Proceedings of the 2013 International Conference on Information, Operations Management and Statistics (ICIOMS2013), Kuala Lumpur, Malaysia, September 1-3, 2013

An Empirical Analysis of Productivity Changes in the Malaysian Polytechnics

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Abstract

In this concept paper an attempt will be made to investigate the effects of government regulation on higher education, and particularly Malaysian Polytechnic sector. Malaysian government has put a greater attention on making polytechnic sector as the main provider of technical and vocational education and training (TVET) in the nation since TVET is a hope to promote nation aspiration in achieving developed nation status by the year 2020. National Higher Education Strategic Plan (NHESP) implemented in 2007 has become the pivotal policy that contributes to the expansion of polytechnic sector. According to [59], NHESP is master key in the higher education transformation. This paper will employ [78] approach to decompose the Hick–Moorsteen index to examine the productivity and efficiency changes experiences by polytechnic sector before and after the regulation. This method makes no assumption for firms' returns to scale condition.[30] suggested that this approach is suitable in measuring the productivity changes index.

Keywords : Hicks-Moorsteen index, polytechnic, technical and vocational education and training, efficiency.

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1. Introduction

According to [71], the nation economic progress depends on technical and vocational educational and training (TVET) sector since this sector are capable to sustain and develop nation's workforce supply. Hence, greater emphasis has been put by Malaysian government towards improving TVET sector performance. This is because TVET promotes in increasing the level of knowledge and skill of the nation's human capital. Ministry of Higher Education (MoHE) is one of the government ministries which act as one of the TVET provider in Malaysia. Under the jurisdiction of MoHE, polytechnics and community colleges are the institutions which offer TVET in the nation. In this paper, the author will focus on polytechnics transformation and performance analysis as one of Malaysia's TVET provider.

Currently, there are 32 polytechnics across the country since the establishment of Ungku Omar Polytechnic in 1969 that was funded under the United Nations Development Plan (UNDP) [42]. The Department of

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Polytechnic Education (DPE) held responsibility in generating competent workforce by 2015 that ready to compete in international arena. Thus, polytechnics sector has undergone some fundamental changes since the implementation of the NHESP (National Higher Education Strategic Plan) in 2007. [59] claimed that NHESP is the key of Malaysia's higher education reformation. The direction of polytechnic transformation intention is in line with NHESP which is to generate skilful and educated manpower with first class mentality that capable to compete in global market.

In 2013, DPE transformation agenda is going through the second phase that is the enhancing phases of polytechnic transformation. There are four phases of implementation involves in the implementation of polytechnic transformation programme to support the NHESP, Government Transformation Programme (GTP) and Economic Transformation Programme (ETP) with specific duration as follows: first phase - (2010-2012) : quicks win and institutional transformation; second phase – (2013-2015) : enhancing ; third phase – (2015-2020) : strengthening ; fourth phase – (2020 onwards) : excellence. DPE objective on the second phase is to increase the performance of polytechnic Centre of Technology (CoT), offering more programme according to National Key Economic Areas (NKEA), making polytechnic reputation well-known in the region, produce a transformative leader in each layer of polytechnic organisation, creating a Curriculum Standard for Polytechnics (CSP) that can be referred by other TVET institution and lastly generating high prestige graduate.

On the transformation agenda of the Malaysian polytechnic sector, one can observe a very strong policy focus on making polytechnic to become the leading provider of the nation TVET sector. The NHESP was formulated with the aim of improving the efficiency by boosting the use of information and communication technology (ICT) and the growth of internationalisation. Largest amount of fund was allocated from the total development budget for TVET sector during the Tenth Malaysia Plan (2011-2015) according to [47]. However, there is no empirical study of polytechnics performance before and after the policy reform despite the allocation of huge funding.

The Malmquist productivity index and the Hicks-Moorsteen index are the two discrete-time primal productivity indices that require a detailed knowledge of the underlying production technology. The Malmquist productivity index is considered as the most prevalent tool in measuring changes in efficiency and productivity of the firms (see [84], [75], [46], [86]) while Hicks-Moorsteen index is still fairly little used in applied research. According to [40] the Hicks-Moorsteen productivity index always has a better TFP index interpretation compared to the Malmquist index which is not always a TFP index. Furthermore, the distance functions formed may be undefined by using general technologies estimation [61].

[78] latest studied creates additional questioned on the Malmquist productivity index as a TFP index. Without making assumptions on the firm's behaviour, market structure or the return to scale of multiple input-output, he decomposed the multiplicatively complete TFP indices into technical and efficiency changes. The term "multiplicatively complete" means that TFP indices can be represented as the combination of inputs and the combination of outputs according to [78]. The well-known Malmquist index by [21] is eliminated from the group of complete TFP indices which consist of the Fisher, Konus, Törnqvist and Hicks–Moorsteen indices as proven by [78]. Apart from special cases such as constant returns to scale, [78] states that the Malmquist index of is not complete, implying that it may be an unreliable measure of TFP change. Hence, the estimation of technical or efficiency changes by [31] popular decomposition Malmquist index become unreliable [78].

Since the polytechnics in Malaysia are not operating at optimal scale and they face imperfect competition, the VRS assumption seems more appropriate than the CRS assumption. [40] showed that the Malmquist index are not maintained under the condition of variable returns to scale (VRS). Therefore, in the present study the new decomposition of the Hicks–Moorsteen TFP index is utilised, allowing one to analyse changes in the productivity of firms under the VRS assumption. Moreover, according to [30] another issue with the use of the Malmquist index is that there is a possibility of having infeasible results. [36], [38] and [12] experienced this difficulty in their studies of the Korean banks, UK building societies, and Iranian banks, respectively. [30] suggest that one can turn to the Hicks–Moorsteen TFP index to address these problems.

2. Literature Review

Numerous of the study using a nonparametric approach in measuring efficiency and productivity changes of higher education as well as TVET sector take place in the developed countries as follows (e.g. [56], [28], [15], [19],[1], [89], [15], [50], [58], [85], [17], [54], [13], [66], [43], [41], [81], [25], [83], [63], [3], [90], [20], [29], [57], [52], [53], [67], [88], [87], [51], [60]). However, a small number of higher education studies related to developing countries for example [26] studies the performance of 78 Philippines State Universities and Colleges (SUCs) in the period 2006-2009 and found that majority of the SUC's are inefficient. The evaluation was done using data envelopment analysis. In a different study of developing countries, [48] investigate China (AVET) Agriculture Vocational Training institution efficiency and study the effectiveness of teaching and management. The result indicates that AVET efficiency depend on the production efficiency changes and the weakened technology growth which affect the education progress total factor productivity (TFP) caused by the pure technical efficiency.

The distance function values could change over time; hence the efficiency estimation on polytechnic performance measure over time may be unreliable if the estimation only focused on the efficiency estimation. There are two values that could changes on the distance function: 1) the movement of polytechnics within the input-output space (efficiency changes); or 2) the progress/regress of the boundary of the production set over time (technological changes). Malmquist index decomposition is able to differentiate the changes of efficiency, productivity and technological. Though few researchers has attempted to use the Malmquist index for this purpose such as [19], [48], [65], [4], [54], and [9].

This study was mainly to focus on the changes in technology and/or efficiency. For instance,[19] used approximately 200 further education (FE) providers in England data to investigate the level of efficiency and change in productivity over the period 1999–2003 and found that there is an increase in the changes of technology and technical efficiency. In a comprehensive study of 38 Taiwanese technical institutes, [65] also identified similar results in productivity growth in term of its technical efficiency.

The conventional Malmquist index had an extensive amount of literature in higher education institution area. However, there is lacking volume of literature regarding the application of Hicks-Moorsteen index listed. To the best of our knowledge, there are only four applications of the Hicks-Moorsteen decomposition in the existing literature on agricultural sector and only one in the context of higher education institution. The contribution study in agricultural area that used TFP index for measuring and decomposing changes in agricultural productivity was: [77], [78], [79] and [45] which have used this. As in higher education institution, [82] used the Hicks-Moorsteen TFP index in analyses efficiency and productivity changes in Malaysia higher education institution. To the best of our knowledge, this is the first study to analyses efficiency and productivity changes in the context of Malaysia polytechnic institutions.

3. The Data

This study utilizes a four-year panel dataset (2007–2010) for analysing the performance of Malaysian polytechnics after the implementation of NHESP. There are 32 main campuses of polytechnics operating in Malaysia and all are considered in this study. The data will be collected from every polytechnics main campus and from the Department of Research and Development in the Ministry of Higher Education.

As Malmquist index is a distance-based index, non-parametric DEA models are employed to estimate the institutions' efficiency and productivity changes. An important advantage of the DEA approach is that it works well with a small sample size. The small sample size of 32 polytechnics in this paper is not sufficient for parametric (econometric) techniques. There are a number of studies in the literature working also with small sample sizes (e.g. [56], [2], [1], [65], [62]). Another advantage of the non-parametric approach pertains to its capability to accommodate multiple inputs and outputs.

The important issue in the use of the DEA approach relates to the correct selection of inputs and outputs. However, there is no consensus in the literature as to how to specify the inputs and outputs ([50], [49], [14]). According to [64] some characteristics of the higher education institutions such as 'lack of profit motivation, goal diversity and uncertainty, diffuse decision making and poorly understood production technology' differentiate this sector from other industries and complicate the specification of the variables. Carrington, [20] also state that it is difficult to accurately define the university inputs and outputs as they are diverse and multi-faceted.

The choice of inputs and outputs in this study is based on the production approach– higher educations which combine labour and non-labour factors of production to produce outputs in the form of teaching. This choice of input-output mix in this paper is somehow similar to previous studies by [91], [16], [17], [49], [50], [66], [13], [1] and [37].

The two inputs included in our analysis, which are fully defined in Table 1, are as follows: 1) total number of undergraduate enrolments; 2) total number of full-time equivalent teaching staff; 4) the number of full-time equivalent non-teaching staff 3) the value of fixed assets as a proxy for capital. Our outputs are the number of undergraduate qualifications awarded.

Table 1. Input and Output Variable

Variables		*Definition of variables*
Outputs		
	Undergraduate qualifications awarded	The total number of diploma and certificate qualifications awarded
Inputs		
	Undergraduate enrolments	The total number of diploma and certificate enrolments
	Teaching staff	The number of full-time equivalent academic staff members
	Non-teaching staff	The number of full-time equivalent non-teaching staff members
	Fixed assets as capital representation	The value of fixed asset that represent capital

Two observations are noteworthy at this point. First, student inputs are assumed to be homogenous as there was no easy way to capture the quality. This is consistent with DEA models of previous studies (e.g. [13], [34], [54], and [91]). Second, we mainly focus on teaching as the most important activities of polytechnics.

Research outputs are not being included because of the unavailability of the data. We also not incorporated community services output as there is no accepted or easy way to evaluate community and consultation services (see [11], [10], [20], [54], [91]).

4. Hick-Moorsteen TFP Index and Its Decompositions

Considering a firm with multiple inputs and outputs, [76] used the usual definition of total factor productivity following [55] and [39]: $TFP_{nt} = Y_{nt} / X_{nt}$, where TFP_{nt} indicates the TFP of the n^{th} firm in period *t*, $Y_{nt} \equiv Y(y_{nt})$ and $X_{nt} \equiv X(x_{nt})$, where Y_{nt} and X_{nt} are the aggregate output and aggregate input of the firm concerned, respectively. According to this definition, one can specify TFP changes as the ratio of an output quantity index to an input quantity index (the ratio of output growth to input growth). [78] refers to such index numbers as multiplicatively complete.

The Hicks–Moorsteen TFP index is the only multiplicatively complete index that we can estimate without requiring price data. This index is a ratio of Malmquist output and input quantity indices, so named because [27] related its origins to [44] and [74]. The Hicks–Moorsteen TFP index operates as follows:

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

where $D_o(x, y)$ and $D_I(x, y)$ are output and input distance functions, respectively, defined as $D_O^T(x, y) = \min\left\{\delta > 0 : (x, y/\delta) \in P^T\right\}$, and $D_I^T(x, y) = \max\left\{\rho > 0 : (x/\rho, y) \in P^T\right\}$, where P^T denotes the period–*T* production possibilities set. Using DEA, one can calculate these distance functions. [78] developed a DEA methodology for computing and decomposing the Hicks–Moorsteen TFP index. All DEA problems necessary for computing and decomposing the Hicks–Moorsteen TFP indices are detailed in [78]. As in [45] and [78], DEA is also used in this paper as a nonparametric method which does not make any assumption about the behaviour of firms, the functional form of the technology or efficiency distribution. However, DEA makes no allowance for statistical inferences; therefore one should be cautious in the interpretation of its results.

Figure 1 shows [78] mapping of multiple-input and multiple-output production points into aggregate quantity space. The curve through points *D* and *C* denotes a mix-restricted frontier as it represents the boundary of the set of all technically-feasible aggregate input-output combinations which hold the same input and output mix as the firm operating at point A. Firm A can raise its TFP by expanding outputs until it achieves point *C*. The vertical distance from point *A* to point *C* is referred to as a measure of output-oriented technical efficiency (OTE):

$$OTE_t = \frac{Y_t}{\bar{Y}_t} = \frac{\tan a}{\tan c}. \qquad (2)$$

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

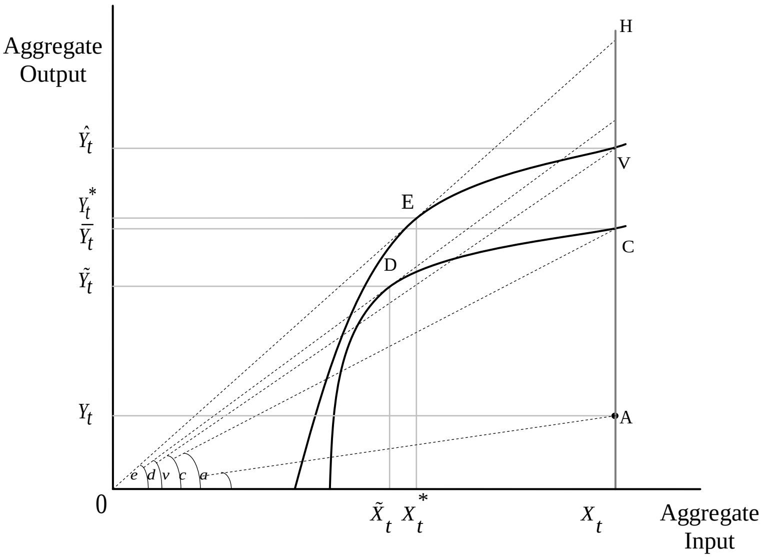

Fig. 1. Output-oriented decompositions of TFP efficiency

The curve passing through point *V* is the unrestricted production frontier which is the limit of the production possibilities set when all mix restrictions are relaxed. Now Firm A can expand aggregate output compared to point *C* and move vertically to point *V* in Figure 1. In this situation, [78] defined the mix efficiency measure as the difference between the TFP at a technically efficient point on the mix-restricted frontier, and the TFP at a technically efficient point on the unrestricted frontier. Hence, the pure output-oriented mix efficiency (OME) is written as:

$$OME_t = \frac{\bar{Y}_t}{\hat{Y}_t} = \frac{\bar{Y}_t / X_t}{\hat{Y}_t / X_t} = \frac{\tan c}{\tan v} \tag{3}$$

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

However, the TFP of Firm A can be maximised only by reaching point E, where a straight line through the origin is tangential to the unrestricted production possibilities frontier. Point E is known as the point of maximum productivity. The residual scale efficiency measure is defined by [78] as the difference between the TFP at point V and the TFP at point E. The residual output-oriented scale efficiency (ROSE) is the vertical distance from point V to point H or:

$$ROSE_t = \frac{\hat{Y}_t / X_t}{Y^*_t / X^*_t} = \frac{\tan v}{\tan e} \tag{4}$$

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

$$\text{TFP Efficiency} = TFPE_t = \frac{TFP_t}{TFP_t^*} = \frac{\tan a}{\tan e} = \frac{\tan a}{\tan c}\frac{\tan c}{\tan v}\frac{\tan v}{\tan e} \tag{5}$$

Equation (5) is a measure of TFP efficiency which calculates the proportionate increase in TFP as the firm moves from point *A* to point *E*. Figure 1 show that there are many pathways from point *A* to point *E*. Thus, there are many ways to decompose TFP efficiency in Equation (5). Pathway ACVE is employed for $TFPE_t$; another possible way is ACDE, which shows that TFP efficiency can also be written as:

$$TFPE_t = \frac{\tan a}{\tan e} = \frac{\tan a}{\tan c}\frac{\tan c}{\tan d}\frac{\tan d}{\tan e} \qquad (6)$$

In relation to the efficiency measures defined in this section (Equations 2 to 4), the following output-oriented decomposition can thus be defined:

$$TFPE_t = \frac{TFP_{nt}}{TFP_t^*} = OTE_{nt} \times OME_{nt} \times ROSE_{nt} \qquad (7)$$

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

$$TFP_{nt} = TFP_t^* \times (OTE_{nt} \times OME_{nt} \times ROSE_{nt}). \qquad (8)$$

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

$$TFP_{ms,nt} = \frac{TFP_{nt}}{TFP_{ms}} = \underbrace{\left(\frac{TFP_t^*}{TFP_s^*}\right)}_{Technical\ changes} \times \underbrace{\left(\frac{OTE_{nt}}{OTE_{ms}} \times \frac{OME_{nt}}{OME_{ms}} \times \frac{ROSE_{nt}}{ROSE_{ms}}\right)}_{Efficiency\ changes} \qquad (9)$$

The term included in the first parentheses on the right-hand side of this equation represents technical changes, measuring the difference between the maximum TFP possible using the technology feasible a times *t* and *s*. Thus, the sector experiences technical improvement or decline depending on whether TFP_t^* / TFP_s^* is greater than or less than 1. In Figure 1, TFP_t^* / TFP_s^* measures the change in the slope of the line that passes through point *E*. Unlike in the decomposition of the Malmquist TFP index, [31] calculate the change in the slope of the line passing through point *D*. Hence, [78] presents that this technical change contains a mixed effect and characteristically differs from firm to firm. The three other ratios on the extreme right hand side of Equation (9) are referred to as measures of technical-efficiency change, mix-efficiency change and (residual) scale-efficiency change. We use Equation (9) to examine various components of technical-efficiency changes. This method has also been employed by [45] and [78] to investigate changes in the agricultural productivity of Organisation for Economic Co-Operation and Development (OECD) countries and Australia, respectively. We used the DPIN software written by [80] to estimate different measures of efficiency and TFP components.

5. Conclusions

This paper is anticipated makes three significant contributions to the literature of efficiency and productivity changes in higher education institutions sector particularly in 32 polytechnics in Malaysia. First, this study is the first attempt to examine the issue of efficiency and productivity change by employing the Hick-Moorsteen TFP over the period 2007–2010. Second, based on observation this is the first paper that will measure the polytechnics efficiency and productivity growth in response to significant policy changes in the Malaysian higher education sector during 2007. The effect of the NHESP on the performance of Malaysian polytechnics over the period of 2007–2011 is investigated. Lastly, no previous study in developing countries has employed Hick-Moorsteen TFP indices method to measure efficiency and productivity changes in polytechnics institution.

Acknowledgements

The researchers would like to acknowledge the Sultan Idris University of Education the financial funding of this research via Research University Grant Scheme (RUGS) [Code no: 2013-0049-106-01].

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