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OPERATION EFFICIENCY ASSESSMENT OF HONG KONG PUBLIC FUNDED UNIVERSITIES – A DEA APPROACH

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Abstract

Operation efficiency assessment is important in measuring the performance of an organization; especially the non-profit making organizations such as educational institutes. DEA is a common tool in evaluating the efficiency of organizations and have been employed to measure the efficiency of universities in different places of the world.

In this study, we will employ output oriented (with the same inputs) DEA methods to study the performances of the seven public funded universities in Hong Kong for an 8 year horizon.

Results of this study indicate that the general efficiency scores obtained by the assessed universities are relatively high. Universities in Hong Kong are broadly divided into research universities (U1, U2 and U3) and teaching universities (U4, U5, U6 and U7) and the results support this general division as teaching universities are generally performing better in teaching and research universities are generally performing better in researches. However, we observe that time (length of history) is not a critical factor on the performances for both groups.

We hope this study will provide some useful information and insights to the performance and efficiency of universities in Hong Kong and indirectly make contribution to the improvements of the same.

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1. Introduction

Efficiency is an important factor from the perspective of management. In these years, different organisations and institutions use various methods to measure their efficiencies and then seek ways to improve them. This does not only apply to profit-making organizations, but also in non-profit making organizations and the public sectors, including educational institutions – universities.

In Hong Kong, the tertiary institutions are mainly funded by the Government. Based on the figures provided by the University Grants Committee (UGC)[1], 13.045 billion Hong Kong dollars were spent on tertiary institutions in the year 2009/10, which was 4.5% of the total government expenditure, and reflected 22.2% of the government expenditure on education of the year. From the perspective of property and facility management, with such great sums are put into the operation of these institutes, it is important to ensure that the fund is used effectively and efficiently as taxpayers' money is at stake.

In Hong Kong, the main universities are public universities and The UGC will allocate the amount of funding that granted to each university on an annual basis based on the following considerations.

1. Level of funding that can be made available
2. Overall student number targets by level of study and year to meet community needs as agreed with the Government
3. The breakdown of these numbers between institutions, as agreed in principle by the institutions

Universities are naturally concerned about their performances as that affect the grant they can get with UGC. Unlike private companies and firms where performance can be easily assessed by comparing profit generated, universities focus on providing teaching and research do not generate any profit, hence other credible methods are needed in evaluating their performance.

Many studies have been made to assess the efficiencies of the universities in different parts of the world. Different methods and indicators have been used. In this study, Data Envelopment Analysis (DEA) would be adopted to evaluate the

[1] University Grants Committee (UGC) is a statutory advisory body responsible for the allocation of funding to the public tertiary institutions.

efficiencies of the UGC-funded universities in Hong Kong. Previous DEA researches on this topic covered the efficiencies of different departments in the same university or efficiencies of different universities in one specific financial year for a single year only. Since the performances of universities may vary over time, the trend movement of the efficiencies is unknown. In this study, we will examine how the efficiencies as measured over time for the various universities. We hope our empirical findings can provide a foundation for better understanding of the efficiency of the operation of universities in Hong Kong and lend some research support to the policy making bodies.

This paper is organized as follows. Section 2 will review the relevant literature on efficiency and the DEA model would be introduced in Section 3. Section 4 will elaborate on the choice of data in this study. The results and the interpretations of the data analysis is in Chapter 5. Conclusion is in Section6.

II
Literature Review

Evaluation of the operational efficiency of education institutions and/ or its component units have been attempted around the world. Tomkins and Green (1988) tried to evaluate the efficiencies of the departments of accounting of UK universities in UK by adopting the DEA method. Johnes (2006) explored the strengths and weakness of the various measuring methods in measuring the efficiencies in the higher education sector. It also applied the DEA method to assess the efficiencies of 100 higher educational institutes in England. Feng, Lu and Bi (2003) made use of the AHP/DEA method in investigating the efficiency of Research and Development (R&D) management activities of the universities in China. Rayeni and Saljooghi (2010) have assessed the performance of the educational institutions in Iran. Apart from the normal application of DEA to the data in obtaining the efficiency of different departments in the university, they adopted the interval efficiency determination on each educational department to find out their ranking. As a result, the number of efficient units is reduced, but the compatibility and stability of the ranking is ensured.

In US, Bougnol and Dulá (2006) attempted to compare the performance and ranking of the research activities of the universities in US given from a published

report “Top American Universities Research” Annual Report by applying DEA method. They found that the results obtained from applying the DEA method are similar to that from the report. They asserted that DEA is a more objective tool in assessing the efficiencies and ranking the units and argued that the critical factor in classification and ranking is the selection of attributes; i.e., the model. In Germany, Fandel (2005) adopted the DEA method to evaluate the effects of the government’s redistribution of funds on the performances of universities. Avkiran (1999) assessed the technical and scale efficiencies of 36 universities in Australia. They suggested theadoption a checklist listing the steps when applying the DEA method in efficiency assessment. Sarrico and Dyson (2000), stepping in the shoes of management, made use of the DEA method to see if improvement could be done to improve the planning of the university. Mcmillan and Datta (1998) assessed the efficiency of 45 universities in Canada, classified as comprehensive with medical school, comprehensive without medical school, and primarily undergraduate. It again confirmed the usefulness of the DEA method in assessing the performance of non-profit making organizations.

Most of the researches in the past are conducted in two directions. One direction is assess the performance of different academic departments in one particular university in a single financial year as in Rayeni and Saljooghi (2010). Barboy, Mehrez and Sinuany-Stern (1994),assessing the efficiencies of the academic departments at Ben-Gurion University, adopted the CCR model of DEA method and subsequently effect organizational changes resulting in an inefficient department closed and joined other departments. Lopes and Lanzer (2002) evaluated the productivity and quality of the academic departments in one Brazilian university by adopting a combination of the DEA method and the fuzzy numbers. It suggested that departments with low performance in one or more dimensions should receive additional evaluation from an external auditing committee and research productivity and quality were found weakly correlated. By applying this method, the strengths of the university and the places that are needed to be improved could be easily found and it is good for an institute to review itself.

The other research direction is the study of efficiency of universities or a particular type of department from universities in a specified region or for the whole country. Feng, Lu and Bi (2003) included a larger size of DMUs in the study, usually 20-30

institutes and compared their performance in a particular financial year, like. Colbert, Levary and Shaner (2000) made use of the DEA method to determine the relative efficiency of 24 top ranked US MBA programs. By so doing, a new ranking of those programs were obtained. This method can also be used for the comparison of universities. The efficient universities can act as a role-model and allow the less efficient ones to learn from them.

However, these two directions of researches have a common drawback, i.e. they usually focussed on one financial year only. The trend of change in the efficiency performance of the assessed universities could not be traced. If the trend of change can be traced, the development of the assessed universities could be followed and a better understanding of their past performance history is known. This can help them to set up better policies and development strategies. As far as we are aware of, there seems few if not none researches conducted on the assessment of the efficiency performance of the universities in Hong Kong by DEA methodology. This study is to fill in this gap.

2. Research Methodology

2.1 The DEA model

Data Envelopment Analysis (DEA) was originated by Farrell (1957). It is a linear programming-based technique for measuring the performance efficiency of organizational units termed Decision-Making units (DMUs). (Ramanathan, 2003). It is developed from the ratio efficiency test and it allows the users to use multiple inputs and produce multiple outputs to measure the efficiencies. The DEA method uses an efficiency score to measure the efficiencies of the DMUs. And this score is measured by the ratio of weighted sum of the outputs to that of the inputs. The efficiency of a single input/output is defined as Output/Input $\leq$ 1. The concept of this method is that the efficiency of each DMU is determined by the ability to convert inputs to the aimed output. An efficient frontier is obtained through arranging the DMUs by their efficiency scores. The most efficient DMUs would lie on the efficient frontier and have an efficiency score of 1and inefficient DMUs would be enveloped within the efficient frontier with an efficiency score of less than 1. The following description of the DEA method follows closely that of R. Ramanathan (2003).

The method of DEA is first developed by Charnes, Cooper, & Rhodes (1978) (CCR) under the assumption that productive activities were characterized by Constant Returns to Scale (CRS), which assumes the increase of outputs is proportional to the increase of inputs at any scale of operation. The model was then modified by Banker, Charnes, & Cooper (1984) (BCC) to take into account Variable Returns to Scale (VRS), which allows the production technology to exhibit the Increasing Returns-to-Scale (IRS) and the Decreasing Returns-to-Scale (DRS) as well as the Constant Return-to-Scale (CRS). The IRS means the output increases by more than the proportional change in the input, while the DRS means the output increases by less than the proportional change in the input. For example, when all inputs increase by a factor of 2, new values for output should only have three kinds of possibilities. One is the value is increased to twice of the previous output, which is a Constant Return-to-Scale (CRS). Another is the value is increased by less than two times than the previous output, which is a Decreasing Returns-to-Scale (DRS). The final possibility is the output increased by more than twice than the previous output, and this is an Increasing Returns-to-Scale (IRS).

The DEA method can be applied by an input-orientation basis or an output-orientation basis. Input-orientation means a DMU would reach a require level of output by using the minimum level of inputs. Output orientation means a DMU would produce the maximum level of output when given with a given limited level of inputs. This helps in finding the degree of relative efficiencies of all the DMUs that have been taken into consideration and labels those efficient DMUs serveing as a benchmark for those that are inefficient. These two bases are instrumental in identifying the strengths and weaknesses of DMUs.

DEA is suitable for this research because it has several advantages. First, the DEA method is suitable for measuring the performance of the non-profit making organizations or public sectors as there is no price or profit output data available but only multiple services are available when multiple inputs are put in. Secondly, the DEA method can quantify the performance of the DMUs by yielding a score representing how efficient or inefficient it is. This efficient score can generalize the performance of the DMUs as different DMUs would have different strengths. A DMU would perform efficiently in one specific aspect while performing inefficiently in the others. The adopting of the DEA method can provide a general platform for the DMUs to be compared with less biased view. Finally, the DEA method finds the best-performing DMU from others which can serve as a benchmark for those inefficient ones. This is of use to the practice of property and facilities management as service providers always seek for improvements in order to meet the ever increasing demand on the satisfaction of the service users and clients. Herebelow a summary of Charnes−Cooper transformation model is provided.

Supposing the total number of inputs and outputs are I and J respectively. The virtual input of a DMU is obtained as the linear weighted sum of all its inputs.

$$\text{Virtual Input} = \sum_{i=1}^{I} u_i x_i \qquad (1)$$

Where u_i is the weight assigned to input x_i.

Similarly, the virtual output of a DMU of a DMU is obtained as the linear weighted sum of all its outputs.

$$\text{Virtual Output} = \sum_{j=1}^{J} v_j y_j \qquad (2)$$

And the efficiency of the DMU would be

$$\text{Efficiency} = \frac{VirtualOutput}{VirtualInput} = \frac{\sum_{j=1}^{J} v_j y_j}{\sum_{i=1}^{I} u_i x_i} \qquad (3)$$

When there are N DMUs to be assessed, and we take the *m*th DMU to assess. And we maximize its efficiency. Here is the equation:

$$\max E_m = \frac{\sum_{j=1}^{J} v_{jm} y_{jm}}{\sum_{i=1}^{I} u_{im} x_{im}}$$

Subject to

$$0 \le \frac{\sum_{j=1}^{J} v_{jm} y_{jn}}{\sum_{i=1}^{I} u_{im} x_{in}} \le 1 \quad \text{where } n=1, 2, \text{K}, N$$

$$v_{jm}, u_{im} \ge 0 \text{ where } i=1, 2, \text{K}, I \quad \text{and } j=1, 2, \text{K}, J$$

Where

E_m is the efficiency of the *m*th DMU,

y_{jm} is *j*th output of the *m*th DMU

v_{jm} is the weight of that output

x_{im} is *i*th input of the *m*th DMU

u_{im} is the weight of that input

y_{jn} and x_{in} are *j*th output and *i*th input, respectively, of the *n*th DMU, *n*=1, 2, …, *N*.

The value of E_m has a maximum value of 1 and this applies to all DMUs. The objective is to obtain the optimum output weight v_j and optimum input weight u_i such that the ratio of the DMU` is maximized. The equation is then converted to a linear form as follows:

$$\text{Max} \sum_{j=1}^{J} v_{jm} y_{jm} = \theta_m \qquad (4)$$

Subject to

$$\sum_{i=1}^{I} u_{im} x_{im} = 1 \qquad (5)$$

$$\sum_{j=1}^{J} v_{jm} y_{jm} - \sum_{i=1}^{I} u_{im} x_{im} \le 0 \quad \text{where} \quad u_{im}, y_{jm} \ge 0 \qquad (6)$$

The weight of u_{im} and y_{jm} under the constraint of DMU_p can acquire the relative efficiency scores of all DMUs greater than 1. The value of θ_m is the score of DMU_m relative to all DMUs between the ranges of 0 to 1. The optimal object value is 1 which has shown in equation (5), and the value of input and output must be positive and greater then zero unless the results are not significant. In general, a DMU is classified as efficient if it obtained an efficiency score of 1. Otherwise it would be classified as inefficient if it obtained a score of less than 1. And now two sets of dual valuables are provided. The set θ_m and λ_n aim at producing the observed outputs with minimum inputs, where θ_m is an optimal value for the efficiency score of DMU_m and the λ_n is the weight of the DMU_n adopted in order to obtain the value of DMU_m.

And the set φ_m and μ_n aim at maximizing the output production with the given resource level, where φ_m is an optimal value for the efficiency score of DMU_m and μ_n is the weight of the DMU_n adopted in order to obtain the value of DMU_m.

According to above, we can obtain the CCR model and the BCC model as follows.

The CCR model

$$\text{Min } \theta_m$$

Subject to

$$\sum_{n=1}^{N} \lambda_n y_{jn} \ge y_{jm} \quad j=1, 2, \text{K}, J \qquad (7)$$

$$\sum_{n=1}^{N} \lambda_n x_{in} \le \theta_m x_{im} \quad i=1, 2, \text{K}, I \qquad (8)$$

$$\lambda_n \ge 0 \qquad \forall n$$

$$\text{Max } \varphi_m$$

Subject to

$$\sum_{n=1}^{N} \mu_n y_{jn} \geq \varphi_m y_{jm} \quad j=1, 2,\text{K}, J \qquad (9)$$

$$\sum_{n=1}^{N} \mu_n x_{in} \leq x_{im} \quad i=1, 2, \text{K}, I \qquad (10)$$

$$\mu_n \geq 0 \qquad \forall n$$

The BCC model

$$\text{Min } \theta_m$$

Subject to

$$\sum_{n=1}^{N} \lambda_n y_{jn} \geq y_{jm} \quad j=1, 2,\text{K}, J \qquad (11)$$

$$\sum_{n=1}^{N} \lambda_n x_{in} \leq \theta_m x_{im} \quad i=1, 2, \text{K}, I \qquad (12)$$

$$\lambda_n \geq 0 \qquad \forall n$$

$$\sum_{n=1}^{N} \lambda_n = 1$$

$$\text{Max } \varphi_m$$

Subject to

$$\sum_{n=1}^{N} \mu_n y_{jn} \geq \varphi_m y_{jm} \quad j=1, 2,\text{K}, J \qquad (9)$$

$$\sum_{n=1}^{N} \mu_n x_{in} \leq x_{im} \quad i=1, 2, \text{K}, I \qquad (10)$$

$$\mu_n \geq 0 \qquad \forall n$$

$$\sum_{n=1}^{N} \mu_n = 1$$

1.2 Applications and limitations of the DEA method

The DEA method adopted in this research can assist university management in the process of allocating their limited resources and providing directions for them to make improvements on efficiencies and performance. Since nowadays the public is more concerned about the transparency and competitiveness, universities need to consider the use of different tools and techniques that assist in the assessment and evaluation of the efficiencies and performance. Since there is no systems and mechanisms in providing a price for the outputs in the educational sector, this makes the normal production or cost measurement methods not suitable. Universities need to find other efficiency assessing methods to perform this function. And DEA provides such a method.

As mentioned in the previous chapter, the DEA method helps to identify peer groups for inefficient DMUs and assists in determining the required efficiency improvements. Under this perspective, it is a valuable benchmarking tool for management. The greatest benefit of adopting this method, as stated above, is that only input and output variables are required. Once the key input and output variables are identified, results could be obtained. Through the optimization process, it is important to ensure the integrity of the data used in the determining process of the input and output variables, if reliable results are required.

However, like other efficiency evaluation techniques, DEA has its own limitations. The DEA method can be used to provide targets for those inefficient units but it cannot provide any suggestions to the users how they can reach these targets. Sometimes there might be unreasonable potential improvement suggested with the results obtained. Before carrying out such improvements, it is essential to investigate what kinds of organizational or environmental changes have to take place. The management of the inefficient units may need to examine the configuration of efficient units for its reference.

Data

In Hong Kong, higher education institutes consist of statutory universities, statutory institutes, registered post-secondary colleges, Vocational Training Council member institutions and general institutes. Statutory universities are those universities incorporated under ordinances. There are eight statutory universities in total, seven of which are funded by University Grants Committee (UGC). The Open University of Hong Kong (OUHK), is the only self-financing statutory university established since 1993. They are University of Hong Kong (U1), The Chinese University of Hong Kong (U2), The Hong Kong University of Science and Technology (U3), Hong Kong Baptist University (U4), The Hong Kong Polytechnic University (U5), City University of Hong Kong (U6) and the Lingnan University (U7).

Apart from the eight statutory universities, there are two statutory institutes in Hong Kong: The Hong Kong Academy for Performing Arts (HKAPA) and The Hong Kong Institute of Education (HKIEd). The HKIEd, although it is yet to be a statutory university, is also one of the member institutes funded by the UGC.

Registered post-secondary colleges are educational colleges registered under the Post-secondary Colleges Ordinance (Cap. 320). This kind of colleges are allowed to give out academic awards at bachelor degree level or above as well as to include the word “university” in their English registration name with permission from the Chief Executive and the Executive Council. In addition, there are four post-secondary colleges namely, Hong Kong Shue Yan University (SYU, founded in 1971, granted university status in 2006, the first private university in Hong Kong), Caritas Francis Hsu College, Chu Hai College of Higher Education and Hang Seng Management College. They are the candidates for private universities scheduled to be recognised by Hong Kong SAR government.

In choosing the DMUs for this study, we would include only the UGC-funded universities. OUHK, being the self-financing statutory university, is excluded because its financial structure would be different from the other UGC-funded university. The HKIEd would also be excluded as it trains teachers only and focus on academic activities with comparative small proportion research activities Hence, this research would be conducted with seven DMUs, including HKU, CUHK, HKUST, HKBU, PolyU, CityU and LU. Inputs and outputs over an eight year period would be determined according to the model specification, to be specified in the following.

5.1 Input and output determination

In the DEA method, multiple inputs and outputs are allowed to be put into the model. The definition of the input and output would be very important to the study since it might change the results obtained completely.

In this study, 2 inputs and 1 output are chosen for each round of optimization process. And 3 rounds would be carried out to evaluate the performance of the universities in Hong Kong. Data from the financial year 2002/03 to 2009/10 are used. As the 7 DMUs that are chosen in this study are UGC-funded universities. They need to give their annual reports and disclose their financial status every year. The main source of data is adopted from the financial statements of the respective university.

The appropriate choice of input(s) and output(s) is critical to the success of the application of the DEA method otherwise inappropriate results might follow and mislead the conclusions. In this study, academic and research efficiencies are the main concerns. **.2.1 Input Variable**

In this study, the relationship between the achievements and the resources that have been input in a university is desired to be reviewed. In choosing the input variables, spending of the respective university would be reviewed. As there is a standard format for the reported financial statements for all UGC-funded universities, the data obtained is therefore comparable between universities. From the expenditure account of the university income and expenditure statement, we have two large items, under the headings of Learning and Research and Institutional Support. Under the heading of Learning and Research item, breakdown items include Institutional and Research, Library, Central Computing Facilities and Other Academic Services. Under the heading of Institutional Support, breakdown items include Management and General, Premises and Related Expenses, Student and General Education services and Other Activities. For the convenience of processing data, the total amount of Learning and Research and the Institutional Support were adopted as the two inputs in this study.

1.2.2 Output Variable

Different indicators have been used as output variables in the literature. For example, number of doctorates granted and the student average score (Bougnol, Dul´a 2006) would be widely adopted in accessing the performance efficiency of a university

in its educational activities. To certain extent, graduates could be considered as the 'product' of one university, information and statistics about them could reflect the performance of a university. As to the output variable about research activities, published articles in professional journals and authored books (Johnes, etc 1995) are usually viewed as outputs.

In this study, since different assessment criteria may be adopted by different universities, the average score of the students is considered not appropriate. As an alternative, the number of graduates for a particular year would be adopted as the output variable for assessing the efficiency of academic activities. As to the assessment of the efficiency of the research activities, since the DMUs adopted are all UGC-funded, they can obtain research funding from it. Hence, we take that the amount of General Research Fund obtained as one of the appropriate measures for output assessment. The other output variable is the number of research projects supported by UGC fundings for that financial year. This can help to show a more balanced review on the level of research activities achieved by one university as there may be cases where large amount of funding is put into a few research projects.

We made use of the online software Data Envelopment Analysis Online Software (DEAOS), developed by Behin-Cara Co. Ltd., in our calculations. In the computation, scale efficiency is adopted and both input-oriented and output-oriented basis were applied to the data respectively.

2. Empirical Results and Data Analysis

The following tables and figures summarize the results obtained from the running of the DEA model.

6.1 Efficiency Scores of All Universities for Each Financial Year

Table 1 (A) Efficiency score of number of Graduates (Input oriented)

Input Oriented							
	University 1	University 2	University 3	University 4	University 5	University 6	University 7
2002-03	0.786	0.962	0.952	0.953	1	0.939	1
2003-04	0.999	0.999	0.992	0.992	1	1	1
2004-05	0.973	0.977	0.999	0.998	0.988	1	0.994
2005-06	0.968	0.968	0.955	0.996	0.998	1	1
2006-07	0.991	0.995	0.998	0.949	0.778	1	1
2007-08	0.846	0.87	0.967	0.897	0.854	1	1
2008-09	0.896	0.911	0.998	0.862	0.909	1	1
2009-10	0.997	0.997	0.986	0.897	1	0.995	1

Table 1 (B) Efficiency score of number of Graduates (Output oriented)

Output Oriented							
	University 1	University 2	University 3	University 4	University 5	University 6	University 7
2002-03	0.786	0.707	0.927	0.922	1	0.939	1
2003-04	0.654	0.815	0.998	0.997	1	1	1
2004-05	0.614	0.623	1	0.999	0.802	1	0.994
2005-06	0.61	0.722	0.997	0.992	0.737	1	1
2006-07	0.676	0.728	0.972	0.927	0.778	1	1
2007-08	0.773	0.806	0.937	0.883	0.854	1	1

2008-09	0.779	0.899	0.966	0.844	0.909	1	1
2009-10	0.751	0.999	0.996	0.855	1	0.985	1

Table 2 (A) Efficiency score of amount of Granted Research fund (Input oriented)

Input Oriented							
	University 1	University 2	University 3	University 4	University 5	University 6	University 7
2002-03	0.752	0.983	1	0.507	0.849	0.871	0.082
2003-04	0.7	0.784	1	0.589	0.898	0.886	0.076
2004-05	0.975	0.985	1	0.607	0.866	0.842	0.051
2005-06	0.771	0.874	1	0.418	0.793	0.818	0.08
2006-07	0.853	0.958	1	0.55	0.823	0.768	0.113
2007-08	0.832	0.936	1	0.632	0.873	0.856	0.138
2008-09	0.857	0.912	1	0.591	0.917	0.865	0.125
2009-10	0.708	0.915	1	0.584	0.902	0.81	0.079

Table 2 (B) Efficiency score of amount of Granted Research fund (Output oriented)

Output Oriented							
	University 1	University 2	University 3	University 4	University 5	University 6	University 7
2002-03	0.752	0.668	1	0.834	0.917	0.913	0.082
2003-04	0.7	0.783	1	0.835	0.951	0.912	0.076
2004-05	0.975	0.967	1	0.834	0.989	0.982	0.051
2005-06	0.771	0.838	1	0.847	0.799	0.997	0.08

2006-07	0.853	0.871	1	0.871	0.804	0.995	0.113
2007-08	0.832	0.843	1	0.882	0.778	0.986	0.138
2008-09	0.857	0.89	1	0.887	0.825	0.961	0.125
2009-10	0.708	0.915	1	0.888	0.764	0.821	0.079

Table 3(A) Efficiency score of number of Granted Researches (Input oriented)

Input Oriented							
	University 1	University 2	University 3	University 4	University 5	University 6	University 7
2002-03	0.979	0.971	1	0.576	0.874	0.913	0.108
2003-04	0.615	0.744	1	0.658	0.947	0.922	0.181
2004-05	0.82	0.986	1	0.635	0.928	0.909	0.105
2005-06	0.681	0.778	1	0.487	0.864	0.876	0.103
2006-07	0.766	0.883	1	0.624	0.906	0.834	0.149
2007-08	0.712	0.864	1	0.683	0.931	0.892	0.165
2008-09	0.733	0.858	1	0.643	0.983	0.924	0.162
2009-10	0.772	0.992	1	0.694	0.958	0.914	0.118

Table 3(B) Efficiency score of number of Granted Researches (Output oriented)

Output Oriented							
	University 1	University 2	University 3	University 4	University 5	University 6	University 7
2002-03	0.704	0.628	1	0.838	0.901	0.904	0.108
2003-04	0.615	0.721	1	0.854	0.937	0.89	0.181

2004-05	0.82	0.821	1	0.843	0.923	0.983	0.105
2005-06	0.681	0.778	1	0.851	0.745	0.997	0.103
2006-07	0.766	0.794	1	0.877	0.751	0.991	0.149
2007-08	0.712	0.73	1	0.886	0.704	0.977	0.165
2008-09	0.733	0.795	1	0.892	0.746	0.927	0.162
2009-10	0.772	0.992	1	0.893	0.796	0.843	0.118

From the above figures, we can observe that in academic aspect, University 7 (U7) is considered as efficient in the 8-year period, both in input-oriented and the output-oriented basis while University 3 (U3) is assessed as the efficient unit in the research aspect. And the difference from the adoption of orientation basis would be interpreted in the following part.

6.2 Data Analysis for Individual Universities Over 8-years Period

6.2.1 University 1 (U1)

U1 obtained an average efficiency score of over 0.9 in the efficiency of number of graduates in the input-oriented basis. And it also obtained an average score of over 0.8 in the area of granted research fund and an average score of over 0.7 in the number of granted researches. From the results, U1 obtains better results in the academic performance efficiency than in that of the research area. Although it obtained relative lower score in the area of number of graduates in output-oriented, this might be accounted by the higher quality of service provided to the students when compared to the other universities.

6.2.2 University 2 (U2)

U2 obtained an average efficiency score of over 0.95 in efficiency of number of graduates in the input-oriented basis. And it also obtained an average score of over 0.9 in the area of granted research fund and an average score of over 0.88 in the number of granted researches. From the results, U2 obtains slightly better results in the performance of the academic performance than that obtained in the research area, which is the same as U1. And another feature of U2 that like U1 is obtaining a relative lower score in the area of number of graduates when output-oriented basis is conducted. And in Research efficiencies, U2 obtain better results than that of the U1 in general. From these data, U2 might have an advantage over U1 in the area of research efficiency.

6.2.3 University 3 (U3)

U3 is an efficient unit in both the areas of granted research fund and in the number of granted researches, which obtains an efficiency score of 1 over the 8-year period. It also obtains an average efficiency score of over 0.97 in efficiency of number of graduates in both the input-oriented and the output-oriented basis. It is reasonable to obtain such results since the university itself focuses in developing in research area; the results fulfil its development principle and policies.

6.2.4 University 4 (U4)

U4 obtained an average efficiency score of aver 0.9 in the efficiency of number of

graduates whether input-oriented or output-oriented basis is adopted. And it obtained an average efficiency score of about 0.56 in the area of granted research fund while obtaining about 0.63 in the area of number of granted researches when an input-oriented basis is adopted. But it shows an interesting phenomenon that its performance is better when an output-oriented basis is adopted, which is opposite to the previous three universities. And this occurs in the research aspect. The efficiency score obtained in the two test areas would be increased by over 0.2 when output-oriented basis is adopted. From these results, this might imply that the limit in the resource obtained and the size of the university restricted U4 in further cutting its running cost effectively. However, it can perform much better in maximizing its performance with limited resources in the research area.

6.2.5 University 5 (U5)

U5 obtained an average efficiency score of about 0.9 in the number of graduates in the input-oriented basis, and about 0.88 in the output-oriented basis. And it obtained an average efficiency score of over 0.85 in both bases in the efficiency of granted research fund, while obtaining an average score of over 0.9 in the number of granted research in the input-oriented basis and an average of 0.8 when the output-oriented basis is adopted. Its performance efficiency in both academic and research area are similar, not being an efficient peer but keeping a constant performance, keeping an overall average score of over 0.8 in the three assessment area.

6.2.6 University 6 (U6)

U6 obtained an average efficiency score of over 0.99 in both input and output-oriented basis in the area of number of graduates, while obtaining an average score of over 0.8 in the efficiency of granted research fund when an input-oriented basis is adopted, and an average of over 0.9 when an output-oriented basis is adopted. And it obtained an average score of 0.89 in the number of granted research in the input-oriented basis and an average of about 0.94 when the output-oriented basis is adopted. In the research aspect, performance of U6 is similar to that of U4, which obtained better results when output-oriented basis is adopted. But the difference between the score of input-oriented and output-oriented basis is less significant in U6, with just about 0.1 in average, which can imply U6 perform better in both minimizing inputs and maximizing outputs in the research field than that of U4.

6.2.7 University 7 (U7)

U7 lies on the efficient frontier in the aspect of efficiency of number of graduates for year period 2002/03 – 2009/10, except in the year 2004-05, which obtain a score of 0.994 on both the input-oriented and output-oriented basis. However, it got an average efficiency score of about 0.09 in both bases in the aspect of granted research fund and an average score of about 0.14 in the aspect of number of granted research. With other universities obtained at least over 0.6 in these two aspects, it seems that U7 has room for improvement. These results might be explained by the relative smaller size and the limited resources obtained by U7. With limited grants, there would be fewer researches carried out. And size of the university might contribute also. U7 only has Faculty of Arts, Faculty of Business and the Faculty of Social Science. In which these faculties limits the production of researches. All these might contribute to the relative weak performance of U7 in the research aspects.

6.3 Concluding remarks

From above, universities are found to perform more efficient in one or the other areas, either academic or research. We can observe that the U1, U2, U4, U5, U6 and U7 perform better in the academic aspect while U3 perform better in the research aspect. Apart from U7, all the DMUs assessed in this study have a general high performance in both aspects. They obtain an efficiency score of about 0.7 in overall. Among all the DMUs, U3 performs best in overall, which obtains an average score of 0.9775 in the number of graduates and obtaining the average score of 1 in both the aspect of granted research fund and the number of granted researches. Coming up is U6, which obtains an average score of 0.9129 in the number of graduates and obtaining an average score of 0.8927 in the area of granted research fund and 0.9185 in the area of number of granted researches. The third comes to the U5. It obtained an average efficiency score of 0.9129 in the area of number of graduates, and getting an average score of 0.8593 in the area of granted research fund and 0.8684 in the area of number of granted researches. These results are inconsistent with the popular view of the ‘Three Big Universities’ (U1, U2 and U3) from the public.

7 Conclusions

This is the first time ever to benchmark the efficiency performance of the UGC-funded universities in Hong Kong. There are lots of studies about the comparison of the performance efficiencies of the university by using DEA method in other countries, but as far as we aware, none in Hong Kong. First, this research provides some insights on the efficiency performance of the UGC-funded universities in Hong Kong. Secondly, this study shows how the trends of the performance of the assessed universities evolve over an eight year time horizon.

Both input-oriented and output-oriented basis were conducted in this study. In other similar studies, they would usually presume one basis because of the research objectives or restrictions in the model. Providing both the input and output-oriented basis might help in analyzing the DMU in a better way. Last but not the least, the public generally holds the view that the 'Three Big Universities' (U1, U2, U3) would have better management and would perform better when comparing with the others. However, from the results obtained, only one out of the 'Three Big Universities' is an efficient unit in the research activities. As to the academic side, U7 was the efficient unit. Overall, U3 performs best, followed by U6 and U5, in contradiction with the general view. The reasons behind this might be complicated and cannot be easily explained. It may relate to the limited pool of students in Hong Kong, university's own policy and other factors that are not considered in this research. Further researches should be carried out to investigate the reasons behind.

7.1 Future Research Area

As this is a pilot study, there are ample rooms for improvement. Due to the limited number of data collected, many factors that may affect the results are neglected. For example, the total number of staff, the number of new students' intake every year, other amount of research fund obtained, etc. should also be taken as inputs. The classification of inputs and outputs should also be reviewed. For example, the number of graduates should be divided into groups of PhD, master degree and bachelor degree. This could help in providing more information of the assessed university in its efficiency analysis.

Based on this study, the DEA method is proved to be applicable in assessing the operational efficiency of the higher educational system in Hong Kong. We may

extend the research area to the secondary education sector. By evaluating their efficiencies, it is hoped that it may contribute to the improvement of their operational efficiencies and performances.

Appendix

In the following tables, all figures that are measured in money terms are shown in thousand Hong Kong Dollars (HK$,000).

Table 22: Summary statistics of variables in financial year 2004-2005

DMU	Input		Output		
	Learning & Resarch (HK$)	Institutional Support (HK$)	Graduates	Granted Research Fund (HK$)	No. of Granted Researches
HKU	3,153,352	873,461	3,511	125,500	193
CU	3,047,304	860,510	3,620	78,500	144
UST	1,635,570	568,132	2,124	83,700	153
PolyU	2,356,673	667,953	3,965	50,300	114
CityU	1,808,311	535,990	4,438	46,500	106
BU	927,112	391,772	1,582	18,100	35
LingU	305,338	136,945	745	800	3

Sources: Financial Reports from respective universities and University Grants Committee

Table 23: Summary statistics of variables in financial year 2005-2006

DMU	Input		Output		
	Learning & Resarch (HK$)	Institutional Support (HK$)	Graduates	Granted Research Fund (HK$)	No. of Granted Researches
HKU	3,175,756	957,783	3,508	111,000	175
CU	3,216,104	809,182	3,511	98,200	169
UST	1,653,212	588,692	2,088	88,500	158
PolyU	2,447,281	834,608	4,020	45,400	100
CityU	1,806,836	584,278	4,344	48,900	104
BU	953,531	416,355	1,619	11,000	24
LingU	305,070	167,987	753	1,300	3

Sources: Financial Reports from respective universities and University Grants Committee

Table 24: Summary statistics of variables in financial year 2006-2007

DMU	Input		Output		
	Learning & Resarch (HK$)	Institutional Support (HK$)	Graduates	Granted Research Fund (HK$)	No. of Granted Researches
HKU	3,344,625	955,292	3,522	145,700	215
CU	3,444,467	887,431	3,644	111,700	187
UST	1,659,012	578,619	2,142	103,400	170
PolyU	2,606,719	885,558	4,201	58,200	123
CityU	1,892,942	587,233	3,819	49,400	98
BU	1,044,108	455,774	1,651	18,600	38
LingU	327,532	169,431	783	2,300	5

Sources: Financial Reports from respective universities and University Grants Committee

Table 25: Summary statistics of variables in financial year 2007-2008

DMU	Input		Output		
	Learning & Resarch (HK$)	Institutional Support (HK$)	Graduates	Granted Research Fund (HK$)	No. of Granted Researches
HKU	3,636,090	1,088,407	3,779	138,300	190
CU	3,903,274	1,041,484	3,646	107,500	167
UST	1,766,934	632,229	2,145	96,500	155
PolyU	2,832,847	1,044,553	4,044	58,700	112
CityU	2,081,792	654,600	3,148	60,300	108
BU	1,133,164	483,685	1,698	23,200	42
LingU	346,189	190,029	762	2,600	5

Sources: Financial Reports from respective universities and University Grants Committee

Table 26 Summary statistics of variables in financial year 2008-2009

DMU	Input		Output		
	Learning & Resarch (HK$)	Institutional Support (HK$)	Graduates	Granted Research Fund (HK$)	No. of Granted Researches
HKU	3,969,186	1,237,754	3,932	148,000	221
CU	4,038,484	1,034,140	3,801	118,900	185
UST	1,888,302	669,049	2,166	93,300	163
PolyU	3,021,214	1,090,547	4,051	68,000	147
CityU	2,340,596	764,465	3,212	61,200	127
BU	1,215,331	561,835	1,674	18,400	37
LingU	356,913	209,617	770	2,200	5

Sources: Financial Reports from respective universities and University Grants Committee

References

Avkiran N. K. (1999), Investigating Technical and Scale Efficiencies of Australian Universities through Data Envelopment Analysis, *Socio-Economic Planning Sciences*, Vol. 35, Issue 1, pp. 57-80

Baldry D. and Barrett, P. (2003), Facilities Management: Towards Best Practice (2nd Ed.) pp. xi

Barboy A., Mehrez A. and Sinuany-Stern A. (1994), Academic Departments Efficiency Via DEA, *Computers & Operations Research*, Vol. 21, Issue 5, pp. 543-556

Bi K., Feng Y.J. and Lu H. (2003), An AHP/DEA Method for Measurement of the Efficiency of R&D Management Activities in Universities, *International Transactions in Operational Research*, Vol. 11, Issue 2, pp. 181–191

Bougnol M.-L. and Dulá J.H. (2004), Validating DEA as a Ranking Tool: An Application of DEA to Assess Performance in Higher Education, *Annals of Operations Research*, Vol. 145, No. 1, pp. 339-365

Colbert A., Levary R. R. and Shaner M. C. (2000), Determining the Relative Efficiency of MBA Programs using DEA, *European Journal of Operational Research*, Vol. 125, Issue 3, pp. 656-669

Datta D. and Mcmillan M. L. (1998), The Relative Efficiencies of Canadian Universities: A DEA Perspective, *Canadian Public Policy / Analyse de Politiques*, Vol. 24, No. 4

Dyson R.G and Sarrico C.S. (2000), Using DEA for Planning in UK Universities - An Institutional Perspective, *Journal of the Operational Research Society*, Vol. 51, No. 7, pp. 789-800(12)

Fandel G. (2005), On the Performance of Universities in North Rhine-Westphalia, Germany: Government's Redistribution of Funds Judged Using DEA Efficiency Measures, *European Journal of Operational Research*, Vol. 176, Issue 1, pp. 521-533

Green R. and Tomkins C. (1988), An Experiment In the Use of Data Envelopment Analysis for Evaluating the Efficiency of UK University Departments of Accounting,

Financial Accountability & Management, *Financial Accountability & Management*, Vol. 4, Issue 2, pp. 147-164

Johnes G. and Johnes J. (1995), Research Funding and Performance in U.K. University Departments of Economics: A Frontier Analysis, *Economics of Education Review*, Vol. 14, Issue 3, pp. 301-314

Johnes J., (2004), Data Envelopment Analysis and Its Application to the Measurement of Efficiency in Higher Education, *Economics of Education Review*, Vol. 25, Issue 3, pp. 273-288

Lanzer E. A. and Lopes A. L. M. (2002), Data Envelopment Analysis – DEA and Fuzzy Sets to Assess the Performance of Academic Departments: A Case Study at Federal University of Santa Catarina – UFSC, *Pesqui. Oper.*, Vol.22, No.2

Mahallati Rayeni M. and Saljooghi F.H. (2010), Performance Assessment of Education Institutions through Interval DEA, *Journal of Applied Sciences*, Vol. 10, Issue 22, pp. 2945-2949

Wikipedia (Retrieved on 20th Feb, 2011), *Higher education in Hong Kong*, http://en.wikipedia.org/wiki/Higher_education_in_Hong_Kong