Determine Potential Efficiency of Publications Amount for Engineering Departments Using Data Envelopment Analysis

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Abstract

This paper investigates the potential efficiency of researches from various departments under a common faculty in terms of their individual publications. The outcome in terms of the number of research publications of the eight departments working under the faculty of engineering at King Abdul-Aziz University was utilized as the case for these investigations. Data Envelopment Analysis (DEA) is utilized for the benchmarking of the research potential efficiency of these departments. The results of these studies are useful to know the potential research efficiency of each department under investigation and enable the respective departments/administration to determine the number of research publications necessary from each department to reach their respective optimal levels. The present study is helpful in diverting the interest of university management towards the quality development in education and research. The study is important as it uses Data Envelopment Analysis (DEA) method to determine the relative efficiency of the publication amount for engineering departments at King Abdul-Aziz University. It further suggests some of the important measures required for the improvement.

Keywords: CAPITALINE database, data envelopment analysis, engineering departments, King Abdul-Aziz University, publications amount

1. Background

The development and economic growth of a country depends on higher education that renders the required quantity of qualified specialist from different fields (Sirbu et al., 2016). The evaluation of the academic performance of higher education institutions is important to find out the change in expenses for learning, teaching, researching, and innovating activities. The identification of optimal performance assists in harnessing the effective association between the existing resources after considering the inputs and outputs (Elena, 2014). The preconditions necessary to comply with the demands of occupied professional abilities and skills are created through the evaluation of the performance of the teaching staff at engineering institutions of higher education (Aziz et al., 2013).

The level of individual performance is likely to improve due to the presence of efficient motivation system (Fuentes et al., 2016). Certain common components are needed to be identified based on periodic assessments of professional performance for determining the salaries and bonuses (Sirbu et al., 2016). Based on the completion and execution of tasks assigned to an individual, the performance is likely to reflect the quantitative as well as qualitative results. The performance of an individual is evaluated by assessing the level of performance reached by the lecturer in accordance with the obligations stated in the common evaluation criteria and individual plan (Goksen et al., 2015).

Recently, King Abdulaziz University is transferring itself to be a research University by proudly announcing its recent elevation in world ranking according to three world-class educational ranking organizations. The well-known U.S. News and World Report rank the Faculty of Engineering at KAU first in engineering amongst its 'Best Arab Universities' class in 2018. Whereas, it is ranked eighth in engineering amongst its 'Best Global Universities for Engineering' class this year. The Academic Ranking of World Universities (ARWU), conducted by researchers at the Center for World-Class Universities of Shanghai Jiao Tong University (CWCU) ranked KAU Engineering as fifth in the world for engineering/technology and computer sciences up from a rank of 101-150 in 2013, 51-75 in 2014, and 45 in 2015. Finally, the QS World University Rankings puts the college between 151 and 200 in the world for its 'World Ranking by Subject' category that is 'Engineering: Mechanical, Aeronautical &

Manufacturing' class.

Studies determining the academic performance and efficiency of higher education institutes have been conducted using Data Envelopment Analysis (DEA) (Aziz et al., 2013; Goksen et al., 2015; Sirbu et al., 2016; Fuentes et al., 2016). However, there is a need to determine potential efficiency of publications for engineering departments using the DEA method. The great happenings at the Faculty of Engineering aim to stand at the forefront of engineering research and innovation excellence in the region and beyond. This helps in positioning their graduates in the first position for governmental and private sectors. King Abdulaziz Engineering's deanship expresses sincere gratitude to the students, faculty, and staff for their invaluable efforts and dedication, and encourages both the persistence and enhancement of performance for climbing even further in excellence and recognition as an institution of higher learning. This signifies the importance of determining the number of publications as an applied science that could be the most important research for social services.

2. Literature Review

A comprehensive overview of the literature on the efficiency of higher education institutions can be found in Rhaiem (2017), De Witte and López-Torres (2017) and Gralka (2018a). The overview shows that the university's research results can be presented in several ways and most research is based on publications or research funds to select evidence. It is not uncommon for both of these indicators to be used in research. Only a few studies seem to use both methods simultaneously. These include Warning (2007) for the German university sector, Johnes and Johnes (1993) for the Faculty of Economics at British universities and Worthington and Lee (2008) and Worthington and Higgs (2011) for Australian universities. With the exception of the latter study, all three adopt the DEA framework and partially recognize that where research and publicity are reciprocal, it is crucial to include funding and research (Johnes & Johnes, 1993).

Given the division of literature, most research publications or research grants Agasisti et al. (2012) provide useful curiosity on this issue. Four types of theoretical research results (including publications and research funding) are compared and show that the optimization ranking varies according to the indicators used. But due to insufficient data, the validity of the DEA conclusion is valid, which they acknowledged in the discussion. The analysis is limited to the cross-sectional assessment of the Faculty of Science in the Italian region. The result of the assessment is a measure of itself based on the questionnaire completed by each department. The scope and timing of publications and citations are not taken into account (see discussion below). Follow Agasisti et al. (2012), who evaluated the choice of indicators, the author also began to evaluate the impact of basic methodological assumptions on the ultimate efficiency of higher education institutions (Eagan & Titus, 2016; Gralka, 2018b; Johnes & Tone, 2017).

Using two different efficiency measurement methods to examine the impact of approved research indicators on value effectiveness, this study can be seen as a valuable addition to the literature in these two areas. In addition to the literature on the effectiveness of higher education, these studies also contribute to research into whether scholarships are a generally appropriate indicator of research success (Hornbostel, 2001; Jansen et al., 2007). Authors such as Schubert (2009) consider it necessary to treat research grants as research results, although they believe that these grants are not necessarily linked to other research activities (such as publications). Orr, Jaeger, and Schwarzenberger (2007) pointed out that the use of research grants is not usually because people think that research grant evidence is a good indicator of production, but because many university administrators, especially governments, use research grants widely. research and evaluation. Adjacent studies such as Schmoch et al. (2010) generally reduce the use of one-dimensional volume. Although this study cannot end the discussion, its findings provide a new basis for the argument.

Evaluation of the effectiveness of research and development and the effectiveness of innovation depend on many European and international studies. Efficiency is usually described in terms of unit cost of production. In research, it can actually be used to test the success of research by measuring whether it is possible to fine-tune the ratio of research output / input, such as comparing with other research programs and / or countries (external criteria) or previous years (Internal benchmark test). Skrinjaric (2020) studied the effectiveness of 29 European countries in achieving and achieving development goals from 2007 to 2017. The author made a powerful analysis and monitored the (effectiveness) effectiveness of change over time. Break down efficiency by dividing key variables of interest in private enterprise, higher education and government agencies and evaluating the reliability of results. Laliene and Sakalas (2014) defined the concepts of productivity and efficiency of research and development, analyzed current research and development evaluations or models, and determined its advantages and disadvantages. Ekinci and Karadayi (2017) compiled studies related to the national effectiveness of research and development, compared the effectiveness of 27 EU countries in research and development, and measured relative

efficacy using data envelope analysis.

Other authors have evaluated the relative performance of research and development (R&D) organizations that conduct similar research in many countries. Assess the institution's relative efficiency with production variables (external cash flow and number of transferred technologies, publications and patents) and input variables (number of grants received from higher institutions and number of researchers working for these public institutions). Beneito, Rochina-Barrachina, and Sanchis (2015) studied the R & D feasibility model based on the number of product innovations that the company achieved over time and proposed a model that clearly explained the dual composition of research and development expenditures, including party expenditures and parties. Funding for research and development projects and payments to scientists. The author believes that the latter part of research and development is a source of strong returns on companies' investment in development and development. Dobrzanski and Bobowski (2020) studied whether 15 countries (the Association of Southeast Asian Nations-ASEAN) used funding for research and development effectively between 2000 and 2016. The study used the following variables: annual public and private spending on innovation, exports of high-tech products as a percentage of exports of manufactured goods, patent applications to the International Intellectual Property Organization in priority years for millions of people, trademark applications for millions people and exports of information and communication technology were a proportion of exports of manufactured goods. The study confirms that increased investment in innovation will lead to relative effects.

3. Research Plan

The relative efficiency of publication amount for engineering departments is evaluated using DEA. DEA is a mathematical linear programming method that determines potential efficiency for units under study by having a set of criteria as inputs and outputs (Emrouznejad & Yang, 2018). It can be used to optimize the resources of the units under study. One of the major advantages of Data Envelopment Analysis is its capability to analyze and quantify various sources of inefficiencies of every investigated department (Zhou et al., 2018). It has focused on the inter-comparison of departments in different universities, along with relative efficiency assessments in higher education. In the present study, the data were collected from 56 engineering departments within the period of 2 years from January 2017 to January 2019. The main source of data for this study is CAPITALINE database that comprises of balance sheet-based financial data of large universities. The data related to several university publications were considered to determine the potential efficiency of publications amount for engineering departments.

In the present study, the number of academic staffs in each department is taken as the input and a corresponding number of publications as the output. The technical efficiencies of individual universities were estimated using CCR and BCC DEA models; whereas, total factor productivity was estimated using a DEA-based MPI method. The relative performance of individual university has been measured using the two-step approach.

- First step – the efficiencies of individual university department was estimated through DEA model; which include; scale efficiency (SE), pure technical efficiency (PTE), and overall technical efficiency (OTE).

- Second step – Tobit regression analysis was used to examine the factor that affects the above-mentioned three kinds of efficiencies.

4. Results

The statistical data that has been selected and analyzed in this study include the number of publications by 56 engineering departments from January 2017 to January 2019. The number of academic staff in each department was taken as the input; whereas, the corresponding number of publications was taken as the output. The results have shown the potential research efficiency of each department under investigation. This has enabled the respective departments and the administration to determine the number of research publications necessary over a period, from each department to reach their respective optimal levels.

The results presented in Tables 1, 2, and 3 have shown the potential efficiency of each department based on other department resources. The corresponding systematization for this study was developed during the processing of primary data obtained from CAPITALINE database that comprise of balance sheet-based financial data of large universities. Similarly, these tables have illustrated the output data showing the target publication as well as the actual publication along with a few professors involved. The engineering departments considered in the present study include Aeronautical, Chemical, Civil, Electrical, Industrial, Mechanical, Mining, Nuclear engineering departments.

The results showed that out of recruited departments, the industrial, mechanical, nuclear, and civil engineering departments achieved fewer scores as compared to other departments (Table 1, 2, and 3). This shows that

aeronautical, chemical, industrial, and mining departments were efficient in publishing a maximum number of publications by utilizing their resources to produce all the defined outputs as compared to other departments.

Table 1. Potential efficiency of publications amount for engineering departments (ALL-BCC-Output)

Unit name	Score	Actual Assistant Professor	Target Assistant Professor	Actual Associate Professor	Target Associate Professor	Actual Professor	Target Professor	Actual Under-Graduate	Target Under-Graduate	Actual Graduated	Target Graduated	Actual Publications	Target Publications
Aeronautical	100.00	6	6	7	7	3	3	167	167	9	9	31	31
Chemical	100.00	7	7	12	12	7	7	378	378	11	11	137	137
Civil	100.00	17	17	7	7	8	8	572	572	27	27	128	128
Electrical	100.00	28	28	22	22	15	15	870	870	117	117	260	260
Industrial	100.00	23	23	10	10	7	7	789	789	121	121	47	47
Mechanical	100.00	20	20	9	9	18	18	1109	1109	40	40	128	128
Mining	100.00	4	4	2	2	4	4	90	90	6	6	20	20
Nuclear	86.30	11	7	5	5	4	4	125	185	6	10	33	38

Table 2. Potential efficiency of publications amount for engineering departments (PUB-BCC-Output)

Unit name	Score	Actual Assistant Professor	Target Assistant Professor	Actual Associate Professor	Target Associate Professor	Actual Professor	Target Professor	Actual Publications	Target Publications
Aeronautical	100.00	6	6	7	7	3	3	31	31
Chemical	100.00	7	7	12	12	7	7	137	137
Civil	100.00	17	17	7	7	8	8	128	128
Electrical	100.00	28	28	22	22	15	15	260	260
Industrial	37.41	23	10.12	10	10	7	7	47	125.64
Mechanical	87.91	20	18.47	9	9	18	8.93	128	145.6
Mining	100.00	4	4	2	2	4	4	20	20
Nuclear	86.30	11	6.52	5	5	4	4	33	38.24

Table 3. Potential efficiency of publications amount for engineering departments (STD-BBC-Output)

Unit name	Score	Actual Assistant Professor	Target Assistant Professor	Actual Associate Professor	Target Associate Professor	Actual Professor	Target Professor	Actual Under-Graduate	Target Under-Graduate	Actual Graduated	Target Graduated
Aeronautical	100	6	6	7	7	3	3	167	167	9	9
Chemical	100	7	7	12	12	7	7	378	378	11	11
Civil	95	17	16	7	7	8	8	572	603	27	65
Electrical	100	28	28	22	22	15	15	870	870	117	117
Industrial	100	23	23	10	10	7	7	789	789	121	121
Mechanical	100	20	20	9	9	18	18	1109	1109	40	40
Mining	100	4	4	2	2	4	4	90	90	6	6
Nuclear	59.16	11.00	7	5.00	5.00	4.00	4.00	125.00	211	6.00	22

5. Discussion

In the preceding section, DEA analysis has been presented for all the departments of the Engineering University. DEA involves the application of the linear programming approach for the determination of the potential efficiency of various departments under investigation with a set of specified criteria as inputs and output without the need for any explicit mathematical representation of the function being investigated. The efficiency of the department is shown based on the number of recruitments held as well as the research publications produced. The results of the study revealed that the score for the departments such as industrial, nuclear, mechanical, and civil engineering was low as compared to other departments. The findings also showed that the research publication efficiency for the chemical, industrial, aeronautical, and mining departments. The recent study of Gül, Yücesan, and Duman (2017) is found to present parallel results demonstrating that the efficacy of the departments varies based on different factors. The university studied in the mentioned research is Turkish.

Previous study outcome of Agha et al. (2011) has also endorsed the findings stating that prevalence of substantial difference in the efficiency scores among the departments stresses the administration to instigate different amount for different resources and departments. Similarly, the study of Tzeremes and Halkos (2010) can also be reviewed which applied the bootstrapped DEA for determination of the department's performance in Greece University. The outcomes exhibited that the efficiency difference is due to the inappropriate resource allocation following ineffective application of policy developments.

To make the efficiency of the department parallel, Nazarko and Šaparauskas (2014) suggested adopting a benchmarking procedure for establishing sturdy criteria aimed at enhancing the department functioning as well as tracking the progress being made. Given the findings of the present study, it is suggested that the administration of the University should promote and motivate its staff to address publications and consider them as a key constituent of their progress and overall learning. The study recommends that research grants should be provided to the inefficient departments which are centralized through dean. The review also mentions that conventional method of accelerating the graduate number to improve the cost efficiency through more aggressive recruitment should not be adopted and as it is not effective in increasing the technical competence of the departments mentioned above.

6. Conclusion

The present study has concluded that a proper system of collecting and documenting pertinent information of each department should be maintained. The study believes that the comparison of the department's efficiency at KAU can instigate them towards quality development of education as well as research. It also serves as a stimulus to improve the education quality and enhance the funds spending efficiency for adequate management and instigation of good practices. Moreover, it also recommends that conclusion should be carefully and cautiously drawn from the present study given the deterministic nature of the study through the application of the DEA.

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