An Application of the Data Envelopment Analysis Method to Evaluate the Performance of Academic Departments within A Higher Education Institution

Nguyen Hoang Oanh
National Economics University, Vietnam
Email: oanhnh@neu.edu.vn

Nguyen Hong Ngoc
National Economics University, Vietnam
Email: ngocnguyenhong94@gmail.com

Abstract

This paper aims to evaluate the efficiency or the productivity of academic departments within a university using Data Envelopment Analysis. As an illustrative example, we investigate the performance of 57 departments of National Economics University (NEU) for three years, from 2013 to 2015. The data set consists of one input variable, which is the number of academic staff, and three output variables in which the number of research hours is considered as research output and the number of graduates and teaching load are defined as teaching outputs. Particularly, the output-oriented CCR, BCC, and SBM model under both the CRS and VRS assumptions are applied in order to determine accurate degrees of efficiency of individual departments and directions for performance improvement for less efficient ones. The output-oriented radial Malmquist DEA model is also employed to make a comparative analysis of the productivity change of the departments over the period. The results reveal some clear policy-making implications for departments to adjust their development plan in an appropriate way.

Keywords: Data envelopment analysis; relative efficiency; higher education institution; academic departments' efficiency.

1. Introduction

It is widely recognized that tertiary education is a major driver of economic development in an increasingly knowledge-driven global economy. Therefore, in recent decades the tertiary education sector in all countries has been expanded rapidly in both width and depth.

In almost all countries, this sector has been experiencing reforms aiming at improving efficiency and quality, thus becoming more responsive to the needs of society and the economy. With regard to an individual higher education institution (HEI), academic departments are the core, so the reform of an HEI should start from its academic departments. The evaluation of the performance of academic departments is part of the process of resource allocation within a university, which is a politically difficult task for most public and private universities (Arcelus and Coleman, 1997). The measurements of the performance of academic activities consist of two major categories: efficiency and effectiveness. 'Efficiency' is a measure of the work-rate of a process by which system inputs are turned into system outputs. 'Effectiveness' on the other hand is considered to be a measure of the 'quality' or 'fitness-for-purpose' of the outcomes being achieved by the system (Woodhouse, 2001). The focus of this paper is to examine the efficiency or the productivity of academic departments within a university.

Efficiency has been studied using economic methods including *cost-benefit analysis*, *cost-effectiveness analysis* or *unit cost analysis*, and *cost-consequences analysis*. Using these methods, it is required to have accurate cost and/or benefit data. However, in the education sector, some costs and benefits are not easy to quantify, so the result gained cannot be ensured to be accurate. An alternative approach to examine internal and external efficiency of educational institutions is *modeling the education production function*. Educational institutions here are treated as 'producers' of educational outcomes. Regression analysis may be used to test these models of the education production function. However, the traditional parametric estimations, like ordinary least squares, fit a regression line through the data. That means they characterize the behavior of the average institution. Institutions lying below the regression line have costs less than the minimum cost. This violates the cost-minimization assumption (Salerno, 2003). Moreover, the education production process is complex and unobtrusive, so it is not easy to model education production functions.

In recent decades, there have been numerous studies assessing the productivity and efficiency of operational units of different fields including education, and thus contributing to the development of the *Stochastic Frontier Estimation* (SFE) and *Data Envelopment Analysis* (DEA). With these tools, researchers are capable of, and more flexible in, modeling the complex production processes and cost structures within higher education institutions. SFEs are parametric programming techniques or regression-based estimators, which are only different from traditional parametric regressions in the error term. SFE analyses has some advantages, but still raises some concerns among researchers. First, it is required to specify production function which is largely unknown in the case of higher education. Second, it is also required to make assumptions on the distribution of efficiencies. Third, it is not generally possible to jointly estimate the influence explanatory variables have on multiple expenditures (in the case of cost functions) or multiple outputs (in the case of production functions) (Salerno, 2003). Meanwhile, DEA is a set of non-parametric programming techniques or mathematical programming estimators which "assist in identifying which set of decision making units may be considered as best practice" in the use of resources among a group of like units (Abbott and Doucouliagos, 2003). DEA is the predominant tool for evaluating the performance of HEIs for a number of reasons. First, it proves to be a useful tool to identify degrees of efficiency of individual units and the direction for performance improvement for less efficient ones. Second, DEA, as a non-parametric technique, has a technical advantage over SFE in the sense that it can avoid "the need to make assumptions regarding the functional form of the best practice frontier … as well as … the need to make distributional assumptions regarding the residuals in the regression analysis" (Abbott and Doucouliagos, 2003). Third, "DEA is widely lauded for its ability to estimate efficiency where firms use multiple inputs to produce multiple outputs and the underlying production relationship is not well understood" (Salerno 2003). Fourth, this method allows us to model "the complex production processes and cost structures within higher education institutions" (Salerno, 2003). Fifth, like production function modeling, DEA is used to discover which types of resources and which allocations have the greatest effect on outcomes and how input-choice and allocative efficiency could be improved. This method "yields more information about the education process than cost-effectiveness analysis" (Belfield, 2000). Besides, it is noted that DEA is a good tool to assess relative efficiency, i.e., the best practice units are recognized as efficient ones relative to the ones being evaluated. However, this may lead to some problems. First, the best performing units or the efficient units may not be operating efficiently in absolute terms. Moreover, it is not possible to undertake tests of statistical significance with DEA scores as is possible with regression analyses (Abbott and Doucouliagos, 2003). Second, there may be the issue of the quality of outputs. However, this issue is not limited to DEA. Third, DEA is sensitive to sample size and data errors as outliers in the data may alter the shape of the efficient frontier and distort efficiency scores of units using similar input/output proportions.

This paper uses DEA to evaluate the efficiency of the academic departments of NEU. We choose NEU as an example of the analysis because it is a leading university in the field of economics and business in Vietnam and it is also one of the first few universities of Vietnam given autonomy by the Ministry of Education and Training (MOET). This pilot program began with financial independence since 2006 and then continued with autonomy in making decisions on training, research, international cooperation and higher tuition fees in recent years. The analysis illustrates how the recent developments in efficiency analysis can be applied when evaluating the performance of an educational institution. Moreover, the results will hopefully be a subjective source of reference for resource allocation policy.

The paper is organized as follows. Section 2 reviews the existing relative literature. In section 3, methodology and data are presented. Section 4 discusses the results of the empirical analysis. Finally, section 5 gives conclusions on the gained results and some policy implications.

2. Literature review

As mentioned above, DEA is a very popular and useful tool to assess efficiency of operating units like HEIs, which use multiple inputs to produce multiple outputs and have an underlying production relationship that is not well understood. We can say that the studies on HEIs' efficiency evaluation applying DEA are very diversified.

The majority of the studies, including both within a country and cross-country ones, relating to performance evaluation are at the university level.

For example, Johnes (2006) introduces an application of DEA to a data set of more than 100 HEIs in England using data for the year 2000/01. The study considers the number and quality of undergraduates, the number of postgraduates, expenditure on administration, and the value of interest payments and depreciation as inputs, and the number and quality of undergraduate degrees, and the number of postgraduate degrees and research as outputs. The results indicate that the English higher education sector has high technical and scale efficiency on average. However, bootstrapping procedures suggest that differences between the most and least efficient English HEIs are significant.

Another example is the study by Kocher et al. (2006) which measures productivity in top-edge economic research of 21 OECD countries using DEA. The output variable is the number of publications in 10 economics journals with the highest average impact factor over the time period 1980-1998 and inputs are R&D expenditures, number of universities with economics departments and (as an uncontrolled variable) total population.

Interestingly, there have been numerous studies evaluating the performance of departments of the same field for different universities such as Tomkins and Green (1988), Johnes and Johnes (1993), Madden et al. (1997), Kao and Hung (2008), Agasisti et al. (2012) and others.

Madden et al. (1997) analyze the effect of the higher education system policy changes on the efficiency of Australian economics departments using the data collected from 29 universities for the years 1987 and 1991. Number of staff is the unique input, while core journals, other journals, books, and edited books are considered as research outputs and undergraduates and postgraduates are teaching outputs.

Agasisti et al. (2012) use DEA to measure the efficiency of 69 academic departments (focused on scientific subjects) located in the Lombardy region of Italy. The study focuses on investigating the trade-off among different research outputs of academic departments which include quantity (publications), quality (citation indexes), research funds obtained through research grants, and applied research funds obtained through external orders. The results of the output-oriented DEA model show that efficiency rankings change significantly when considering different research-related outputs, and thus the study has room for discussion of different research strategies among the academic departments.

While the majority of the relative existing studies evaluate the performance of departments of the same field for different universities, a smaller number of studies (e.g. Sinuany-Stern et al., 1994; Arcelus and Coleman, 1997; Kao and Hung, 2008; George et al., 2012; and others) examine efficiency of departments of different fields within the same university.

Sinuany-Stern et al. (1994) were the first to measure the efficiency of departments within the same university (the Ben-Gurion University) using the DEA CCR model. For them, DEA has many advantages, but still encompasses some drawbacks in dealing with this kind of analysis. The main drawback of DEA is that it assumes that *DMU*s (decision-making unit–departments in this situation) are homogeneous. So, the study applies cluster analyses to divide the departments into several sets and uses discriminant analysis to test the match of the efficiency/inefficiency division of the CCR ratio. It also tests organizational changes for inefficient departments.

George et al. (2012) measure efficiency of the departments of a public owned university (the University of Thessaly) using DEA. Efficiency scores are estimated under the CRS and VRS assumption. This study assumes that departments inside a university may be considered as homogeneous because they have similar activities and are willing to achieve the same goals. However, the departments under examination are somewhat heterogeneous in some aspects. First, since the university under examination is a state owned university, the funding from the government is allocated to the different departments based on different resource criteria. Second, the departments are of different fields. Thus, bootstrap techniques are applied to overcome these problems and determine more accurate performance estimates. The inclusion of these procedures helps minimize the heterogeneity related problems regarding the comparability of departments from different fields and thus produce bias corrected results. The results show that there are strong inefficiencies among the departments, indicating the misallocation of resources or/and inefficient application of departments' policy developments. Like other studies using DEA, the study provides benchmarks for the long term sustainability of the departments.

In Vietnam, we could find only a few studies on evaluating the performance of the Vietnamese higher education system. Nguyen (2008) evaluated efficiency of the state budget for universities in Vietnam and Austria using the data of 2001 and 2006. The two-stage DEA method is used to measure relative efficiency compensating for non-homogeneity of *DMU*s. The study also compares the efficiency between two points in time using the output-oriented radial Malmquist DEA model. The results show that the overall efficiencies of the system were rather low and the discrepancy of efficiency scores between universities was big in both time periods evaluated.

Carolyn-Dung et al. (2016) conducts an analysis of the academic performance of HEIs in Vietnam with 50 universities and 50 colleges in 2011/12 using the two-stage semi-parametric DEA. The study reveals some important findings in that: (i) there are still potential avenues to improve the existing performance; (ii) there appears to be a difference in the efficiencies of public and private HEIs in the reported year;

and (iii) the inefficiency of HEIs is not entirely a result of managerial performance, but is also influenced by other factors such as location, age and the contribution of tuition fees.

It should be noted that we have not found so far any research on evaluating the efficiency of different departments within a university in Vietnam.

3. Methodology and data

3.1. Methodology

DEA framework

DEA was developed on the basis of the seminar paper by Farrell (1957) and first introduced by Charnes et al. (1978) to measure relative efficiency between like organizations. They introduced a ratio definition of efficiency, also called the CCR ratio definition, which generalizes the classical engineering science ratio definition of single output and single input to multiple outputs and multiple inputs without requiring pre-assigned weights. The efficiency of a *DMU* (department in this case) is measured in relation to the other observed *DMU*s while assuming that all *DMU*s lie on or below the efficiency frontier. The data set used in this study contains 57 *DMU*s, assuming that all efficient *DMU*s' positions represent the efficiency frontier, below which lie inefficient *DMU*s.

This definition is expressed in the following fractional model:

$$\max f_o = \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{m} v_i x_{io}} \tag{3.1}$$

$$\text{subject to} \quad \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1, \quad j = 1,\ldots,n$$

$$u_r, v_i > 0, \qquad i = 1,\ldots,m, \qquad r = 1,\ldots,s.$$

whereb y_{rj}, x_{ij} (> 0) represent output and input data for DMU_j with the ranges for i and r. The objective is to obtain weights v_i and u_r that maximize the ratio of the evaluated DMU_o (θ^*). The model can be written in the linear programming form as follows:

$$\max_{v,u} \qquad \theta = \sum_{r=1}^{s} u_r y_{r0} \tag{3.2}$$

$$\text{subject to} \qquad \sum_{i=1}^{m} v_i x_{i0} = 1$$

$$-\sum_{i=1}^{m} v_i x_{ij} + \sum_{r=1}^{s} u_r y_{rj} \leq 0$$

$$v_i \geq 0,\ u_r \geq 0.$$

The CCR-type models, under "weak efficiency"[1] (or Farrell efficiency), evaluate the radial (proportional) efficiency θ^*, but do not take account of the input excesses and output shortfalls. Under the CCR-efficiency, which adds the Pareto-Koopmans efficiency conditions, a *DMU* is called CCR-efficient if it satisfies both conditions: θ^*= 1 and all slacks are zero (Cooper et al., 2007).

In reality, there are many approaches to the definition of efficiency in its relation to productivity. Efficiency can be considered as an attempt to minimize inputs while producing at least the given output levels, or in another way, efficiency involves maximizing outputs while using no more than the given inputs (Cooper et al., 2007). The first approach is an input-oriented approach, and the second is an output-oriented one. In this study, we employ the output-oriented CCR model to measure the relative efficiency of all observed *DMU*s. The model is written in the dual linear programming form as follows:

$$\max_{\delta,\mu} \quad \delta \tag{3.3}$$

$$\text{subject to} \quad x_{i0} - \sum_{j=1}^{n} x_{ij}\mu_j \geq 0$$

$$\delta y_{r0} - \sum_{j=1}^{n} y_{rj}\mu_j \leq 0$$

$$\mu_j \geq 0.$$

In this model, δ is a scalar satisfying $\delta \geq 1$ and a measure of technical efficiency of the observed *DMU* or a measure of the distance of its position to the efficiency frontier. If $\delta > 1$, the *DMU* is inside the frontier or inefficient. If $\delta = 1$, the *DMU* is on the frontier or efficient. μ, a vector of constants, measures the weights to project inefficient *DMU*s on the frontier.

We also test the relative efficiency of *DMU*s taking into account variable return-to-scale characterizations by adopting the output-oriented BCC model developed by Banker et al. (1984). The constraint $e\mu = 1$ will be added to the equation (3.3).

As mentioned above, the CCR and BCC models have a drawback, that is they do not take into account non-radial non-zero slacks, while the slack-based models (SBM) proposed by Tone (2001) do. According to Tone, a *DMU* is CCR-efficient if and only if it is SBM-efficient. Based on this relationship between CCR-efficiency and SBM-efficiency, the study will also use the output-oriented SBM model to have a deeper look into the status of *DMU*s when knowing their non-radial non-zero slacks. The output-oriented SBM model is formulated as follows: $\rho_0^* = \min\limits_{\lambda, s^+} \frac{1}{1 + \frac{1}{s}\sum_{r=1}^{s} s_r^+ / y_{r0}}$ (3.4)

$$\text{subject to} \quad x_0 \geq X\lambda$$

$$y_0 = Y\lambda - s^+$$

$$\lambda \geq 0, \quad s^+ \geq 0.$$

In the formula (3.4), ρ^* is the efficiency score of the observed *DMU*. s_r^+ is the output shortfall. Please note that ρ^* in (3.4) is never greater than δ^* in (3.3) because (3.4) includes output slacks.

Comparison of efficiency between different time periods using the Malmquist index

The Malmquist index was first introduced by Malmquist (1953) and further developed by many authors to measure total factor productivity (TFP) growth of a *DMU* between different points in time in the non-parametric framework. In other words, it allows one to make a comparative analysis of the productivity change of a *DMU* between different periods of time.

The Malmquist index consists of two components: catch-up and frontier-shift. The catch-up component indicates "the degree to which a *DMU* improves or worsens its efficiency", and the frontier-shift represents "the change in the efficient frontiers between the two time periods" (Cooper et al., 2007, 328). As mentioned in the previous sections, the data set has *n DMU*s, each of which uses *m* inputs (denoted by vector x_j) to produce *s* outputs (denoted by vector y_j) over the periods 1 and 2, assuming that $x_j > 0$ and $y_j > 0$. Here, DMU_o in period *t* is denoted by $(x_o, y_o)^t$ and efficiency score of DMU_o at period *t* by $\delta^t(x_o, y_o)^t$. The production possibility set $(X, Y)^t$ (t = 1 and 2) is defined as follows:

$$(X,Y)^t = \left\{ (x,y) \middle| \, x \geq \sum_{j=1}^{n} \lambda_j x_j^t, 0 \leq y \leq \sum_{j=1}^{n} \lambda_j y_j^t, L \leq e\lambda \leq U, \lambda \geq 0 \right\}$$

Where *e* is the row unit vector, λ is the intensity vector, and *L* and *U* are the lower and upper bounds for the sum of the intensities. Then, the catch-up effect (*C*) from period 1 to 2 is calculated as follows:

$$Catch-up = \frac{\delta^2(x_o, y_o)^2}{\delta^1(x_o, y_o)^1}. \quad (3.5)$$

If C> 1, there is progress in relative efficiency from period 1 to 2. If C = 1, there is no change in efficiency. If C< 1, there is regress in efficiency.

Frontier-shift effect (F) is measured by:

$$Frontier-shift = \left[\frac{\delta^1((x_o, y_o)^1)}{\delta^2((x_o, y_o)^1)} \times \frac{\delta^1((x_o, y_o)^2)}{\delta^2((x_o, y_o)^2)}\right]^{1/2} \quad (3.6)$$

If F> 1, there is progress in the frontier technology around DMU_o from period 1 to 2. If F = 1, there is no change. If F< 1, there is regress in the frontier technology.

The Malmquist index (MI) is synthesized from catch-up and frontier-shift as follows:

$$Malmquist\ index = (Catch-up) \times (Frontier-shift)$$
$$= \left[\frac{\delta^1((x_o, y_o)^2)}{\delta^1((x_o, y_o)^1)} \times \frac{\delta^2((x_o, y_o)^2)}{\delta^2((x_o, y_o)^1)}\right]^{1/2} \quad (3.7)$$

If MI> 1, there is growth in the total factor productivity of the DMU_o from period 1 to 2. If MI = 1, there is no change. If MI< 1, there is decay in the total factor productivity (Cooper et al., 2007).

As presented in the previous section, this study measures efficiency of DMUs on a performance basis or on an output-oriented basis. Thus, following Nguyen (2008), it will employ the output-oriented CCR-, output-oriented BCC-, output-oriented SBM-, and output-oriented radial Malmquist DEA models to evaluate the change in efficiency scores, the technological change as well as the total factor productivity change of the DMUs from period 1, represented by the year 2013, to period 3, represented by the year 2015.

3.2. Data

To illustrate an approach to evaluate efficiency of academic departments within a university in Vietnam, we took NEU as an example. The data for the three years 2013, 2014 and 2015 were requested from the Office of Personnel Management, the Office of Research Management, the Office of Training Management, the Advanced Educational Programs, the Department of In-Service Training, and the Graduate School of NEU. This data set consists of input and output variables for all 57 departments at the NEU (except for the Department of Physical Education and the Faculty of Military Education).

Inputs

Alongside capital and funding amounts and sources, academic staff is the principal input into the departmental production and also the most commonly used input variable in the existing literature. However, capital and funding are commonly shared between departments and are not allocated by apparent criteria. Therefore, this study used as input the number of academic staff, which is constituted only by lecturers. Furthermore, there are five ranks of lecturers at NEU, namely professors, associate professors, lecturers having Ph.D.'s, master's and bachelor's degrees, so we pre-assigned weights to each rank in order to construct a proper aggregate measure to capture both the quantity and the quality of academic staff. Weights were pre-assigned based on the assumption that higher-ranking lecturers are expected to be more efficient in teaching and produce more research works than lower-ranking ones so they need to be assigned with a greater weight. Thus, professors were assigned with 1, associate professors with 0.8, PhDs with 0.6,

Table 1: Correlations among outputs

2013				2014				2015			
	Research	Grad	Teach		Research	Grad	Teach		Research	Grad	Teach
Research	1.000	0.151	0.349	Research	1.000	0.160	0.253	Research	1.000	0.274	0.396
Grad	0.151	1.000	0.083	Grad	0.160	1.000	0.128	Grad	0.274	1.000	0.234
Teach	0.349	0.083	1.000	Teach	0.253	0.128	1.000	Teach	0.396	0.234	1.000

Masters with 0.4 and Bachelors with 0.2. Results from various robustness checks show that the choice of the weights does not alter the final results; therefore our pre-assigned arbitrary choice is not affecting the calculated efficiencies (George et al., 2012). These weights are chosen so the distance between the two ranks is 1/5=0.2.

Outputs

Outputs were classified into teaching outputs and research outputs. Teaching outputs consist of the teaching load and the number of graduating students of each department yearly. Specifically, a department's teaching load was constituted by the total number of periods taught by the department in graduate and undergraduate programs, which comprise all types of programs ranging from the ordinary programs, second-degree programs, advanced educational programs to in-service training programs. Whereas the number of graduates was calculated by the total number of postgraduate and undergraduate degrees awarded each year weighted by training levels. That is, doctoral students were assigned with 1, master students with 0.666, and undergraduates with 0.333 (George et al., 2012). Besides, research outputs were measured by the total number of research hours of each department in a year following the current NEU's internal controlling regulations. That is, the amount of a department's research was calculated by the sum of the weighted numbers of projects of different levels, recognized journal articles, conference papers, text-books and reference books published, prized student research projects instructed, and other forms of research done by all academic staff of the department.

At the end, we have completed data for 57 academic departments at NEU for the period of three years, 2013-2015. The provision of incomplete data from nine departments in the year 2015, however, reduced the sample of 2015 to 48 observations.

As can be seen from Table 1, there is little accordance among the three outputs. Table 2 illustrates the descriptive statistics for the input and outputs employed in the study. It is evident from the summary statistics that while the number of graduates and the teaching load saw a slight decline due to some changes in regulations, the number of staff and the number of research hours of each department increased steadily over the three-year period. It is also noteworthy that the standard deviations are significantly high for all variables, especially for the number of graduating students, which implies considerable differences among the de-

Table 2: Descriptive statistics: input and outputs

	Variables	Staff number	Research hours (1)	Graduates number (2)	Teaching load (3)
2013 Obs = 57	Max	12.6	43977	498	33210
	Min	1.4	1275	0	381
	Mean	5.87	10945.77	76.22	4708.16
	SD	2.7	7158.21	126.53	4700.33
2014 Obs = 57	Max	13.2	30766	473	37665
	Min	1.4	1900	0	450
	Mean	5.97	11885.12	76.6	4441.49
	SD	2.75	6108.68	124.51	4997.88
2015 Obs = 48	Max	13	45200	325	23895
	Min	0.8	2476	0	501
	Mean	6.3	13300.4	60.67	4165.05
	SD	2.88	8413.72	80.43	3769.98

partments.

We ran four different DEA models, namely CCR, BCC, SBM (CRS) and SBM (VRS) for the data set in each year, using an output-oriented approach. The output-oriented radial Malmquist DEA model is applied to the full data set to examine the improvement in efficiency of the departments from 2013 to 2015.

4. Results

Results from the four DEA models are presented in Tables 3, 4 and 5.

In the output-oriented CCR models, which are obtained under the hypothesis of constant returns to scale, *DMU*s 5, 7, 28, and 57 were reported to be efficient in 2013; *DMU*s 7, 28, 32, and 39 in 2014; and *DMU*s 7, 18, 20, 28, 32, 33, 37, and 39 in 2015. These *DMU*s also achieved full efficiency in all the other three models, and, according to CCR models, had no slack. The remaining departments had efficiency scores less than 1, thus were less efficient. The average efficiency score across all 57 departments saw slight improvement from 2013 to 2015, which were 0.608, 0.608, and 0.673, respectively.

The output-oriented BCC models, which are built on the assumption of variable returns to scale, on the other hand, indicate more efficient departments, as BCC-efficiency scores are not less than that of the corresponding CCR models. The BCC-efficient *DMU*s that were reported to be inefficient in CCR models were *DMU*s 6, 8, 29, 32, and 37 in 2013, *DMU*s 5, 30, 33, 37, and 50 in 2014, and *DMU*s 23 and 57 in 2015. We can also see how departments can improve their performance by analyzing their slacks (output shortfalls in this output-oriented approach). For instance, if *DMU* 19 wanted to be fully efficient in 2015, it would have to raise its teaching load by approximately 1712 periods in that year (See Table 5). Moreover, both CCR and BCC models measure the "technical efficiency". The average technical efficiency values of the 57 departments were 0.657, 0.694, and 0.688 in 2013, 2014, and 2015, respectively.

Table 3: Estimated efficiency scores and output slacks for *DMU*s in 2013

DMU*	CCR-O				BCC-O				SBM-O-C				SBM-O-V			
	Score	S+(1)	S+(2)	S+(3)	Score	S+(1)	S+(2)	S+(3)	Score	S+(1)	S+(2)	S+(3)	Score	S+(1)	S+(2)	S+(3)
1	**0.549**	0.00	0.00	0.00	**0.562**	0.00	0.00	0.00	**0.328**	234.63	335.83	0.00	**0.333**	972.89	325.01	0.00
2	**0.332**	0.00	0.00	0.00	**0.368**	0.00	14.35	0.00	**0.076**	1827.41	470.10	1908.69	**0.077**	1920.54	466.11	1940.66
3	**0.194**	0.00	4.05	0.00	**0.207**	0.00	6.50	0.00	**0.036**	1997.03	170.62	996.77	**0.066**	985.37	88.87	743.20
4	**0.317**	0.00	0.00	0.00	**0.332**	0.00	0.00	0.00	**0.189**	1705.11	170.19	607.59	**0.264**	3754.60	82.39	1311.16
5	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00
6	**0.868**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**0.401**	0.00	26.91	0.00	**1.000**	0.00	0.00	0.00
7	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00
8	**0.929**	683.51	0.00	0.00	**1.000**	0.00	0.00	0.00	**0.884**	2796.57	0.00	974.57	**1.000**	0.00	0.00	0.00
9	**0.539**	0.00	0.00	0.00	**0.562**	0.00	0.00	0.00	**0.400**	1034.36	387.85	0.00	**0.400**	1117.51	386.65	0.00
10	**0.766**	0.00	0.00	0.00	**0.779**	0.00	0.00	0.00	**0.443**	0.00	89.29	0.00	**0.490**	0.00	73.92	0.00
11	**0.573**	0.00	0.00	0.00	**0.607**	0.00	0.00	0.00	**0.424**	0.00	356.02	350.56	**0.429**	0.00	345.61	472.90
12	**0.636**	0.00	0.00	0.00	**0.656**	0.00	0.00	0.00	**0.210**	0.00	249.63	0.00	**0.211**	0.00	248.64	0.00
13	**0.837**	0.00	0.00	0.00	**0.881**	0.00	0.00	0.00	**0.785**	0.00	165.65	0.00	**0.827**	0.00	126.43	0.00
14	**0.520**	0.00	0.00	0.00	**0.522**	0.00	0.00	0.00	**0.215**	0.00	234.32	259.53	**0.237**	0.00	200.32	770.81
15	**0.268**	0.00	0.00	0.00	**0.327**	0.00	33.86	1340.14	**0.046**	3101.09	503.53	2821.31	**0.047**	1777.17	489.31	3116.67
16	**0.809**	0.00	0.00	0.00	**0.844**	0.00	0.00	0.00	**0.646**	0.00	145.64	0.00	**0.671**	0.00	129.92	0.00
17	**0.541**	0.00	0.00	0.00	**0.561**	0.00	0.00	0.00	**0.208**	0.00	327.01	0.00	**0.211**	0.00	322.05	0.00
18	**0.653**	0.00	0.00	0.00	**0.679**	0.00	0.00	0.00	**0.552**	0.00	282.37	0.00	**0.553**	0.00	281.58	0.00
19	**0.849**	0.00	0.00	0.00	**0.920**	0.00	0.00	0.00	**0.763**	0.00	153.67	0.00	**0.853**	0.00	82.12	93.50
20	**0.515**	0.00	0.00	0.00	**0.591**	0.00	0.00	551.17	**0.288**	0.00	126.96	558.87	**0.375**	779.67	59.85	1333.32
21	**0.347**	0.00	0.00	0.00	**0.348**	0.00	0.00	0.00	**0.121**	1436.63	257.83	801.47	**0.148**	2927.15	193.98	1313.16
22	**0.538**	0.00	3.38	0.00	**0.646**	0.00	80.09	0.00	**0.024**	0.00	576.83	0.00	**0.037**	0.00	377.05	1114.83
23	**0.672**	0.00	0.00	0.00	**0.696**	0.00	0.00	0.00	**0.073**	0.00	258.86	0.00	**0.074**	0.00	255.05	0.00
24	**0.160**	0.00	0.00	0.00	**0.162**	0.00	0.00	0.00	**0.059**	5153.63	264.15	1127.47	**0.071**	6644.15	200.30	1639.16
25	**0.330**	0.00	0.00	0.00	**0.338**	0.00	0.00	0.00	**0.132**	10903.75	596.24	0.00	**0.170**	7057.55	448.55	0.00
26	**0.706**	0.00	0.00	0.00	**0.782**	0.00	6.89	0.00	**0.303**	0.00	298.62	0.00	**0.353**	0.00	238.50	0.00
27	**0.676**	0.00	0.00	0.00	**0.760**	0.00	0.00	1182.55	**0.549**	527.26	0.00	8080.58	**0.550**	689.83	0.00	8021.29
28	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00
29	**0.968**	7030.99	0.00	0.00	**1.000**	0.00	0.00	0.00	**0.694**	8904.05	0.00	0.00	**1.000**	0.00	0.00	0.00
30	**0.539**	0.00	0.00	0.00	**0.596**	0.00	16.29	0.00	**0.104**	1130.95	573.05	0.00	**0.155**	0.00	365.08	0.00
31	**0.673**	0.00	10.83	0.00	**0.770**	0.00	44.95	147.53	**0.025**	0.00	262.60	59.92	**0.031**	0.00	208.95	690.74
32	**0.982**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**0.946**	0.00	13.37	0.00	**1.000**	0.00	0.00	0.00
33	**0.599**	0.00	0.00	0.00	**0.728**	0.00	3.28	542.16	**0.065**	0.00	94.89	189.77	**0.141**	0.00	37.81	1047.97
34	**0.883**	0.00	0.00	0.00	**0.940**	2219.03	0.00	0.00	**0.822**	3945.47	0.00	0.00	**0.826**	3844.60	0.00	0.00
35	**0.308**	0.00	0.00	0.00	**0.319**	0.00	0.00	0.00	**0.110**	5030.66	422.56	686.91	**0.113**	5403.26	406.60	814.82
36	**0.443**	0.00	0.00	0.00	**0.451**	0.00	0.00	0.00	**0.200**	2466.49	332.58	0.00	**0.209**	3399.46	311.14	0.00
37	**0.875**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**0.671**	0.00	196.58	0.00	**1.000**	0.00	0.00	0.00
38	**0.429**	0.00	0.00	0.00	**0.432**	0.00	0.00	0.00	**0.095**	186.71	274.71	323.79	**0.116**	0.00	219.89	306.76
39	**0.857**	0.00	0.00	0.00	**0.892**	0.00	0.00	0.00	**0.846**	2347.90	0.00	2861.02	**0.871**	0.00	0.00	3281.67
40	**0.418**	0.00	0.00	0.00	**0.437**	1482.86	0.00	0.00	**0.246**	4285.53	230.20	0.00	**0.261**	5909.15	192.52	0.00
41	**0.671**	0.00	0.00	0.00	**0.779**	2077.87	0.00	0.00	**0.642**	6592.62	0.00	0.00	**0.668**	5881.40	0.00	0.00
42	**0.576**	3349.16	0.00	0.00	**0.607**	0.00	0.00	0.00	**0.407**	27127.65	0.00	0.00	**0.458**	21034.21	0.00	856.53
43	**0.644**	0.00	0.00	0.00	**0.656**	0.00	0.00	0.00	**0.602**	0.00	163.12	0.00	**0.613**	976.74	12.54	3493.21
44	**0.497**	0.00	2.27	0.00	**0.505**	0.00	3.03	0.00	**0.036**	0.00	179.26	0.00	**0.053**	1443.38	116.92	0.00
45	**0.508**	0.00	0.00	0.00	**0.513**	0.00	0.00	0.00	**0.306**	0.00	295.52	121.42	**0.330**	915.28	253.61	476.32
46	**0.346**	0.00	0.00	0.00	**0.370**	0.00	0.00	521.19	**0.087**	0.00	297.86	1798.12	**0.098**	955.60	250.60	2221.16
47	**0.786**	0.00	0.00	0.00	**0.803**	0.00	0.00	0.00	**0.125**	0.00	118.97	0.00	**0.128**	0.00	115.30	0.00
48	**0.613**	0.00	0.00	0.00	**0.631**	0.00	0.00	0.00	**0.291**	0.00	245.81	6.05	**0.300**	0.00	233.32	193.83
49	**0.455**	0.00	0.00	0.00	**0.473**	0.00	0.00	0.00	**0.147**	6257.76	483.25	0.00	**0.167**	4302.24	420.06	0.00
50	**0.244**	0.00	1.26	0.00	**1.000**	0.06	0.00	0.00	**0.060**	1231.60	99.53	308.70	**1.000**	0.02	0.00	0.00
51	**0.363**	0.00	0.00	0.00	**0.382**	0.00	0.00	0.00	**0.047**	7864.04	557.04	0.00	**0.055**	0.00	481.66	0.00
52	**0.579**	0.00	7.69	0.00	**0.659**	0.00	50.06	0.00	**0.015**	0.00	443.38	0.00	**0.016**	0.00	405.29	0.00
53	**0.542**	0.00	0.00	0.00	**0.584**	0.00	7.48	0.00	**0.076**	3674.78	516.39	0.00	**0.105**	0.00	367.77	0.00
54	**0.407**	0.00	0.00	0.00	**0.412**	0.00	0.00	0.00	**0.143**	0.00	266.48	1333.69	**0.158**	414.00	226.73	1806.82
55	**0.640**	0.00	0.00	0.00	**0.669**	0.00	0.00	1.27	**0.204**	0.00	110.99	209.41	**0.286**	0.00	65.14	898.86
56	**0.693**	0.00	1.13	0.00	**0.698**	0.00	1.51	0.00	**0.057**	0.00	110.01	0.00	**0.080**	1076.47	75.63	0.00
57	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00

*Notes: *DMU 1 to 57 are Insurance, Information Technology, Population, Valuation, Political Revolution Roadmap of the Communist Party of Vietnam, Management Information Systems, Managerial Accounting, Financial Accounting, Auditing, Real Estate Business, International Business, Public Economics, Investment Economics, Human Resource Economics, Agricultural Economics and Rural Development, Development Economics, (Natural Resources and) Environmental Economics and Management, International Economics, Commercial Economics and Business, Real Estate Business and Land Administration, Urban economics, Microeconomics, Macroeconomics, Economic History, Monetary and Financial Theories, Marketing, Commercial Bank, Non-specialized Foreign Language, Accounting Principles, Basic principles of Marxism – Leninism, Basic Law, Business Law, Management of Technology, Economic Management, Social Management, Travel and Tourism Management, Enterprise Management, Hospitality Management, General Business Management, Human Resource Management, Public Finance, Corporate Finance, International Finance, Sociology, Stock Market, Business Statistics, Socio-Economic Statistics, International trade, Business English, Vietnamese and Linguistic Theories, Economic Informatics, Basic Mathematics, Mathematical Economics, Mathematical Finance, Marketing Communications, Ho Chi Minh Ideology, Business Culture Department, respectively.*

S+(1), S+(2), and S+(3) are shortage of research hours, graduates number, and teaching load output, respectively.

Table 4: Estimated efficiency scores and output slacks for *DMU*s in 2014

DMU	CCR-O				BCC-O				SBM-O-C				SBM-O-V			
	Score	S+(1)	S+(2)	S+(3)	Score	S+(1)	S+(2)	S+(3)	Score	S+(1)	S+(2)	S+(3)	Score	S+(1)	S+(2)	S+(3)
1	**0.457**	0.00	0.00	0.00	**0.481**	0.00	0.00	0.00	**0.338**	124.13	327.96	0.00	**0.338**	124.13	327.96	0.00
2	**0.334**	0.00	45.45	4399.30	**0.402**	0.00	24.17	3131.46	**0.034**	1472.25	446.65	2310.79	**0.034**	1472.25	446.65	2310.79
3	**0.590**	0.00	21.06	2069.27	**0.623**	0.00	9.70	1018.26	**0.015**	0.00	65.61	545.61	**0.015**	0.00	65.61	545.61
4	**0.714**	0.00	0.00	2377.98	**0.779**	0.00	0.00	1285.81	**0.468**	0.00	51.39	744.88	**0.468**	0.00	51.39	744.88
5	**0.903**	0.00	22.39	0.00	**1.000**	0.00	0.00	0.00	**0.999**	0.00	0.00	0.00	**0.999**	0.00	0.00	0.00
6	**0.576**	0.00	3.00	0.00	**0.721**	0.00	0.00	0.00	**0.340**	0.00	48.47	0.00	**0.340**	0.00	48.47	0.00
7	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00
8	**0.865**	0.00	0.00	0.00	**0.947**	338.98	0.00	2090.14	**0.787**	1008.96	0.00	3783.34	**0.787**	1008.96	0.00	3783.34
9	**0.517**	0.00	0.00	0.00	**0.603**	0.00	0.00	0.00	**0.424**	0.00	360.82	971.33	**0.424**	0.00	360.82	971.33
10	**0.525**	0.00	0.00	0.00	**0.630**	0.00	0.00	0.00	**0.513**	2163.66	70.15	0.00	**0.513**	2163.66	70.15	0.00
11	**0.531**	0.00	0.00	3230.54	**0.610**	0.00	0.00	3020.19	**0.307**	0.00	303.73	2079.04	**0.307**	0.00	303.73	2079.04
12	**0.910**	0.00	27.62	2625.79	**0.933**	0.00	25.44	2503.78	**0.394**	0.00	73.17	2430.54	**0.394**	0.00	73.17	2430.54
13	**0.586**	0.00	0.00	0.00	**0.652**	0.00	0.00	0.00	**0.584**	1944.38	279.97	1775.41	**0.584**	1944.38	279.97	1775.41
14	**0.638**	0.00	0.00	1735.73	**0.644**	0.00	0.00	1560.51	**0.395**	0.00	166.07	754.86	**0.395**	0.00	166.07	754.86
15	**0.383**	0.00	51.89	3938.00	**0.478**	0.00	25.12	2528.93	**0.032**	12.20	453.04	2638.38	**0.032**	12.20	453.04	2638.38
16	**0.876**	0.00	0.00	1502.17	**0.879**	0.00	0.00	1438.63	**0.738**	0.00	61.64	1189.62	**0.738**	0.00	61.64	1189.62
17	**0.454**	0.00	14.66	1593.66	**0.529**	0.00	2.08	966.86	**0.137**	0.00	367.54	836.22	**0.137**	0.00	367.54	836.22
18	**0.820**	0.00	0.00	3093.87	**0.897**	0.00	0.00	3397.60	**0.632**	0.00	75.33	4043.68	**0.632**	0.00	75.33	4043.68
19	**0.591**	0.00	0.00	1815.01	**0.747**	0.00	0.00	2614.16	**0.516**	0.00	0.00	12066.25	**0.516**	0.00	0.00	12066.25
20	**0.699**	0.00	0.00	1518.89	**0.775**	0.00	0.00	403.28	**0.610**	0.00	38.24	210.04	**0.610**	0.00	38.24	210.04
21	**0.407**	0.00	0.00	2344.41	**0.415**	0.00	0.00	1944.88	**0.199**	0.00	210.38	773.17	**0.199**	0.00	210.38	773.17
22	**0.517**	0.00	63.92	2097.85	**0.742**	0.00	11.42	194.85	**0.100**	0.00	277.38	2817.34	**0.100**	0.00	277.38	2817.34
23	**0.488**	0.00	40.93	0.00	**0.618**	0.00	15.21	0.00	**0.072**	0.00	405.63	1436.80	**0.072**	0.00	405.63	1436.80
24	**0.283**	0.00	0.00	0.00	**0.326**	0.00	0.00	0.00	**0.194**	2035.19	153.29	129.34	**0.194**	2035.19	153.29	129.34
25	**0.337**	0.00	35.58	0.00	**0.483**	0.00	0.00	0.00	**0.083**	1185.00	459.04	2643.33	**0.083**	1185.00	459.04	2643.33
26	**0.651**	0.00	0.00	3013.18	**0.832**	0.00	0.00	2059.82	**0.449**	0.00	157.28	3116.96	**0.449**	0.00	157.28	3116.96
27	**0.622**	2480.22	0.00	0.00	**0.660**	2571.59	0.00	330.84	**0.525**	7493.09	0.00	8526.05	**0.525**	7493.09	0.00	8526.05
28	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00
29	**0.917**	4942.95	0.00	0.00	**0.983**	4609.79	0.00	0.00	**0.847**	4718.53	0.00	621.60	**0.847**	4718.53	0.00	621.60
30	**0.689**	0.00	50.20	1920.78	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00
31	**0.558**	0.00	49.13	1298.23	**0.586**	0.00	43.80	1121.70	**0.004**	0.00	272.40	564.88	**0.004**	0.00	272.40	564.88
32	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00
33	**0.914**	0.00	13.60	1250.33	**1.000**	0.00	0.00	0.02	**1.000**	0.00	0.00	0.02	**1.000**	0.00	0.00	0.02
34	**0.877**	0.00	0.00	0.00	**0.965**	0.00	0.00	0.00	**0.925**	2132.32	0.00	0.00	**0.925**	2132.32	0.00	0.00
35	**0.378**	0.00	0.00	3934.17	**0.422**	0.00	0.00	3508.03	**0.162**	206.45	373.42	1559.67	**0.162**	206.45	373.42	1559.67
36	**0.773**	0.00	0.00	3808.29	**0.806**	0.00	0.00	3756.63	**0.452**	0.00	126.95	2913.44	**0.452**	0.00	126.95	2913.44
37	**0.712**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00
38	**0.842**	0.00	11.64	1764.64	**0.863**	0.00	4.78	1117.10	**0.466**	0.00	47.63	827.59	**0.466**	0.00	47.63	827.59
39	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00
40	**0.342**	0.00	0.00	0.00	**0.368**	0.00	0.00	0.00	**0.263**	5610.55	233.54	0.00	**0.263**	5610.55	233.54	0.00
41	**0.688**	0.00	0.00	0.00	**0.885**	0.00	0.00	0.00	**0.759**	5071.57	0.00	0.00	**0.759**	5071.57	0.00	0.00
42	**0.605**	0.00	0.00	0.00	**0.755**	0.00	0.00	759.07	**0.579**	0.00	0.00	12195.90	**0.579**	0.00	0.00	12195.90
43	**0.518**	1097.74	0.00	0.00	**0.677**	1608.77	0.00	0.00	**0.384**	10643.61	0.00	953.14	**0.384**	10643.61	0.00	953.14
44	**0.509**	0.00	18.86	0.00	**0.657**	0.00	1.93	0.00	**0.025**	0.00	38.44	0.00	**0.025**	0.00	38.44	0.00
45	**0.529**	0.00	0.00	3933.81	**0.535**	0.00	0.00	3678.18	**0.233**	0.00	206.58	1624.88	**0.233**	0.00	206.58	1624.88
46	**0.384**	0.00	37.74	438.58	**0.388**	0.00	34.50	166.05	**0.004**	0.00	246.79	52.83	**0.004**	0.00	246.79	52.83
47	**0.499**	0.00	1.93	0.00	**0.529**	0.00	0.00	0.00	**0.157**	0.00	198.27	0.00	**0.157**	0.00	198.27	0.00
48	**0.380**	0.00	0.00	0.00	**0.401**	0.00	0.00	0.00	**0.302**	3982.39	232.07	0.00	**0.302**	3982.39	232.07	0.00
49	**0.352**	0.00	0.00	0.00	**0.408**	0.00	0.00	0.00	**0.137**	6069.00	448.55	564.33	**0.137**	6069.00	448.55	564.33
50	**0.298**	0.00	12.28	428.79	**1.000**	0.00	0.00	0.00	**0.999**	0.00	0.00	0.00	**0.999**	0.00	0.00	0.00
51	**0.384**	0.00	0.00	0.00	**0.419**	0.00	0.00	0.00	**0.139**	5025.50	442.49	614.75	**0.139**	5025.50	442.49	614.75
52	**0.497**	0.00	49.25	0.00	**0.569**	0.00	33.38	0.00	**0.002**	0.00	420.86	0.00	**0.002**	0.00	420.86	0.00
53	**0.414**	0.00	0.00	0.00	**0.500**	0.00	0.00	0.00	**0.146**	3621.49	423.42	0.00	**0.146**	3621.49	423.42	0.00
54	**0.362**	0.00	0.00	2243.31	**0.378**	0.00	0.00	1550.87	**0.283**	3036.46	0.00	5381.84	**0.283**	3036.46	0.00	5381.84
55	**0.635**	0.00	6.55	2261.39	**0.674**	0.00	0.00	1250.79	**0.293**	0.00	67.35	617.33	**0.293**	0.00	67.35	617.33
56	**0.569**	0.00	17.33	0.00	**0.664**	0.00	1.44	0.00	**0.014**	0.00	68.36	0.00	**0.014**	0.00	68.36	0.00
57	**0.729**	0.00	14.69	2959.21	**0.744**	0.00	8.54	2361.56	**0.259**	0.00	93.01	1513.60	**0.259**	0.00	93.01	1513.60

Table 5: Estimated efficiency scores and output slacks for *DMU*s in 2015

*DMU**	CCR-O				BCC-O				SBM-O-C				SBM-O-V			
	Score	S+(1)	S+(2)	S+(3)	Score	S+(1)	S+(2)	S+(3)	Score	S+(1)	S+(2)	S+(3)	Score	S+(1)	S+(2)	S+(3)
1	**0.486**	0.00	0.00	0.00	**0.488**	0.00	0.00	0.00	**0.411**	0.00	161.59	2829.50	**0.413**	0.00	159.08	2895.67
2	**0.254**	0.00	0.00	0.00	**0.266**	0.00	0.00	0.00	**0.129**	1663.06	224.99	3473.68	**0.132**	2402.04	217.67	3536.92
3	**0.194**	0.00	10.58	0.00	**0.200**	0.00	17.90	0.00	**0.063**	1019.63	94.92	1680.47	**0.074**	2952.38	75.77	1845.88
4	**0.545**	0.00	0.00	0.00	**0.557**	0.00	0.00	0.00	**0.439**	0.00	40.32	1583.62	**0.446**	0.00	41.18	1455.75
6	**0.894**	0.00	9.33	0.00	**0.896**	0.00	6.88	0.00	**0.377**	0.00	28.05	0.00	**0.404**	0.00	25.09	0.00
7	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00
8	**0.971**	0.00	0.00	0.00	**0.972**	0.00	0.00	0.00	**0.937**	1034.61	0.00	915.92	**0.938**	848.84	0.00	948.59
9	**0.658**	0.00	0.00	0.00	**0.662**	0.00	0.00	0.00	**0.639**	0.00	135.94	945.03	**0.640**	0.00	133.81	1001.24
10	**0.589**	0.00	0.00	0.00	**0.595**	0.00	0.00	0.00	**0.484**	0.00	76.07	420.77	**0.497**	0.00	70.36	571.46
11	**0.550**	0.00	0.00	0.00	**0.551**	0.00	0.00	0.00	**0.533**	0.00	126.54	1587.10	**0.536**	0.00	123.13	1677.10
13	**0.693**	0.00	0.00	0.00	**0.695**	0.00	0.00	0.00	**0.682**	0.00	81.41	3603.51	**0.683**	0.00	102.56	2732.38
14	**0.403**	0.00	0.00	0.00	**0.405**	0.00	0.00	0.00	**0.395**	12789.00	43.33	1917.53	**0.398**	13101.85	36.05	2054.62
15	**0.415**	0.00	0.00	0.00	**0.460**	0.00	0.00	0.00	**0.209**	0.00	206.34	3687.19	**0.210**	0.00	204.33	3740.25
17	**0.643**	0.00	0.00	0.00	**0.714**	0.00	0.00	0.00	**0.380**	0.00	117.35	2350.96	**0.384**	0.00	113.93	2441.04
18	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00
19	**0.562**	0.00	0.00	0.00	**0.575**	0.00	0.00	1712.31	**0.446**	16641.70	0.00	6907.11	**0.448**	22754.98	0.00	5227.62
20	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00
21	**0.376**	0.00	0.00	0.00	**0.378**	0.00	0.00	0.00	**0.291**	0.00	110.91	2222.82	**0.294**	13.27	105.86	2353.56
22	**0.588**	0.00	42.59	0.00	**0.670**	0.00	0.00	0.00	**0.092**	0.00	257.80	0.00	**0.092**	0.00	255.01	474.70
23	**0.911**	0.00	30.77	0.00	**1.000**	0.00	0.00	0.00	**0.210**	0.00	97.80	0.00	**1.000**	0.00	0.00	0.00
24	**0.487**	0.00	1.67	0.00	**0.501**	0.00	10.46	0.00	**0.154**	0.00	85.95	436.34	**0.161**	0.00	81.74	419.31
25	**0.934**	0.00	0.00	0.00	**0.945**	0.00	0.00	0.00	**0.820**	0.00	15.79	0.00	**0.847**	0.00	13.06	0.00
27	**0.707**	0.00	0.00	0.00	**0.708**	0.00	0.00	0.00	**0.682**	16049.11	0.00	1789.40	**0.683**	15783.03	0.00	1824.53
28	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00
29	**0.865**	97.83	0.00	0.00	**0.865**	128.78	0.00	0.00	**0.674**	14908.59	0.00	0.00	**0.682**	14375.66	0.00	0.00
31	**0.699**	0.00	19.43	0.00	**0.735**	0.00	28.58	0.00	**0.053**	0.00	125.12	0.00	**0.054**	0.00	121.77	0.00
32	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00
33	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00
34	**0.785**	0.00	0.00	0.00	**0.788**	0.00	0.00	0.00	**0.607**	15852.19	0.00	0.00	**0.608**	15784.31	0.00	0.00
35	**0.398**	0.00	0.00	0.00	**0.415**	0.00	0.00	0.00	**0.270**	0.00	147.80	3272.75	**0.272**	0.00	144.16	3368.86
36	**0.496**	0.00	0.00	0.00	**0.496**	0.00	0.00	0.00	**0.388**	0.00	141.42	1833.73	**0.392**	0.00	137.90	1926.66
37	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00
39	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00	**1.000**	0.00	0.00	0.00
40	**0.693**	0.00	0.00	0.00	**0.699**	0.00	0.00	0.00	**0.544**	12508.42	17.22	0.00	**0.546**	12766.29	13.72	0.00
41	**0.531**	0.00	0.00	0.00	**0.533**	0.00	0.00	0.00	**0.495**	13245.00	41.76	1130.60	**0.499**	13531.78	35.08	1256.26
42	**0.787**	0.00	0.00	0.00	**0.855**	0.00	0.00	398.13	**0.744**	15056.45	0.00	2200.68	**0.748**	14735.34	0.00	2161.01
43	**0.737**	0.00	0.00	0.00	**0.751**	0.00	0.00	0.00	**0.685**	3223.45	0.00	2273.54	**0.688**	3267.15	0.00	2212.78
45	**0.530**	0.00	0.00	0.00	**0.543**	0.00	0.00	0.00	**0.374**	0.00	90.56	1909.11	**0.380**	0.00	85.53	2041.95
47	**0.402**	0.00	15.67	0.00	**0.402**	0.00	15.16	0.00	**0.101**	0.00	167.33	587.21	**0.105**	72.47	157.57	1585.83
49	**0.553**	0.00	26.81	0.00	**0.620**	0.00	0.00	0.00	**0.161**	0.00	271.06	0.00	**0.162**	0.00	267.46	613.32
50	**0.546**	0.00	6.79	0.00	**0.549**	0.00	7.48	0.00	**0.158**	0.00	36.03	288.31	**0.202**	428.50	24.36	705.19
51	**0.476**	0.00	28.71	0.00	**0.491**	0.00	17.68	0.00	**0.029**	0.00	266.27	100.47	**0.029**	313.45	264.32	0.00
52	**0.673**	0.00	34.88	0.00	**0.697**	0.00	21.84	0.00	**0.033**	0.00	201.66	0.00	**0.033**	0.00	201.56	0.00
53	**0.672**	0.00	13.34	0.00	**0.722**	0.00	0.00	0.00	**0.219**	0.00	214.24	0.00	**0.224**	0.00	207.90	0.00
54	**0.259**	0.00	0.00	0.00	**0.264**	0.00	0.00	0.00	**0.239**	1460.50	140.42	2792.67	**0.242**	2824.79	126.90	2909.42
55	**0.736**	0.00	16.04	0.00	**0.762**	0.00	8.85	0.00	**0.181**	0.00	49.95	1307.42	**0.187**	0.00	50.95	360.92
56	**0.606**	0.00	14.44	0.00	**0.607**	0.00	11.96	0.00	**0.075**	0.00	85.89	0.00	**0.077**	0.00	83.03	0.00
57	**0.986**	0.00	13.68	543.24	**1.000**	0.00	0.00	0.00	**0.578**	0.00	15.50	609.90	**1.000**	0.00	0.00	0.00

*Notes: *There are only 48 DMUs in the sample of the year 2015. Nine missing departments due to incomplete data consist of DMUs 5, 12, 16, 26, 30, 38, 44, 46, and 48.*

There are, in fact, two types of measures or approaches in DEA: radial and non-radial. The two previous models, under weak efficiency, evaluate only the radial or proportional efficiency, but do not take account of the output shortfalls that are represented by non-zero slacks. On the contrary, the non-radial approach, which is represented by SBM, deals with slacks directly in the objective function and reflects non-zero slacks in outputs when they are present. The SBM model is perhaps more suitable and practical in this case when all the variables employed seem to be non-radial. Furthermore, SBM accounts for all inefficiencies instead of accounting only for purely technical inefficiencies as did the previous models, therefore it measures "mix efficiency". We ran the output-oriented SBM (which puts emphasis on the output shortfalls) under both the constant and variable returns-to-scale assumptions.

It is apparent from the results that a *DMU* is SBM-efficient under constant returns-to-scale if and only if it is CCR-efficient, and similarly, a *DMU* is SBM-efficient under variable returns-to-scale if and only if it is BCC-efficient, following strictly Tone's theorem (Tone and Cooper, 1997). In the SBM, the efficiency scores of the less efficient *DMU*s, however, were significantly lower than those in the CCR or BCC model, which leads to large differences among *DMU*s. This is because the SBM model takes into account slacks for the less efficient *DMU*s. The general efficiency score in the SBM, thus, was very low; for example, the figures for SBM models under constant and variable returns-to-scale in 2015 were respectively just 0.479 and 0.509. Nonetheless, in the output-oriented SBM models, we can analyze the output slacks of the less efficient *DMU*s in order to explain why they did not reach the efficient positions and how they could improve their positions. *DMU* 1, for instance, performed well in research in 2015, but proved to be less efficient in training under both the CRS and VRS assumptions. In fact, it would have to increase its teaching load by 2896 periods a year and produce 159 graduating students more to reach the highest efficiency level in 2015 (according to the result of the SBM (VRS) model). Meanwhile, *DMU* 2, however, needed to expand all of their outputs to be an efficient one in 2015, especially the research and teaching load outputs (see Table 5).

The Malmquist results shown in Table 6 allow us to evaluate the change in efficiency scores and the technological change as well as the total factor productivity (TFP) change of the *DMU*s over the period. Due to some missing data in 2015 as mentioned above, there were 48 *DMU*s being analyzed using the output-oriented Malmquist DEA model. In each year (period), the first column ('firm') shows the *DMU*s' names, the second ('effch') reflects technical efficiency change (catch-up effect), the third ('techch') reflects technology change (frontier-shift effect), the fourth ('pech') reflects pure technical efficiency change, the fifth ('sech') reflects scale efficiency change, and the last ('tfpch') indicates total factor productivity change or Malmquist index, which is a combination of the catch-up and the frontier-shift effects. As can be seen from the results, in terms of catch-up effect, a significant proportion of *DMU*s (66.67%) made progress in efficiency, that is their catch-up value is higher than 1, from 2013 to 2015. The average improvement rate in the technical efficiency of 48 de-

Table 6: Results of the output-oriented Malmquist DEA model applied to the data set in three years, 2013-2015

MALMQUIST INDEX SUMMARY												MALMQUIST INDEX SUMMARY OF FIRM MEANS					
year = 2						year = 3											
firm	effch	techch	pech	sech	tfpch	firm	effch	techch	pech	sech	tfpch	firm	effch	techch	pech	sech	tfpch
1	0.819	1.126	0.856	0.957	0.922	1	1.063	0.864	1.013	1.049	0.918	1	0.933	0.986	0.931	1.002	0.920
2	0.997	0.970	1.182	0.843	0.967	2	0.760	0.954	0.613	1.241	0.725	2	0.871	0.962	0.851	1.023	0.837
3	3.004	0.896	2.998	1.002	2.692	3	0.329	1.051	0.321	1.028	0.346	3	0.995	0.971	0.980	1.015	0.965
4	2.231	1.002	2.306	0.967	2.235	4	0.763	1.004	0.715	1.067	0.766	4	1.304	1.003	1.284	1.016	1.308
5	0.652	1.144	0.721	0.904	0.746	5	1.552	0.811	1.243	1.248	1.258	5	1.006	0.963	0.947	1.062	0.968
6	1.000	0.933	1.000	1.000	0.933	6	1.000	0.579	1.000	1.000	0.579	6	1.000	0.735	1.000	1.000	0.735
7	0.931	0.953	0.947	0.983	0.886	7	1.123	0.643	1.026	1.094	0.722	7	1.022	0.783	0.986	1.037	0.800
8	0.946	1.106	1.071	0.883	1.046	8	1.272	0.782	1.099	1.158	0.994	8	1.097	0.930	1.085	1.011	1.020
9	0.677	1.158	0.782	0.866	0.784	9	1.121	0.803	0.944	1.187	0.900	9	0.871	0.964	0.859	1.013	0.840
10	0.920	1.027	1.017	0.905	0.945	10	1.036	0.867	0.894	1.159	0.898	10	0.976	0.944	0.953	1.024	0.921
11	0.691	1.070	0.740	0.934	0.739	11	1.183	0.802	1.066	1.110	0.949	11	0.904	0.926	0.888	1.018	0.838
12	1.217	1.062	1.216	1.000	1.292	12	0.631	0.844	0.629	1.004	0.533	12	0.876	0.947	0.875	1.002	0.830
13	1.422	0.934	1.600	0.889	1.328	13	1.083	1.026	0.878	1.233	1.111	13	1.241	0.979	1.186	1.047	1.215
14	0.830	1.123	1.001	0.829	0.932	14	1.415	0.986	1.270	1.114	1.395	14	1.084	1.052	1.127	0.961	1.140
15	1.246	1.024	1.323	0.942	1.275	15	1.219	0.940	1.114	1.094	1.145	15	1.232	0.981	1.214	1.015	1.209
16	0.692	1.020	0.812	0.852	0.706	16	0.951	0.755	0.770	1.235	0.718	16	0.811	0.878	0.791	1.026	0.712
17	1.355	0.952	1.312	1.033	1.290	17	1.430	1.063	1.290	1.109	1.521	17	1.392	1.006	1.301	1.070	1.400
18	1.162	1.055	1.169	0.993	1.226	18	0.925	0.981	0.911	1.015	0.907	18	1.037	1.017	1.032	1.004	1.054
19	0.942	1.077	1.363	0.691	1.014	19	1.138	0.901	0.760	1.496	1.025	19	1.035	0.985	1.018	1.017	1.020
20	0.700	1.113	0.948	0.739	0.779	20	1.867	0.922	1.510	1.236	1.721	20	1.143	1.013	1.196	0.956	1.158
21	1.716	1.121	1.924	0.892	1.924	21	1.724	0.891	1.532	1.125	1.535	21	1.720	0.999	1.717	1.002	1.719
22	1.005	1.103	1.596	0.630	1.109	22	2.769	0.805	1.750	1.582	2.229	22	1.668	0.942	1.671	0.998	1.572
23	0.919	0.952	0.868	1.058	0.874	23	1.137	0.675	1.073	1.060	0.767	23	1.022	0.801	0.965	1.059	0.819
24	1.000	1.062	1.000	1.000	1.062	24	1.000	0.671	1.000	1.000	0.671	24	1.000	0.844	1.000	1.000	0.844
25	0.948	0.957	0.983	0.964	0.907	25	0.943	0.666	0.880	1.072	0.628	25	0.945	0.798	0.930	1.016	0.755
26	0.823	0.985	0.775	1.061	0.811	26	1.252	0.939	1.232	1.016	1.176	26	1.015	0.962	0.977	1.039	0.976
27	1.000	1.152	1.000	1.000	1.152	27	1.000	0.847	1.000	1.000	0.847	27	1.000	0.988	1.000	1.000	0.988
28	1.517	0.909	1.373	1.104	1.379	28	1.094	1.008	1.000	1.094	1.103	28	1.288	0.957	1.172	1.099	1.233
29	0.990	1.024	0.979	1.011	1.014	29	0.895	0.715	0.817	1.096	0.640	29	0.942	0.856	0.895	1.053	0.806
30	1.198	1.053	1.353	0.885	1.261	30	1.055	1.009	0.962	1.096	1.064	30	1.124	1.031	1.141	0.985	1.159
31	1.707	1.035	1.769	0.965	1.766	31	0.642	0.948	0.616	1.042	0.608	31	1.046	0.990	1.044	1.003	1.036
32	0.806	1.085	1.000	0.806	0.874	32	1.405	0.836	1.000	1.405	1.174	32	1.064	0.952	1.000	1.064	1.013
33	1.155	0.997	1.121	1.030	1.151	33	1.000	0.648	1.000	1.000	0.648	33	1.075	0.804	1.059	1.015	0.864
34	0.808	1.063	0.794	1.017	0.859	34	2.028	0.733	1.899	1.068	1.487	34	1.280	0.883	1.228	1.042	1.130
35	1.011	1.033	1.100	0.920	1.045	35	0.772	0.745	0.603	1.281	0.576	35	0.884	0.878	0.814	1.085	0.775
36	1.050	0.990	1.244	0.844	1.040	36	1.302	0.704	1.132	1.150	0.916	36	1.169	0.835	1.187	0.985	0.976
37	0.799	1.022	1.014	0.788	0.816	37	1.422	0.741	1.109	1.282	1.054	37	1.066	0.870	1.060	1.005	0.928
38	1.030	1.016	1.038	0.992	1.047	38	1.001	1.034	1.014	0.987	1.035	38	1.016	1.025	1.026	0.990	1.041
39	0.612	1.110	0.635	0.964	0.680	39	0.806	0.805	0.760	1.060	0.649	39	0.703	0.945	0.695	1.011	0.664
40	0.753	1.091	0.890	0.846	0.821	40	1.570	0.788	1.472	1.066	1.237	40	1.087	0.927	1.144	0.950	1.008
41	1.187	1.077	1.000	1.187	1.279	41	1.833	1.004	0.549	3.342	1.841	41	1.475	1.040	0.741	1.992	1.535
42	1.021	1.105	1.107	0.922	1.128	42	1.240	0.777	1.161	1.068	0.964	42	1.125	0.927	1.133	0.992	1.042
43	0.837	1.115	0.899	0.932	0.933	43	1.353	0.798	1.178	1.149	1.080	43	1.065	0.943	1.029	1.035	1.004
44	0.736	1.097	0.900	0.818	0.807	44	1.622	0.772	1.374	1.181	1.252	44	1.093	0.920	1.112	0.983	1.005
45	0.889	0.933	0.916	0.970	0.829	45	0.714	0.908	0.698	1.024	0.649	45	0.797	0.921	0.800	0.997	0.734
46	0.987	0.911	1.008	0.979	0.899	46	1.159	1.116	1.130	1.025	1.293	46	1.070	1.008	1.068	1.002	1.078
47	0.792	1.097	0.872	0.908	0.869	47	1.064	0.797	0.907	1.173	0.848	47	0.918	0.935	0.889	1.032	0.858
48	0.729	0.854	0.744	0.980	0.623	48	1.353	1.118	1.344	1.007	1.513	48	0.993	0.977	1.000	0.993	0.970
mean	0.994	1.033	1.075	0.925	1.027	mean	1.122	0.845	0.979	1.147	0.949	mean	1.056	0.934	1.026	1.030	0.987

*Notes: *Firm (DMU) 1 to 48 are Insurance, Information Technology, Population, Valuation, Management Information Systems, Managerial Accounting, Financial Accounting, Auditing, Real Estate Business, International Business, Investment Economics, Human Resource Economics, Agricultural Economics and Rural Development, (Natural Resources and) Environmental Economics and Management, International Economics, Commercial Economics and Business, Real Estate Business and Land Administration, Urban economics, Microeconomics, Macroeconomics, Economic History, Monetary and Financial Theories, Commercial Bank, Non-specialized Foreign Language, Accounting Principles, Basic Law, Business Law, Management of Technology, Economic Management, Social Management, Travel and Tourism Management, Enterprise Management, General Business Management, Human Resource Management, Public Finance, Corporate Finance, International Finance, Stock Market, Socio-Economic Statistics, Business English, Vietnamese and Linguistic Theories, Economic Informatics, Basic Mathematics, Mathematical Economics, Mathematical Finance, Marketing Communications, Ho Chi Minh Ideology, Business Culture Department, respectively.*

partments over the period was 5.6%. However, regarding the frontier-shift effect, there were only 9 *DMU*s that improved their frontier technology between 2013 and 2015, while 39 other *DMU*s demonstrated frontier-shift values less than 1, leading to the mean technological contribution to the *DMU*s' efficiency declined by 6.6% during the period. As a result, the average Malmquist index, which is a more comprehensive indicator (as mentioned above), was merely 0.987, with just 23 out of 48 DMUs, that is, nearly a half showed TFP growth in the period.

5. Discussion and concluding remarks

While the existing literature on the application of DEA in evaluating the efficiency of educational institutions is rich and plenteous, this method is still new for the education sector in Vietnam. Actually, we have found two studies applying this method to evaluating efficiency of Vietnamese higher education institutions, but so far this study is still the first one applying this method to examining the efficiency of academic departments within the same university.

As an illustrative example, this paper evaluates the performance of 57 departments of NEU. The data set used consists of one input (number of academic staff) and three outputs (number of research hours, number of graduates, and teaching load). We ran four different DEA models to investigate efficiency of the departments, then computed the Malmquist index to examine the improvement in efficiency of the departments from 2013 to 2015.

This study reveals some clear policy-making implications. First, the results provide a deeper insight into the current status of teaching and research activities of the department (reflected in the efficiency scores, output-slacks, and Malmquist index). Second, the information about output-slacks is especially useful for departments to improve their efficiency position (in terms of output expansion). Thus, such information helps departments adjust their development plan in a more appropriate way. Last but not least, to fully exploit the benefits of this method for the purpose of efficient resource allocation, we wish the data on all activities of the institution and its departments should be available and up-to-date.

Notes:

1. "Weak efficiency" satisfies the condition $\theta^* = 1$; "strong efficiency" satisfies two conditions: $\theta^* = 1$ and all slacks are zero (Cooper et al., 2007).

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