MEASURING MALAYSIAN POLYTECHNIC PERFORMANCE USING A BOOTSTRAPPED DATA ENVELOPMENT ANALYSIS MODEL

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Abstract

The purpose of this article is to investigate the effects of government regulation on higher education, particularly in the Malaysian Polytechnic scenario. The Malaysian government has put a greater attention on developing the polytechnic sector as the main provider of technical and vocational education and training (TVET) in the nation in an effort to achieve the developed nation status by the year 2020. The National Higher Education Strategic Plan (NHESP) which was implemented in 2007 has become the pivotal policy which contributes to the expansion of the polytechnic sector. This study will employ the bootstrapped Data Envelopment Analysis (DEA) model to examine the technical efficiency experiences by members of the polytechnic sector before and after the regulation.

Keywords: bootstrapped, DEA, polytechnic, technical and vocational education and training, technical efficiency.

INTRODUCTION

A nation's economic progress depends on the technical and vocational educational and training (TVET) sector as this sector is seen as being capable of sustaining and developing the nation's workforce supply (Minghat & Yasin, 2010). Subsequently, TVET hopes to enhance the level of knowledge and skill of the nation's human capital. Hence, greater emphasis has been put by Malaysian government towards improving the TVET sector performance. Ministry of Education (MOE) is one of the government ministries which act as one of the TVET provider in Malaysia. Under the jurisdiction of MOE, polytechnics and community colleges are the institutions, which offer TVET in the nation. As such, the author will focus on the performance analysis of the polytechnics which fall under the umbrella of Malaysia's TVET provider.

Currently, there are 24 polytechnics across the country since the establishment of Ungku Omar Polytechnic in 1969 which was funded under the United Nations Development Plan (UNDP) (Hamed, Wahab, Zakaria, & Jasmi, 2010). The Department of Polytechnic Education (DPE) is responsible for generating competent workforce by 2015, a time when it is deemed ready to compete in the international arena. Thus, the polytechnic sector has undergone some fundamental changes since the implementation of the NHESP (National Higher Education Strategic Plan) in 2007. According to Kaur and Sirat (2010), NHESP is considered the key for Malaysia's higher education reform. The direction of the polytechnic transformation is in line with NHESP which is to generate skilful and educated manpower with first class mentality capable to compete in global market.

On the transformation agenda of the Malaysian polytechnic sector, one can observe a very strong policy focus on making the polytechnic to become the leading provider of the nation's 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. The largest amount of fund was allocated for the total development budget of the TVET sector during the Tenth Malaysia Plan (2011-2015) according to Izyan, Zainudin, Saud and Nordin, (2012). However, there is no empirical study of the polytechnics' performance before and after the policy reform despite the allocation of huge funding.

There is little documented literature on the performance of the TVET institution sector (Johnes, Bradley & Little, 2012). Thus, this study will provide an analysis on the technical efficiency level using DEA to explore the consequences of policy changes in the polytechnic sector. The use of DEA in this paper employs the same approach used by Johnes (2006a) for assessing the performance of further education institution. Furthermore, the application of bootstrapped procedure by Simar and Wilson (1998) is to provide statistical precision for the nonparametric efficiency measures based on DEA. The application of the proposed model concerns 20 polytechnics across Malaysia and it may be of vital importance for the policy makers and the regulator since this sector consumes huge funding from the government in order to enhance the performance of these institutions.

This study will complement the existing research in four ways:

1) To the best of the authors' knowledge, it appears to be the first paper to utilise DEA on a sample of Malaysia polytechnic institutions to determine the mean efficiency level
2) This study applied the bootstrapping approach to eliminate the drawbacks of DEA which lacks estimates of the uncertainties among the individual efficiencies
3) The application of bootstrapped DEA approach allows the identification of a specific polytechnic campus with respect to resources used (i.e: labour, number of students, qualification awarded) which is performing better than other campuses. The identified campus can also be known as the benchmark campus for other less performing campuses.
4) It investigates the consequences of policy changes, namely the NHESP 2007 on polytechnic education institution using the bootstrapped DEA in Malaysia.

LITERATURE REVIEW

Traditional ways of measuring tertiary education institution performance take various forms of ratio such as return on capital employed, return on total assets and market-to-book-value ratio (Johnes & Johnes, 2004). However, Johnes (2004) also states that the measurement in ratio form is not suitable in this context since it cannot describe the differences in institutional environment and capture the performance of an institution's activities in a long period of time. In addition, Johnes (2008) mentions that the efficiency and productivity studies in tertiary education sector are problematic because of the sector's characteristics: it is a non–profit organisation; it lacks a price mechanism in input and output; and lastly, the sector produces multiple outputs from multiple inputs. Thus, the measurement of tertiary education sector performance cannot be the same as other industries which aims for profit maximisation.

There are numerous studies which used the nonparametric approach in measuring the efficiency of higher education, as well as the efficiency of TVET sector, in the developed countries (e.g. Mills (2004), Johnes (2008), Johnes (2006b), Johnes (2006b), Wolszczak-Derlacz and Parteka (2011), Alexander, Haug, Jaforullah, and Haug (2007), and Johnes et al. (2012)). However, a small number of higher education studies are related to developing countries; for example, Cuenca's study (2011) which focused on the performance of 78 Philippines State Universities and Colleges (SUCs) in the period 2006-2009 and found that the majority of the SUC's are inefficient. The evaluation was done using data envelopment analysis. In a different study of developing countries, Jing and Shen (2011) investigated China's Agriculture Vocational Training (AVET) institution's efficiency; specifically the effectiveness of teaching and management. The result indicates that AVET efficiency depends on the production efficiency changes and the weakened technology growth which affect the education progress's total factor productivity (TFP) caused by the pure technical efficiency. Sunitha and Duraisamy (2010) studied the technical and scale efficiency in higher technical education institution in Kerala, India by comparing engineering and polytechnic institutions. Their results showed better technical efficiency in polytechnic institutions in Kerala.

DEA is suitable to be applied in tertiary education institutions since the production function usually produces multiple outputs from multiple inputs (Banker & Natarajan, 2008). In addition, DEA allows each DMU under the analysis to select its own weight assigned to inputs and outputs, despite using value judgements on their relative importance. According to Lothgren and Tambour (2010), the absence of price for input and output components in the service sector (in this case polytechnic) shows that this is the best choice of technique for measuring the relative importance of the inputs and outputs. A survey done by Emrouznejad, Parker and Tavares (2008) highlighted that there were more than 4000 research publications as of 2007 which applied DEA techniques in both the industrial and service sectors. According to the survey, education institutions were found to be one of the most popular areas where DEA application was used.

To the best of our knowledge, this is the first study to analyse efficiency using the bootstrapped DEA approach in the context of Malaysian polytechnic institutions.

THE DATA

This study utilises a four-year panel dataset (2006–2010) for analysing the performance of Malaysian polytechnics after the implementation of NHESP. There are 24 main campuses of polytechnics operating in Malaysia and all are taken into account in this study. The data would be collected from each polytechnic's main campus as well as the Department of Research and Development in the Ministry of Higher Education.

A non-parametric DEA model is employed to estimate the institution's efficiency. An important advantage of the DEA approach is that it works well with a small sample size. The small sample size of 20 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. Mills (2004) and Johnes (2008)). 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 the inputs and outputs are specified (Avkiran, 2001). According to Lindsay (1982) as cited from Salleh (2012), some characteristics of the higher education institutions, such as lack of profit motivation, goal diversity and uncertainty, diffused decision making and poorly understood production technology differentiate this sector from other industries and complicate the specification of the variables. Carrington, Coelli, and Rao (2005) 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 education which combines 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 somewhat similar to study done by Worthington and Lee (2008). The two inputs included in our analysis, which are fully defined in Table 1, are as follows:

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

Two observations are noteworthy at this point. First, student inputs are assumed to be homogenous as there is no easy way to capture the quality. This is consistent with DEA models of previous studies (e.g. Sunitha and Duraisamy (2010)). Second, we mainly focus on teaching as the polytechnics' most important activity since there is little emphasis towards research activities in the polytechnics which makes the institution different from universities.

METHODOLOGY

This study on efficiency and productivity changes in Malaysian Polytechnics employed a non-parametric DEA model. The reason for choosing DEA is because the DEA model is capable of accommodating a small sample size as this study only includes 20 polytechnics as the sample study (Sufian, 2007). Therefore, a parametric approach is not appropriate in the case of this study (see Tomkins & Green, 1988; Sinuany-Stern, Mehrez, & Barboy, 1994; Sarafoglou & Haynes, 1996). Secondly, by using the DEA technique, DEA does not require the definition of the production function in the analysis. The third strength is that DEA will have no problems of misspecification in the production function and also the inefficiency distribution since no functional form is specified.

The original DEA, CRS model by Charnes, Cooper and Rhodes (1978) employs the input orientation and assumes the condition of CRS. This CRS assumption is acceptable only when all the DMUs are operating at an optimal scale. In practical circumstances the DMUs may face either economies or diseconomies of scale. It is difficult for DMUs to function at the optimal scale since there are various factors which might contribute to the disability, such as imperfect competition, the regulation of the environment, and financial load. Hence, by using the specification of CRS when the DMUs are not fully operating at the optimal scale, scale efficiency may affect the measurement of technical efficiency.

Therefore Banker, Charnes and Cooper (1984) introduced an extension of the CCR model known as the BCC model, which allows the assumption of VRS and relaxes the CRS assumption in the CCR model. VRS assumption is allowed in the BCC model which will separate pure technical efficiency from scale efficiency. Hence, this study will use the BCC model which allows the VRS assumption since it is not easy to change the scale of the polytechnics' operations in a short term.

Measurement of scale efficiency and the nature of scale economies

To measure the scale efficiency for each DMU in the sample, both CRS and VRS models must be estimated. The technical efficiency score obtained from the CRS model will then be decomposed into two elements: scale inefficiency and pure technical efficiency. According to Cooper, Seiford and Tone (2007) this decomposition is unique because it can be used to represent the basis of inefficiency either caused by inefficient operation (pure technical efficiency) or by disadvantageous conditions within scale efficiency, or from both sources. If there are differences between the estimated technical efficiency score in the CRS model compared to the estimated technical efficiency score in the VRS model, it can be concluded that the DMU has scale inefficiency. According to Coelli, Rao, O'Donnell and Battese, (2005) the inefficiency in scale efficiency can be defined by Equation (1) below:

$$TE_{CRS} = TE_{VRS} \times SE \tag{1}$$

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

Input and output orientation in DEA

DEA model comprises of input orientation and output orientation. The input orientation approach aims to reduce as many of the inputs as possible while the outputs remain unchanged. The output orientation approach aims to expand as much of outputs proportionally as the inputs remain constant. Ultimately, these two approaches differ in terms of the amount to which input and output can be controlled. Both of the approaches obtain the same core of efficiency under the assumption of CRS. However, it is not under the assumption of VRS.

Coelli (1996) demonstrates that both of the approaches' estimate with the same frontier and identify the same efficient DMUs, and the only difference is in terms of the inefficiency scores of the DMUs. In the context of tertiary education institutions, output orientation is much more appropriate in this sector since the polytechnics may contain a fixed quantity of inputs such as student enrolments (controlled by the government) which are required to generate as many outputs as possible. Major studies in this context have used output orientation in measuring technical efficiency such as Johnes et al. (2012), Flegg, Allen, Field and Thurlow (2004), Joumandy and Ris (2005), Johnes (2006), Agasisti and Johnes (2009), Agasisti (2009), Salleh (2012) and Bradley, Johnes and Little (2010).

The VRS output-oriented is the same as the DEA model input-oriented. The VRS model output-oriented is given as follows:

$$\begin{aligned} &\max_{\emptyset,\lambda} \emptyset, \\ &st - \emptyset y_i + Y\lambda \geq 0 , \\ &\qquad x_i - X\lambda \geq 0 , \\ &N1'\lambda = 1 \\ &\lambda \geq 0, \end{aligned} \tag{2}$$

Bootstrapped DEA Procedure

Simar (1992) and Simar and Wilson (1998) discovered the use of the bootstrap in frontier models to obtain non-parametric envelopment estimators. The original idea of bootstrapping is to approximate a true sampling distribution by mimicking the data-generation process. This procedure is based on constructing a pseudo-sample and re-solving the DEA model for each Decision Making Unit (DMU) with the new data. A continual repeating process constructs an approximation of the true distribution. According to Simar and Wilson (2000), the DEA scores lack statistical inference since it is a nonparametric approach. Thus, they conclude that bootstrapping is the only available means of statistical test in order to estimate bias, variance and confidence interval.

We will conduct the bootstrapped procedure following the general methodology for the nonparametric approach by Simar and Wilson (2000). The procedure would be conducted using the commands *boot.sw98*in the FEAR software program (Wilson, 2006).

RESULT

The empirical findings presented in this section discuss the efficiency analysis of the polytechnics using the bootstrapped DEA with the output orientation under the assumption of VRS. An efficient polytechnic is indicated by the efficiency score equal to unity which is 1. The efficient polytechnics appear on the production possibility boundaries of the period of time. An institution with efficiency estimates below unity indicates inefficiency.

Table 2 provide a general picture of the sector efficiency and productivity performance over the study period. The mean efficiency estimates of the sector are presented annually. The second, third and fourth columns of this table provide the means of efficiency, bias-corrected efficiency and bias estimates of the entire sector, respectively. The fifth and sixth columns present the lower and upper bounds of the 95% confidence intervals for the annual mean efficiency scores.

Table 2 Mean of Efficiency Score of Malaysian Polytechnics Sector for 2006-2010

Polytechnics	Mean of Efficiency	Bias	Bias corrected	Lower Bound	Upper Bound	Bound Width
2006	1.023	-0.015	1.038	1.023	1.069	0.045
2007	1.089	-0.046	1.135	1.092	1.199	0.107
2008	1.081	-0.038	1.119	1.083	1.177	0.095
2009	1.046	-0.026	1.072	1.047	1.112	0.065
2010	1.045	-0.024	1.069	1.046	1.108	0.062
Mean	**1.057**	**-0.030**	**1.086**	**1.058**	**1.133**	**0.075**

Source: Author’s calculations

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

In addition, as theoretically expected, Table 2 indicates that the bias estimates for all periods were negative (Simar & Wilson, 2000). As we can see, in most periods the bias mean is small, which indicates the results stability from the models. The bias ranged from -0.015 to -0.046. As a whole, the findings indicate that the sector bias-corrected efficiency level improved during 2007 and slightly declined in 2008. The bias corrected also continued to decline from the year 2008 onwards. The mean efficiency of the sector achieved its peak during the year of NHESP implementation which was 2007.

Tables 3 to 7 deliver more useful findings of estimated efficiency scores for individual polytechnics from 2006 to 2007. The tables present the estimated technical efficiency levels in the second column, the bias estimates in column 3, bias-corrected estimates in column 4, the 95% confidence interval bounds and the confidence interval ranges for the individual polytechnics in the period 2006–2010 in column 5 and the bound width in column 6.

Table 3 Efficiency Score of Malaysian Polytechnics Sector in 2006

Polytechnics	Efficiency	Bias	Bias corrected	Lower Bound	Upper Bound	Bound Width
PUO	1.000	-0.025	1.025	1.001	1.087	0.087
POLISAS	1.000	-0.024	1.024	1.001	1.083	0.082
POLIMAS	1.000	-0.016	1.016	1.001	1.044	0.043
PKB	1.005	-0.013	1.019	1.006	1.048	0.042
PKS	1.052	-0.007	1.060	1.053	1.069	0.016
PPD	1.039	-0.010	1.049	1.040	1.062	0.022
PKK	1.000	-0.024	1.024	1.001	1.085	0.084
PSA	1.044	-0.011	1.055	1.045	1.073	0.028
PJB	1.033	-0.009	1.042	1.034	1.056	0.022
PSP	1.000	-0.011	1.011	1.001	1.026	0.026
PKM	1.000	-0.025	1.025	1.001	1.088	0.087
PKT	1.000	-0.018	1.018	1.001	1.045	0.045
PSMZA	1.015	-0.009	1.024	1.016	1.034	0.018
PMM	1.023	-0.014	1.037	1.024	1.063	0.039
PSAS	1.037	-0.010	1.047	1.038	1.061	0.023
PTSB	1.053	-0.013	1.067	1.054	1.093	0.039
PSIS	1.033	-0.015	1.048	1.034	1.075	0.041
PTSS	1.100	-0.014	1.114	1.101	1.134	0.032
PMS	1.014	-0.013	1.027	1.015	1.058	0.044
PMU	1.000	-0.024	1.024	1.001	1.085	0.084
Mean	**1.023**	**-0.015**	**1.038**	**1.023**	**1.069**	**0.045**

Source: Author calculations

The results suggest that out of 20 institutions, only six polytechnics were ostensibly efficient with the efficiency score = 1. The other polytechnics' efficiency score varied from 1.005 to 1.053.The bias estimated for all institution in the year 2006 showed negative values. The bias corrected for the estimates showed greater than unity for all the polytechnics. The PMU scores of efficiency equal to unity with bias corrected value of 1.024 means that the input could be held constant while the output had been adjusted to be more than 2.4%. The confidence interval of the PMU observation suggests that the output could have been reduced by between 8.5% and -91.6%.

Table 4 Efficiency Score of Malaysian Polytechnics Sector in 2007

Polytechnics	Efficiency	Bias	Bias corrected	Lower Bound	Upper Bound	Bound Width
PUO	1.000	-0.082	1.082	1.003	1.202	0.199
POLISAS	1.183	-0.023	1.206	1.184	1.246	0.062
POLIMAS	1.000	-0.068	1.068	1.003	1.150	0.146
PKB	1.079	-0.043	1.121	1.081	1.186	0.105
PKS	1.111	-0.024	1.135	1.114	1.169	0.055
PPD	1.124	-0.027	1.151	1.128	1.190	0.063
PKK	1.000	-0.071	1.071	1.003	1.148	0.145
PSA	1.090	-0.036	1.126	1.093	1.176	0.083
PJB	1.027	-0.040	1.068	1.030	1.118	0.088
PSP	1.085	-0.042	1.127	1.089	1.180	0.091
PKM	1.000	-0.062	1.062	1.003	1.143	0.140
PKT	1.000	-0.084	1.084	1.003	1.194	0.191
PSMZA	1.097	-0.038	1.135	1.100	1.188	0.088
PMM	1.076	-0.019	1.095	1.078	1.125	0.047
PSAS	1.104	-0.022	1.125	1.107	1.159	0.052
PTSB	1.237	-0.029	1.266	1.240	1.320	0.080
PSIS	1.204	-0.041	1.245	1.206	1.304	0.098
PTSS	1.224	-0.045	1.270	1.226	1.338	0.111
PMS	1.000	-0.082	1.082	1.003	1.198	0.195
PMU	1.145	-0.044	1.189	1.148	1.256	0.107
Mean	**1.089**	**-0.046**	**1.135**	**1.092**	**1.199**	**0.107**

Source: Author calculations

The results for 2007 suggest that, the same amount of institutions are ostensibly efficient with the efficiency score = 1. However, the institutions' score differed from the previous year. The other polytechnics' efficiency scores varied from 1.027 to 1.237.The level of efficiency score variation for the 12 polytechnics which scored more than 1 were higher than the one in the previous year. The bias estimated for all institution in the year 2007 showed negatives value. The bias corrected for the estimates showed greater than unity for all the polytechnics. For example, regarding the PMS observation, the scores of efficiency equal to unity with the bias corrected value of 1.082 indicate that the output could be more than 8.2% given its inputs. The confidence interval of the PMU observation suggests that the output could have been reduced by between 25.6% and

-89.3%. The year 2007 can be considered the benchmark year for the analysis of the results. This is because 2007 was the NHESP policy was implemented in 2007. Further analysis of the coming year can be seen in Table 5 to Table 7.

The results for 2008 indicated that, the amount of institutions which were ostensibly efficient with the efficiency score = 1 was reduced to five institutions from the previous year. The other polytechnics' efficiency score varied from 1.002 to 1.248.The level of efficiency score variation for the 12 polytechnics which scored more than 1 were higher than the previous year. The bias estimated for all institution in the year 2007 showed negatives value. The bias corrected for the estimates showed greater than unity for all of the polytechnics.

Table 5 Efficiency Score of Malaysian Polytechnics Sector in 2008

Polytechnics	Efficiency	Bias	Bias corrected	Lower Bound	Upper Bound	Bound Width
PUO	1.000	-0.073	1.073	1.002	1.194	0.192
POLISAS	1.135	-0.033	1.168	1.137	1.227	0.090
POLIMAS	1.062	-0.027	1.088	1.063	1.139	0.075
PKB	1.000	-0.073	1.073	1.002	1.174	0.171
PKS	1.160	-0.017	1.177	1.162	1.208	0.046
PPD	1.083	-0.019	1.102	1.085	1.134	0.049
PKK	1.017	-0.034	1.051	1.019	1.095	0.076
PSA	1.087	-0.041	1.128	1.089	1.182	0.092
PJB	1.095	-0.025	1.120	1.098	1.161	0.064
PSP	1.000	-0.063	1.063	1.003	1.130	0.127
PKM	1.002	-0.041	1.043	1.003	1.111	0.107
PKT	1.000	-0.073	1.073	1.002	1.192	0.190
PSMZA	1.127	-0.012	1.140	1.129	1.163	0.034
PMM	1.112	-0.014	1.127	1.114	1.155	0.041
PSAS	1.110	-0.014	1.125	1.112	1.148	0.036
PTSB	1.118	-0.015	1.133	1.119	1.159	0.039
PSIS	1.107	-0.031	1.137	1.109	1.183	0.075
PTSS	1.248	-0.031	1.279	1.250	1.343	0.093
PMS	1.000	-0.075	1.075	1.002	1.186	0.184
PMU	1.154	-0.043	1.197	1.155	1.268	0.112
Mean	**1.081**	**-0.038**	**1.119**	**1.083**	**1.177**	**0.095**

Source: Author calculations

Table 6 Efficiency Score of Malaysian Polytechnics Sector in 2009

Polytechnics	Efficiency	Bias	Bias corrected	Lower Bound	Upper Bound	Bound Width
PUO	1.000	-0.048	1.048	1.002	1.135	0.133
POLISAS	1.085	-0.020	1.104	1.086	1.143	0.057
POLIMAS	1.000	-0.037	1.037	1.002	1.094	0.092
PKB	1.000	-0.033	1.033	1.001	1.086	0.085
PKS	1.076	-0.012	1.088	1.077	1.105	0.028
PPD	1.018	-0.022	1.040	1.019	1.071	0.051
PKK	1.000	-0.025	1.025	1.001	1.048	0.047
PSA	1.025	-0.017	1.042	1.026	1.064	0.038
PJB	1.092	-0.011	1.102	1.093	1.117	0.024
PSP	1.000	-0.044	1.044	1.002	1.108	0.107
PKM	1.000	-0.028	1.028	1.002	1.081	0.079
PKT	1.000	-0.048	1.048	1.002	1.132	0.129
PSMZA	1.069	-0.014	1.084	1.071	1.103	0.032
PMM	1.131	-0.015	1.146	1.133	1.164	0.032
PSAS	1.039	-0.011	1.050	1.040	1.066	0.026
PTSB	1.095	-0.014	1.109	1.097	1.130	0.033
PSIS	1.041	-0.018	1.058	1.042	1.079	0.037
PTSS	1.161	-0.031	1.192	1.163	1.235	0.073
PMS	1.000	-0.048	1.048	1.001	1.132	0.131
PMU	1.082	-0.025	1.107	1.084	1.153	0.069
Mean	**1.046**	**-0.026**	**1.072**	**1.047**	**1.112**	**0.065**

Source: Author calculations

Table 7 Efficiency Score of Malaysian Polytechnics Sector in 2010

Polytechnics	Efficiency	Bias	Bias corrected	Lower Bound	Upper Bound	Bound Width
PUO	1.000	-0.047	1.047	1.001	1.142	0.140
POLISAS	1.076	-0.021	1.097	1.077	1.137	0.060
POLIMAS	1.000	-0.035	1.035	1.001	1.078	0.076
PKB	1.043	-0.022	1.065	1.044	1.102	0.059
PKS	1.172	-0.020	1.192	1.174	1.226	0.052
PPD	1.088	-0.011	1.100	1.090	1.113	0.024
PKK	1.000	-0.018	1.018	1.002	1.038	0.036
PSA	1.069	-0.022	1.092	1.071	1.123	0.053
PJB	1.080	-0.009	1.089	1.081	1.102	0.020
PSP	1.035	-0.019	1.054	1.036	1.081	0.045
PKM	1.000	-0.031	1.031	1.001	1.081	0.079
PKT	1.000	-0.046	1.046	1.002	1.139	0.137
PSMZA	1.033	-0.016	1.049	1.034	1.071	0.037
PMM	1.061	-0.009	1.070	1.062	1.082	0.020
PSAS	1.032	-0.010	1.042	1.033	1.054	0.021
PTSB	1.080	-0.013	1.092	1.081	1.107	0.026
PSIS	1.000	-0.017	1.017	1.001	1.035	0.033
PTSS	1.130	-0.026	1.156	1.132	1.206	0.075
PMS	1.000	-0.046	1.046	1.002	1.139	0.137
PMU	1.000	-0.043	1.043	1.001	1.114	0.112
Mean	**1.045**	**-0.024**	**1.069**	**1.046**	**1.108**	**0.062**

Source: Author calculations

The results for 2009 and 2010 indicated that, the amount of institutions which were ostensibly efficient with the efficiency score = 1 increased to eight institutions from the previous year. The other polytechnics' efficiency score varied from 1.025 to 1.161 and 1.032 to 1.172 for the year 2009 and 2020, respectively. The value of bias estimates and bias-corrected followed the same pattern as the one recorded in the previous year of the study.

CONCLUSION

A non-parametric approach, bootstrapped DEA indices was applied in this study to analyse empirically the score of technical efficiency in Malaysian polytechnic institutions. As for the analysis in technical efficiency, the sector as a whole has undergone improvement in the level of mean efficiency post-NHESP period which was from 2007 onwards. This article is expected to make significant contributions to the literature of efficiency studies, particularly in the TVET sector comprising the 20 polytechnics in Malaysia. The effect of the NHESP on the performance of Malaysian polytechnics over the period of 2006–2010 was investigated. Lastly, to the best of our knowledge, no previous study in Malaysia had employed the bootstrapped DEA method to measure efficiency in the polytechnic institution.

As such, for further research, it is suggested that a similar analysis of DEA is conducted using bootstrap simulation to analyse the Malaysian Polytechnics' performance for the year 2010 onwards, particularly focusing on the effects of the Transformation Program on the polytechnics' performance. Besides, the determinant of efficiency and inefficiency can be determined using regression analysis corresponding to the level of technical efficiency measured.

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