), the operational efficiencies of universities and colleges are estimated in terms of their respective frontier and metafrontier teaching technology. The metatechnology ratio is estimated to provide the efficiency scores of both groups in an unrestricted technology represented by the metafrontier. An extension of this method is used to compute the capacity utilisation of quasi-fixed inputs that could not be adjusted by managers of HEIs in a short period of time. This should offer useful information for educational leaders and policymakers to reformulate more appropriately the land-usage policy for private education.

The last empirical analysis examines the role of financial efficiency as a crucial intermediate stage in the production process of public HEIs using a dynamic network DEA approach across multiple periods. The advanced approach of the dynamic network DEA slacks-based measurement, proposed by Tone and Tsutsui (2014), is developed and applied in Chapters 8 and 9 for public universities and colleges, respectively. This dynamic network DEA model is a combination of the dynamic and network models and accounts for internal heterogeneous divisions of firms. These divisions are linked together by the connecting variables and internal products. The dynamic network model provides the overall efficiency over the three years involved, the dynamic changes in both the period and the divisional efficiencies. In this framework, the contribution of the financial efficiency to the overall efficiency of public HEIs was examined to provide useful information for HEIs to improve their performance and to respond to the concern of society about their financial efficiency.

The main findings of the above empirical analyses are presented below.

3. Summary of core findings

In this section, we summarise the core findings in Chapters 4 to 9 using the same dataset of universities and colleges with panel data for the three years, 2011–2013. This ensures that the empirical findings are analysed and compared consistently throughout the thesis. Table 1 presents a summary of research questions and the corresponding findings obtained from the empirical papers in this thesis. A detailed discussion of these findings is illustrated accordingly.

Table1: Summary on research questions and main findings in the thesis

No	Research questions	Analytical contents and main findings
	Chapter 4: Operational efficiencies of Vietnamese higher education institutions: An evaluation using a semi-parametric DEA approach	
1	How efficiently do Vietnamese HEIs operate?	Efficiency scores of 0.777 and 0.697 for universities and colleges, respectively. This implies that with their own teaching technology, on average, universities and colleges could potentially improve their performance by 22.2 and 30.3 per cent, respectively, to obtain the full efficiency of one. However, the bootstrap DEA models generate lower efficiencies for universities and colleges, 0.694 and 0.623, respectively.
2	Are there any differences in the efficiencies of public and private HEIs?	There is no significant difference in efficiencies of public and private universities.
3	What factors contribute most to changes in efficiencies of HEIs?	Performance of HEIs is influenced by contextual variables such as age, type, location, national entrance examination (NEE) marks, the ratio of staff with postgraduate degrees, and tuition fees as a proxy for an indirect impact of the years following Decree 49/2010/ND-CP. For universities, the ratio of staff with postgraduate degrees is significantly related to their efficiencies; older universities were more efficient and tuition revenues positively contributed to efficiency. For colleges, location, type and NEE marks contribute significantly to their efficiencies.
	Chapter 5: On the measurement of environmentally-adjusted efficiencies of Vietnamese higher education institutions: An analysis using a bootstrap multi-stage DEA approach	
4	To what extent do environmental factors affect the input usages of HEIs?	Factors such as location, type, age, NEE marks, and revenue are assumed to affect the input usages of universities and colleges including floor area, nonacademic staff, academic staff, and operating cost.
5	After filtering out the effects of environmental factors on input usages, to what extent are the efficiencies improved?	As compared with the efficiencies obtained from the DEA standard model, the environmentally-adjusted efficiencies of HEIs are improved by 5.0 per cent for universities and 15.7 per cent for colleges.
6	Using the bootstrap method to eliminate serial correlation biases and unobserved disturbances, how efficient are Vietnamese HEIs?	After isolating serial correlation and random noise using the bootstrapping method, there is still evidence of inefficiency in the system. Under their own teaching technology, universities could potentially improve their performance by on average 17.3 per cent. Also, colleges need to improve their efficiencies by 14.5 per cent.
	Chapter 6: Measuring input mix efficiencies of higher education institutions in Viet Nam	
7	What is the nature and sources of input mix efficiency of HEIs, both universities and colleges?	Evidence of input mix inefficiency was found for both universities and colleges. Empirical findings indicate that for universities, input mix efficiency of 0.829 is greater than input technical efficiency of 0.784 but less than input scale efficiency of 0.866. For colleges, their input mix efficiency of 0.842 is greater than both technical efficiency of 0.796 and scale efficiency of 0.703.
8	Are there any differences in the indicators of private and public HEIs?	Public universities are more efficient than private ones in input mix efficiency. This is similar to the college case. However, these indexes are less than the full efficiency of one in the reported period.
9	What are the factors affecting input mix efficiencies of HEIs?	Type, location, age, and financial capacity have certain impacts on input mix efficiency of universities. For colleges, age and financial capacity are significantly positively correlated to input mix efficiency.

No	Research questions	Analytical contents and main findings
	Chapter 7: Technological heterogeneity and efficiencies of Vietnamese higher education institutions: A metafrontier directional distance function approach	
10	What are the efficiencies of universities and colleges under their own teaching technology?	Under their own teaching technology, the efficiencies of universities are on average 0.837, whereas those of colleges are 0.774.
11	What are the levels of inefficiencies of HEIs under a common production environment?	Under a common context, the efficiencies of universities are greater than those of colleges, 0.773 versus 0.732, at the five per cent significance level. Three universities and three colleges obtain the full efficiency of unity under the metafrontier teaching technology.
12	What are the metatechnology ratios of universities and colleges represented by the metafrontier technology?	The metatechnology ratio of universities is 0.922, and that of colleges is 0.950. The results indicate that the gap between their own frontier and metafrontier technologies is less than 10 per cent, implying that universities and colleges are operating relatively well with respect to their own teaching technology.
	Chapter 8: Financial efficiencies of Vietnamese public universities: A dynamic network DEA approach **Chapter 9: Measuring efficiency of Vietnamese public colleges: An application of the DEA-based dynamic network approach**	
13	What are dynamic efficiencies of financial and academic divisions of public HEIs, both universities and colleges, in the network structure?	For public universities, the average estimated efficiency of the financial operations is 0.826, whereas that of the academic division is 0.782. For public colleges, the average efficiencies of the financial and academic operations are 0.722 and 0.760, respectively.
14	What are dynamic changes in the overall operational efficiencies of HEIs across multiple periods under a network structure?	The overall dynamic network efficiencies of public universities are on average 0.804. However, the overall efficiencies of public colleges are on average 0.741.
15	How strong are financial efficiencies correlated to the academic and overall efficiencies of HEIs?	For public universities, there is no strong correlation between efficiencies of their financial and academic divisions. There are strong correlations between the overall dynamic network efficiency and the academic division rather than that of the financial division. For public colleges, there is no strong correlation in the efficiencies of financial and academic divisions in the public colleges but the overall dynamic network efficiencies are strongly related to efficiency of the finance division rather than that of the academic division.

3.1 Technical efficiencies of HEIs and the environmental impacts

The empirical results from Chapter 4 indicate that, with respect to the standard DEA model, universities and colleges are operating less than the full efficiency of one, with the average efficiency scores of 0.777 and 0.698, respectively. This shows that they could potentially improve their efficiencies by 22.3 per cent and 30.2 per cent, respectively, to obtain the full frontier efficiency. Under the bootstrapped DEA model to eliminate the serial correlation between inputs and outputs and noise errors, the bootstrapped efficiencies of HEIs are relatively low, 0.694 and 0.623for universities and colleges, respectively. These results are quite low compared with the efficiency scores of HEIs in the Philippines and Malaysia, which are 0.966 and 0.843, respectively (Castano and Cabanda, 2007a; Husain, 2012). It can be seen that the proportion of total government expenditure on education in Viet Nam was 20.9% (6.3% of GDP) in 2010, equivalent to that of Malaysia in 2011 (5.9% of GDP), and higher than that of the Philippines at 13.2% in 2009 (2.7% of GDP) (Economic and Social Commission for Asia and the Pacific, 2014). However, Vietnamese HEIs did not operate as efficiently as expected with respect to the government investment levels in higher education (around 1.2% of GDP).

As in most developing countries, private higher education institutions in Viet Nam have more autonomy in human and financial resource management; thus, they should use this advantage to enhance their performance (Pham, 2015a). However, the Wilcoxon rank-sum test reveals that there is no significant difference between the efficiencies of public and private universities in both standard and bootstrapped DEA models. Specifically, the efficiencies scores of public and private universities are 0.780 and 0.768 in the standard DEA models, and 0.694 and 0.693, respectively in the bootstrapped model. On the other hand, private colleges are slightly more efficient than their public counterparts at the 1% significance level for both models, 0.792 versus 0.685 in the standard DEA model, and 6.92 versus 6.14 in the bootstrapped model. Because the number of private colleges in our sample is small relative to that of public colleges, this result should be validated by a study using a larger sample size. Compared with the efficiencies of private institutions in the Philippines, 0.807 on average, (Guzman and Cabanda, 2009), these efficiency scores are relatively low.

Using the truncated regression model with the double bootstrap method, the impacts of contextual factors on efficiency of HEIs were investigated. Location has a positive effect on the efficiencies of both universities and colleges. This implies that metropolitan HEIs are more efficient than others. The work of Carrington, Coelli, and Rao (2005) provided similar evidence that Australian metropolitan universities were more efficient than others. Age of institution affects positively the efficiencies of universities but not those of colleges. Castano and Cabanda (2007b) and Munisamy and Talib (2008) came to the same conclusion, namely, that age was significantly related to the efficiencies of private HEIs. On the other hand, ownership does not make a difference in the efficiencies of universities. This result is consistent with findings of Anderson, Daim, and Lavoie (2007), in which there was no difference in the service industry efficiencies of public and private universities. However, private colleges in our study are more efficient than public ones. Duh et al. (2014) came to a similar conclusion that private institutions were found to be more efficient in teaching-related activities. The proportion of academics with postgraduate qualifications had the expected positive effect on efficiency of universities and its coefficient is statistically significant. This result is consistent with the study of McMillan and Chan (2006) who found that the proportion of research academics influenced positively the efficiencies of Canadian universities.

From the theoretical perspective, there is evidence that the efficiencies of HEIs are affected by contextual factors which to some extent are out of managers' control. The findings in this thesis are consistent with those of different studies across various nations. From the empirical context, the impact of these factors should be integrated directly into the production process to provide fairer evaluation of the role of managers of HEIs.

3.2 The adjusted efficiencies of HEIs accounting for the impacts of environmental factors

By taking into account the impacts of environmental factors on input usages of HEIs and filtering out these impacts to generate the environmentally-adjusted efficiencies for HEIs, there is still evidence of inefficiencies in the system. That is, findings from Chapter 5 reveal that efficiency scores of universities and colleges with the standard DEA approach are not high, 0.777 and 0.698, respectively. However, this procedure does not account for the effects of the operating environment on the input slacks. The results of the second-stage regression model indicate that some contextual variables such as age, location, the national examination entrance results, and financial capacity are influential on input usages of HEIs. We found that the older universities have more academic and non-academic staff and spend more on their operations. However, the average national entrance examination results have a striking influence on floor area, academic staff, non-academic staff, and operating costs of colleges. After filtering out the effects of contextual factors on the input slacks, the DEA method was reapplied to estimate the efficiencies of HEIs. Findings reveal that the adjusted efficiency scores of universities and colleges increase significantly by 0.871 and 0.886, respectively. An increase in the efficiency scores after the environmental adjustment process is consistent with those of recent studies such as those of Ferrera, Cebada, and Zamorano (2014), Sav (2013), and Fried, Schmidt, and Yaisawarng (1999).

We extended the adjusted efficiency measurement approach by implementing the bootstrap procedure at the final stage to remove serial correlation and biases of unobserved disturbances to generate more robust efficiency scores. The bootstrap-corrected efficiency scores of universities and colleges decreased to 0.827 and 0.855, respectively, but were significantly greater than their initial scores by 5.0 per cent and 15.7 per cent, respectively. Again, these results imply that there is still room for improving the performance of universities and colleges. We found that the environmentally adjusted bootstrapping efficiencies of public HEIs were statistically significantly less efficient than those of private HEIs. However, all these efficiency scores were less than one. From the practical context, to improve their performance, HEIs in Viet Nam need to be aware of the need to reduce technical inefficiency, or indeed scale inefficiency and also need to heed the nature of inefficiency, particularly, input mix inefficiency. These issues are investigated in the next section.

3.3 Input mix inefficiency of HEIs

Input mix inefficiency in the higher education context is referred to as productivity shortfall due to poor input mix. It is contended that suboptimal input mixes resulting from overspecialisation of labour inputs, inconsistency of allocative/mix efficiency, and impacts of policy environment are the main factors causing inefficiency in academic operations of HEIs. This inefficiency was investigated for 2011–2013 using the advanced DEA method to estimate and decompose the Färe-Primont productivity index into meaningful economic indicators. The empirical findings from Chapter 6 reveal that both universities and colleges are input mix inefficient, at 0.829 and 0.842, respectively. It implies that HEIs inadequately respond to changes in the educational environment by being flexible and altering their input resources to obtain the desired productive efficiency at the national and international levels. These shortcomings result from inadequate policies for a long-term vision and deficient incentives to improve education quality, especially insufficient financial resources (Dam and Pham, 2014).

It is noted that public HEIs are more efficient than their private counterparts in flexibly using input mix to reach their goals. These results provide insights into the performance of universities and colleges when investigated under their own individual frontiers. The fractional regression model was used in the second stage to estimate the influences of contextual factors on the input mix efficiency of HEIs. It was found that an HEI far from the frontier is not a consequence wholly of managerial inefficiency. Some determinants including ownership, age, and financial capacity are influential in the performance of HEIs, in which the financial capacity plays a crucial role in enhancing mix efficiency indicators.

3.4 Technological heterogeneity and metafrontier efficiency of HEIs

According to the 2012 *Law of Higher Education*, universities and colleges are classified as HEIs in the Vietnamese higher education system. However, they are operating under relatively different environments in terms of educational objectives and teaching technology. Universities train students for a period of four years, whereas colleges train them for only three years. Only universities offer postgraduate programs. Colleges provide students with more practical skills, whereas universities teach students research skills. The research output of universities focuses on academic research, whereas colleges mainly focus on projects involving technological transfers and on consultancy services. To meet the objectives and mission, universities invest more in learning facilities and human resources than colleges. Beside this, college students after graduation, if they desire, can study for another year to get a university bachelor degree.

Differences between universities and colleges can also be found in Western and Asian nations such as the US, the UK, Thailand, the Philippines, and Malaysia. However, in Viet Nam, the existing gap between universities and colleges is not only due to their distinctive characteristics but to the policy environment as well. Universities and colleges are governed by different regulations. In many cases, any regulation that was issued for both would have distinct indicators required for universities and for colleges. In other words, the government has considered the difference in the performance assessment of universities and colleges. In this sense, it is essential to examine whether this gap actually does exist in teaching technology and in the efficiencies of universities and colleges when placed in a common context.

To establish whether this gap does exist, we used the metafrontier directional distance function approach to answer this question. Our findings reveal that using their own teaching technology, on average, the university group could potentially increase their efficiency by 16.3 per cent, while the colleges group could potentially improve their efficiency by 22.6 per cent. Using the different teaching technologies, the university group was found to be more efficient than the college group, under the metafrontier framework, 0.773 versus 0.732, respectively, at the five per cent significance level. However, the metatechnology ratio indicates that the gap between their own frontiers and the metafrontier technology is less than 10 per cent, suggesting that universities and colleges are operating comparatively well with respect to their individual teaching technologies. It is also worth highlighting that public universities are more efficient than private ones using the same teaching technology. By contrast, under the teaching technology used by the colleges group, private colleges are more efficient in a common context.

Furthermore, the capacity utilisation of floor area for academic spaces of HEIs was investigated under the pressure of scarce resources, namely, land. The results indicate that the capacity utilisation of floor area for academic spaces, as a proxy for the quasi-fixed input, was underutilised in the years considered. This means that, given the output levels, both universities and colleges are not efficient in using this quasi-fixed input to improve their performance, assuming that they can make decisions to simultaneously expand their outputs and save their input resources. Regarding ownership, we found that there is no significant difference in the capacity utilisation of the quasi-fixed floor area between public and private HEIs although both of them have less than full technical efficiency.

3.5 Financial efficiency and its role in the organisational network structure

Investigating the financial efficiency in the process of public educational production is needed to build a comprehensive profile of public HEIs. Financial efficiency is referred to as divisional efficiency of the financial department, the so-called supporting unit to provide financial resources for the academic division; thus, contributing to the overall efficiency of public HEIs. We focused on the dynamic changes of efficiencies of public HEIs within the network structure of financial and academic divisions using the DEA dynamic network approach.

The empirical findings show that the dynamic changes in the period-divisional efficiency scores of public HEIs vary across the period 2011–2013. The dynamic network efficiency scores of public universities and colleges are, on average, 0.804 and 0.741, respectively. For individual division-efficiency, the results indicate that the financial and academic efficiencies of universities are 0.826 and 0.782, whereas those of colleges are 0.722 and 0.760, respectively, in the years considered. A closer look at the internal structure reveals that the period-divisional efficiencies of the financial and the academic divisions fluctuate in the years involved, with a notable decrease in 2013. The correlation in the efficiencies between the financial and academic divisions of HEIs is not sufficiently strong, 0.495 and 0.572 for universities and colleges, respectively. Whereas the overall efficiencies of universities are strongly linked to academic efficiencies, those of colleges are strongly correlated to financial efficiencies. The number of efficient HEIs is quite low, six and four for public universities and colleges, respectively. In addition, the metropolitan public HEIs were found to be more efficient than others. This finding may attract the attention of policymakers and encourage them to develop more suitable policies for out-city HEIs to further improve their efficiencies.

3.6 Summary on empirical findings of efficiencies of HEIs

The summary of the efficiency scores of HEIs obtained using different approaches is presented in Table 2.

Table 2: Summary statistics on efficiencies of HEIs obtained from different methods

Chapters	Methods	Universities			Colleges		
		Public	Private	Overall	Public	Private	Overall
Chapter 4	Standard DEA	0.780	0.768	0.777	0.685	0.792	0.697
	Bootstrapped DEA	0.694	0.693	0.694	0.614	0.692	0.623
Chapter 5	The adjusted DEA	0.869	0.877	0.871	0.883	0.914	0.886
	The adjusted DEA with bootstrap	0.822	0.842	0.827	0.852	0.884	0.855
Chapter 6	Input technical efficiency	0.786	0.779	0.784	0.690	0.802	0.703
	Input scale efficiency	0.897	0.779	0.866	0.787	0.864	0.796
	Input mix efficiency	0.856	0.757	0.829	0.847	0.803	0.842
Chapter 7	Group frontier efficiency	0.841	0.824	0.837	0.764	0.856	0.774
	Metafrontier efficiency	0.781	0.752	0.773	0.724	0.795	0.732
Chapter 8 and Chapter 9	Financial efficiency	0.826			0.722		
	Academic efficiency	0.782			0.760		
	Overall efficiency	0.804			0.741		
	Average efficiency scores	**0.812**	**0.786**	**0.806**	**0.756**	**0.822**	**0.768**

It is clear that, as expected, the efficiency scores of HEIs vary depending on the research objectives and methods used in the individual papers. Nevertheless, regardless of the methods used, the efficiency scores of HEIs are less than the full frontier efficiency of one. This indicates that there are possibilities for improving the performance of Vietnamese HEIs. We attempted to obtain a single measure of efficiency for HEIs using the indicators obtained using different approaches. A simple arithmetic average indicated efficiency scores of 0.806 for universities and of 0.768 for colleges. However, it is noted that each method is used to evaluate the performance of HEIs with respect to specific objectives.

4. Implications

HEIs today are much more aware of their duties to society and display multiple functions, missions and purposes in their academic operations. The highlight among these duties is the accountability of HEIs to the government and community in using their scarce resources wisely. Clearly, resource management of an HEI is closely related to its performance. The government budget invested in higher education used to be a helpful leverage for the academic operations of HEIs but this trend has changed in the contemporary context of the world's higher education. A recent study of the Economist Intelligence Unit (2014) indicated that in the powerful nations such as the US and the UK, public funding for educational institutions is decreasing, while tuition fees are increasing. In addition, enrolments are declining because students are sceptical, weighing the price of a degree against their chances of employment after graduation. As a consequence, universities and colleges must find ways to cut costs and uncover new revenue streams. In other words, tertiary institutions need to have appropriate resource allocations and management strategies to obtain greater operational efficiencies.

With the trend of internationalisation and ASEAN economic integration, higher education in Viet Nam will inevitably have to meet the high standards of the higher education sectors in countries of the region and the world, at large. Otherwise, Viet Nam will continue to lag behind others countries on the challenging educational playing field. Clearly, HEIs are suffering more challenges from both internal and external pressures. Recognising these challenges, the government has been, and is, implementing many reform policies for the sector, especially the Higher Education Reform Agenda 2006–2020 [HERA] issued in 2005 as a milestone for the comprehensive renewal of the Vietnamese higher education system. In fact, HERA has made great attempts to provide more autonomy to institutions and more flexibility in the governance system. However, until now, many of the quantitative targets contained in the HERA remain unmet because both government and institutions are struggling to find a way to implement the HERA (Dao and Hayden, 2010; Dao, 2014). A World Bank project supports the government's implementation of its "Socio-Economic Development Strategy 2011–2020" and "HERA 2006–2020". This project's objectives are to strengthen governance, financing, and quality of higher education by: (a) improving the responsiveness of higher education and research and increasing the quantitative capacity of the system; (b) enhancing fiscal transparency, sustainability, and effectiveness of the higher education sector; and (c) improving the quality of HEIs (World Bank, 2013).

Based on the analyses and recommendations of the World Bank, the New Universities Model, using USD400 million in loans from the World Bank and the Asian Development Bank, has been deployed. To date, the Vietnamese-German University was established in 2008 and has the goal of becoming a fully-fledged research institution (Lawrence, 2011). The government has recently approved, in principle, the establishment of an international university in partnership with Japan, under management of Hanoi National University.[9] Other projects including partnerships with France and the US are under consideration. There is great optimism that these universities will revolutionise Vietnamese higher education and will, in time, be among the world's leading universities. However, it will not be easy for newly-established universities to meet world standards in a short time (Olsson and Meek, 2013; Pham, 2014). In addition, many decrees and circulars have been promulgated to restructure the higher education system and improve education quality but the implementation of these policies is still inadequate in the current context of Vietnamese higher education (Pham, 2015a).

In a recent report of the World Economic Forum (Schwab, 2013), higher education of Viet Nam was ranked 95th, a very low position among the 114 nations involved, just higher than Laos and Cambodia in the Asian area. Only Ha Noi National University was ranked in the Asian top 170 universities in the 2014 ranking table of Quacquarelli Symonds and at 1,133th in the 2015 world's universities ranking of Webometrics (Vietnamplus, 2014; Lan Ha, 2015). This result suggests that the target of the government to get at least one university in the world's top 200 universities by 2020 may not be feasible. National scholars and researchers claim that the performance of HEIs has been dropping at an alarming level as a consequence of the complexity of the governance system

[9] Document 325/2014/TTg-KGVX was issued by the government on 17 March 2014 on approving, in principle, to establish the Viet Nam–Japan University under Hanoi National University

and the inadequateness of the policy environment (Trinh, 2012; Pham, 2015a). In the opinion of Dam and Pham (2014), public HEIs have lacked innovation incentives, whereas private ones just focus on a short-term vision without a long-term sustainable development strategy; consequently this inevitably leads to their deficient education quality and productivity shortfall. These claims are rational and need to be supported by empirical evidence. The analytical findings of this thesis support these arguments for improvement in the performance of HEIs.

First, this thesis provides empirical evidence that Vietnamese HEIs are inefficient in their operations based on their available academic resources. This result is consistent with recent judgements of national researchers and scholars. However, improving the performance of HEIs should not only focus on changes in the policy environment but also on the perception of HEIs themselves by (a) moving from the producer-driven education model to one that is increasingly shaped by student and consumer demands; (b) needing to be cautious of making decisions to reduce technical inefficiency alone or scale inefficiency as university resources are scarce and unchangeable in the short term; (c) needing to focus on the nature of inefficiency, that is, input mix inefficiency that requires more flexibility from HEIs in response to changes in educational environments and greater interdisciplinary efforts to improve existing teaching technology.

Second, the movement towards upgrading colleges to universities has emerged in recent years in Viet Nam. Many colleges were elevated to universities without being well prepared for a university model. After running the university model, they faced challenges due to lack of human resources and inefficiency in teaching and management methods. Policymakers argued that both universities and colleges play crucial roles in the national education system in providing knowledge for learners and meeting the requirements of socio-economic development (Hoang, 2013b, Pham, 2013). It can be seen that a college can do very well in their own teaching model but this does not mean that a college can do well in a university model. Empirical findings in this thesis back up this statement. Indeed, under the metafrontier technology, the efficiency of the university group is greater than that of the college group, 0.773 versus 0.732, respectively. However, the metatechnology ratios show that both groups are doing relatively well with respect to their different teaching technologies. This implies that upgrading colleges to university status is not necessary as colleges are operating relatively well in their own teaching technology. Hence, upgrading colleges to universities without careful consideration can lead to a negative impact on the efficiency of the university group, and, thus, on the whole sector.

Third, university financial resources have been attracting much interest of researchers and educators in the current context of Vietnamese higher education. The state budget allocations for public universities have been increasing but not fast enough to keep up with the increase in student numbers and the need for more infrastructure development (Dao, 2014). The tuition policy of the government via Decree 49/2014/ND-CP allowing public HEIs to increase their tuition fees to a higher level for the period 2010/11–2014/15 was a significant breakthrough in the provision of more financial resources for public HEIs. However, Hayden (2012) argued that the tuition range determined by the government was not rational because it was not calculated based on the real demands of HEIs. Indeed, tuition fees of public HEIs are currently very low, but if adding the government funding to this, public expenditure per student accounts for 39.8% of GDP per capita, which is not really low in comparison with some Asian nations such as Cambodia (27.8%), Indonesia (24.2%), Myanmar (11.8%), the Philippines (9.7%), and Thailand (19.5%) (Economic and Social Commission for Asia and Pacific, 2014). Increasing tuition fees can be an appropriate solution, but more important is an improvement in the financial performance of institutions and removal of "top-down" state budget distribution (Chau and Tran, 2015; Duong, 2013). The empirical results in this thesis indicate that the financial efficiencies of public HEIs across the three years are less than the full efficiency of one. This means that universities and colleges are not efficient in financial operations. In addition, the correlation in the efficiencies of the financial and academic divisions is also not high. This implies that the financial capacity of the public HEIs in our sample is not sufficiently strong to contribute significantly to the efficiency of academic operations. Although attributing the change in efficiencies of HEIs to the influence of government policy is beyond the scope of our study, removal of the tuition cap, enrolment quotas and "top-down" budget distribution is imperative to achieve the aim of providing more financial autonomy for HEIs; thus, contributing to increasing efficiency in the operations of HEIs. For Vietnamese HEIs, to keep pace with the world's higher education standards, they need to better use the financial resources available to maintain and improve the education quality, even in the face of serious financial constraints. Also, they are aware of the fact that their institutions are fully efficient only when each of their divisions in the organisational structure is efficient. Thus, specific strategies at the departmental and institutional levels should be implemented to improve their performance and education quality.

Fourth, the share of staff with postgraduate degrees influenced positively the efficiencies of universities. This provides strong evidence that such staff play a crucial role in the performance of universities. In the colleges' case, although the share of staff with postgraduate degrees did not demonstrate clear impacts on their performance, the development of highly-qualified academic staff is necessary for colleges to improve their performance including their education quality. The human resource development strategy of the government is to obtain 20,000 academics with doctorates by 2020 by providing PhD scholarships for study abroad, such as Projects 911 and 165, and each year around 1,000 students are chosen to study abroad for a PhD degree. This policy is clearly promising to increase the proportion of staff with postgraduate degrees in HEIs and thus can improve their research activities, such as publications and patents. China is a successful example in sending graduate students on PhD programs at top-tier and middle-tier universities worldwide, even though as few as one in five may return to China within 10 years. However, the web of knowledge connections from creating a pool of international Chinese research talent has been seen as worth the government's costs. In the Vietnamese case, faculty salaries are generally currently low, so the retention of the PhD-qualified academics in tertiary education should be a concern of the government and institutions because PhD-qualified academics have an important role to play in getting Vietnamese universities ranked among the world's top universities.

Fifth, the issue of transparent accountability of HEIs to learners and the community needs to be enhanced. Although the government has required all HEIs to provide publicly their performance data in terms of indicators of quantity, education quality, and finance from the academic year 2009/10, this requirement has not been implemented adequately. The dataset used in this thesis came from MOET archives, where annual reports of HEIs are stored for analysis. However, only 60 per cent of the total number of Vietnamese HEIs had sufficient data for all three years, 2011–2013. This reveals that their accountability to learners and the community is weak, which leads to a lack of innovation incentives in operations and improving education quality. In this sense, tighter regulations should be established to augment the accountability of HEIs. It is clear that once the accountability of HEIs is transparent, then their performance can be more adequately evaluated; thus, stakeholders can make correct investment decisions in higher education. More importantly, students and their parents will have enough information to choose a suitable HEI for their studies. This should result in decreasing international mobility and, above all, saving social costs.

Finally, but not least in importance, we realise that the operational efficiencies of HEIs cannot be detached from the leader's role. Leadership plays a pivotal role in effectiveness of the system, in which outputs of the system can achieve the specified objectives with the most economical inputs (Denman, 2013). Hayden and Lam (2007) asserted that institutional autonomy requires leadership expertise at the institutional level. Ryan et al. (2010) held the view that improving leadership becomes pivotal for sustaining initiatives in higher education in the Asia-Pacific Region. More specifically, Julius, Baldridge, and Pfeffer (1999, pp. 5–6) argued that effective academic leaders are ones who can well manage structural features in terms of an organisational communication network, personal attributes in the relationships with academic staff, and situational contexts relating to external and internal pressures. Furthermore, Ramayah, Yeah, and Ignatius (2013, p. 151) asserted that university administrators should maintain an open and conducive environment that welcomes new ideas, considers criticism, and constantly strives for unity among the staff. This would make the academic staff feel more at ease in engaging in knowledge-sharing behaviours. In the Vietnamese context, the university manager's role becomes crucial as job security and satisfaction are incentives for academics in tertiary education (Asian Development Bank, 2011).

5. Contributions to the literature

This thesis provides the most comprehensive research to estimate the performance of Vietnamese higher education institutions by integrating different advanced nonparametric methods to measure their performance. From a methodological perspective, extensions of DEA models are proposed and various empirical models are estimated. For the empirical context, the results of this thesis offer insights and provide useful information for the educational leaders and policymakers to reformulate relevant policies for the sector.

5.1 Contributions to efficiency methodology

The main contributions of this thesis to the literature of efficiency in higher education are detailed as follows:

- By using the bootstrap method, we extend the conventional DEA environmentally-adjusted approach by taking into account the external impacts on given outputs at the final stage to eliminate serial correlation and biases of unobserved errors and thus provide more robust estimates of technical efficiencies of HEIs. Among approaches used for evaluating the impacts of exogenous variables on technical efficiency, the environmentally-adjusted four-stage approach proposed by Fried, Schmidt, and Yaisawarng (1999) is the most common. The approach, however, is not designed to deal with the serial correlation and disturbance biases relating to given outputs. This can overestimate the efficiencies of HEIs because the given outputs are not taken into account in the environmentally-adjusted process. By applying the bootstrap procedure at the final stage using the original output and the adjusted input set, the environmentally-adjusted, bias-corrected efficiency scores are achieved. This extends the environmentally-adjusted approach to provide more robust results than the traditional approach by using double bootstrap at different stages in the adjustment process. Our results were confirmed by Hotelling's test, which showed the significant difference between the initial, adjusted, and bootstrapped efficiency scores. However, a tricky and unresolved methodological issue relates to the fact that, although placing all HEIs in either the commonly least- or most-favourable environment, as suggested by Fried, Schmidt, and Yaisawarng (1999), is methodically relevant, in the practical context it seems not to fit with the specific operating environments of HEIs. This problem needs to be addressed in future research. One possible solution is to place HEIs in a "run-of-the-mill" environment. This should be perused if it works in the tertiary education context.

- The second methodological contribution of the thesis is to adapt and develop the novel DEA productivity index and disaggregate it into meaningful economic components, as proposed by O'Donnell (2008, 2012b, 2014). This method allows us to estimate the Färe-Primont productivity index and decompose it into measures of technology, technical efficiency, scale efficiency, and mix efficiency for an input orientation. This index is considered as an alternative for the Malmquist productivity index. We integrated the factional regression model in the second stage to evaluate the effects of contextual factors on input mix efficiency of HEIs. The two-stage DEA fractional regression model was first developed and applied in this thesis to investigate input mix efficiency in higher education—something that has not been explored before. However, O'Donnell's model does not indicate whether inputs can be contracted and outputs expanded simultaneously. This situation may occur in the higher education sector, in which HEIs expect to expand their outputs with an increase in productivity and obtain the frontier efficiency in using inputs.
- To assess technological heterogeneity of universities and colleges, we adopt and combine the advanced directional distance function (Chambers, Chung, and Färe, 1998) into a metafrontier

framework (O'Donnell, Rao, and Battese, 2008) to analyse technical efficiencies of HEIs relative to the group frontiers and the metafrontier of two separate groups. This method itself has made a methodological contribution to educational research because it realises technological differences that would be kept hidden using conventional approaches based on rational measures of the efficiencies of HEIs. Further, we extended the capacity utilisation approach proposed by Färe and Grosskopf (2000b) by using the directional distance function under the DEA approach to compute the capacity utilisation of quasi-fixed inputs proxied by floor area for academic spaces, an indispensable input in the production process of HEIs. This thesis is the first to apply these approaches to the higher education sector and, thus, contributes to the literature by unveiling different angles in this complex higher education sector. However, a veiled issue has not been mentioned in this approach. In certain cases, individual group frontiers can be the metafrontier of other smaller group frontiers and these sub-group frontiers can possibly affect the performance of HEIs under the grand metafrontier technology. For example, in Viet Nam, universities and colleges are two group frontiers in the higher education sector. Under these group frontiers, there are private and public institutions. What is more, under each sub-metafrontier of private or public HEIs, there are smaller group frontiers of in-city and out-city institutions. This issue needs to be untangled in further studies.

- Another methodological contribution we note is the adoption of the novel dynamic network slacks-based measurement model, proposed and developed by Tone and Tsutsui (2014). This method is a combination of the dynamic (Tone and Tsutsui, 2010) and network (Tone and Tsutsui, 2009) models to account for internal heterogeneous divisions of firms. The dynamic network model with internal structure can provide details for evaluating the performance of HEIs including the overall efficiency, the divisional efficiency, and the dynamic changes in efficiencies across multiple periods. We develop this model in a new empirical framework by incorporating two important divisions in the operational process of HEIs: financial and academic divisions. This allows us to directly assess impacts of financial resources on the performance of public HEIs in their production process. This advanced methodology and empirical application makes a substantial contribution to the higher education and the efficiency literature. Nevertheless, it is noted that, in some cases, if a great number of larger periods and divisions are registered, determining individual weights for each period and each division would be difficult if there were no support from the current policy. Otherwise, these weights would probably depend on the subjective judgement of researchers.

5.2 Contributions to the empirical context

Individual papers presented in this thesis significantly contribute to the empirical understanding on the performance of Vietnamese HEIs by exploring different aspects in their production process. The problem statements of this thesis are based on the current debates in Viet Nam about the complex governance system, non-transparent accountability, and the unevaluated performance of HEIs. These have caused much concern to the community and the government as they try to find a way forward for the sector.

- By using different advanced methods, research on the performance of HEIs present evidence about inefficiency of HEIs in the years considered. Both universities and colleges were operating at less than the full efficiency of unity. Input mix inefficiency was found in both universities and colleges relating to delays in responding to changes in educational environments. The findings also indicate that inefficiencies of HEIs are not entirely a result of managerial inefficiency. Instead, contextual factors such as age, location, ownership, and financial capacity are influential in the performance of HEIs.
- More advanced methods are applied to evaluate the feasibility of implementing the government policies. The metafrontier directional distance function approach reveal that using their different teaching technologies, universities and colleges were operating relatively well in a common context during the years considered. This means that it is not necessary to upgrade colleges to universities because colleges are operating quite well with respect to their own teaching technology. Thus, upgrading colleges to universities without careful consideration may be detrimental to the efficiency of the university group and the industry as a whole. Further, the results of the dynamic network with the internal structure approach implied that policy interventions can affect the efficiencies of HEIs over a certain period. The financial division efficiencies of public HEIs were less than the full frontier efficiency of one and its contribution to academic operations was weak; thus, policies on financial issues should be carefully reconsidered to enhance the performance of public HEIs.

6. Suggested directions for future research

This thesis attempts to provide a global picture about the performance of HEIs in Viet Nam under different aspects embodied in different advanced nonparametric methods. However, limitations are inevitable and, therefore, further studies should be undertaken to supplement our important findings.

- First, the methods used in this thesis are based on the DEA, nonparametric approach. It goes without saying that the shortcoming of this approach is its inability to distinguish between managerial inefficiency and statistical noise. Although the double bootstrap method, a preferable solution, can be integrated into the standard DEA in the two-stage process to overcome this problem, further studies are suggested to use the alternative method, stochastic frontier analysis, which can simultaneously disaggregate technical efficiencies of HEIs from external influences and unobserved errors, to compare and supplement our findings in this thesis.
- Second, more data for inputs and outputs should be gathered to complement the data used in this study. In this study, research output was estimated by research income from consultancies and research services, but publications of academic staff were not included. Another data concern relates to the quality of output such as the employer satisfaction rating of graduates. In addition, because the reporting system of HEIs has not been adequate, some surrogate variables were used in this study that could limit our results. Therefore, additional statistical data across multiple periods would be desirable to achieve a more complete and refined analysis.
- Third, using data over a longer time span would be preferable to capture the dynamic changes in productivity and efficiencies of HEIs across multiple periods. In our study, growth in productivity was not investigated. Thus, more periods of data would be useful to evaluate change in productivity of HEIs and capture the impacts of the government policies. To do so, data on the performance indicators of HEIs should be stored systematically and analysed statistically to provide sufficient information for consideration and analysis by policymakers and researchers.
- Fourth, it is widely recognised that the organisational structure of an HEI is complex with many different divisions linked in the production process. Thus, besides the two most crucial divisions, financial and academic, exploring the efficiencies of different divisions such as administration and employability in a dynamic network structure may be an interesting subject for further

research. By doing this, managers of HEIs could have an overall picture of the efficiencies of heterogeneous divisions and their contributions to the overall efficiency of the whole organisation. Hence, managers of HEIs would have appropriate strategies for improving their performance at the divisional level. However, a more detailed dataset with more indicators would be needed to undertake this.

- Finally, qualitative studies of leadership behaviours and their outcomes via organisational performance effectiveness and commitment of staff could be added to this study. Needless to say, the leader of an HEI plays a vital role in enhancing the organisational efficiency through not only setting up a long-term strategic vision but stimulating individual achievements as well. Undoubtedly, a combination of management sciences and operational economics to estimate the performance of an HEI would provide a new avenue in the literature. However, applying quality indicators to the efficiency model will be challenging because these indicators need to be calculated for each HEI by a composite index, which can lead to estimated biases due to subjective perceptions of interviewees. It is obvious that if these indicators can be measured reasonably, the efficiency of an HEI would be explained more comprehensively. Such research is relevant not only for Viet Nam but also for other countries where the role of university managers can affect efforts and responsibilities of their staff. Thus, the overall technical efficiency of an organisation would be considerably impacted.

7. Concluding comments

The reform process of the Vietnamese higher education sector, which aims to enhance the autonomy and accountability of HEIs, makes this study fitting, timely and beneficial for the needs of policymakers and educational managers. Measurements of their performance are pivotal to assess and estimate the actual practices of HEIs. These performance measurements can contribute significantly to reform policies of the government to strengthen the status of higher education. Against the background of a trend in international integration, Vietnamese higher education needs to make significant breakthroughs to have one of their universities ranked among the world’s top 200 universities, as desired by the government, and to be an efficiency enhancer for the competitiveness capacity of the national economy.

This thesis has undertaken a comprehensive evaluation of the performance of Vietnamese HEIs. By using the advanced DEA methods, this thesis provides a useful and complete profile of the performance of HEIs including efficiency scores, productive efficiency, input mix efficiency, technological differences of universities and colleges represented by the metafrontier, and financial efficiencies of public HEIs in the production process. This thesis not only endeavours to contribute to the literature of efficiency analysis in higher education in terms of a new research context and extensions of the theoretical models, but also provides important new empirical findings and a benchmark or reference for further studies about Vietnamese higher education.

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