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Data Envelopment Analysis for Measuring Performance Efficiency in Public Sector Organizations: The Case of Saudi Universities

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Abstract

The Kingdom of Saudi Arabia is on the cusp of becoming a developed country from a developing one. Programs for e-government are being developed and applied in many fields. The main objective of the development includes education. Universities in Saudi Arabia are primarily responsible for preparing students for participation in real-world employment. Universities must also work to improve the cultural awareness of the general public. The output of universities influences the destiny of our society, hence their efficiency should be excellent. Data envelopment analysis The DEA tool can be used to assess the relative efficacy of universities. Using input and output variables, it is a complex linear programming tool that evaluates relative efficacy. Because the computations were so sophisticated, a lot of software was developed to use them. To analyze the relative effectiveness of Saudi university performance, four models—General, Budget, Academic Staff, and Non-Academic Staff—were developed. The effectiveness of each university has evolved during the last six years. Some colleges' relative efficacy increased, whereas it decreased at other institutions. Additionally, numerous universities' relative efficacy rose and fell in a non-ascending or decreasing pattern throughout the previous six years. The paper recommended that the Ministry of Education review the university's standing in the kingdom, that university budgets review the funding given to each institution, that academic staff members be distributed equally among all institutions, that non-academic workers be distributed more evenly among all institutions, that student enrollment be changed, and that the study be improved by using more pre-existing data.

Keywords: *Measuring Performance Efficiency; Banker, Chames and Cooper Model (BCC); Charnes, Cooper and Rhodes Model (CCR); Constant Return Scale (CRS); Data Envelopment Analysis (DEA); Decision Making Unit (DMU).*

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1. Introduction

Efficiency in education refers to its utility, or how pertinent it is to the social, economic, and psychological advancement of the community. Internal and external education efficiency come in two flavors. Internal efficiency has to deal with the productivity level as determined by the level of consumption, such as the number of scholars for pupils, and the budget. It makes use of several forms of analyses to quantify shortages. External efficiency measures the usefulness or marketability of university outputs like research and graduates.

Efficiency is the ratio of spending the least amount of time, money, or effort possible on creating a quality product or achieving a goal. The efficiency of the public sector is being measured more and more frequently in current studies. Researchers have compiled examples of efficiency measurements in the public sector, with varied degrees of success. This quantitative study's estimate techniques, which are used to gauge efficiency, are a key component. Tools for measuring technological efficiency include data envelopment analysis (DEA).

Data envelopment analysis is a technique created to assess the comparative effectiveness of decision-making units (DMU). With the method of determining a technical efficiency score for each observed DMU, Farrell (1957) invented modern empirical efficiency measurement. Twenty years later, in 1981, Charnes, Cooper, and Rhodes created DEA as a programming method for comparing DMU efficiency scores.

All observed efficiency scores are combined to form the efficiency frontier by DEA. The border is formed by the DMUs that achieve the highest efficiency scores, enclosing all other scores. DEA has already been used in studies to gauge the effectiveness of the public sector in various contexts. The effectiveness of public universities in the Kingdom of Saudi Arabia is the main topic of this study.

By transforming a number of inputs into a number of outputs, Data Envelopment Analysis (DEA) is an intriguing technique used to assess the technical effectiveness of a group of entities known as Decision Making Units (DMU). The DMU definition is open-ended and

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universal. Numerous DEA applications have been utilized to assess the performance of various sorts of entities engaged in various activities in various nations according to the nature of an entity. These DEA apps employ several DMU formats to assess the effectiveness and technical efficiency of the operations carried out by a variety of institutions, including nations, regions, businesses, hospitals, universities, and many more. The minimal assumptions required by DEA allow for usage in a variety of situations and are resistant to other methods that are complex in terms of inputs and outputs (Cooper et al, 2011).

The growth of information technology offers scientists in various study domains the opportunity to use novel methodologies in their work (Rosenmayer, 2014). One of the common uses of DEA is the comparison of the effectiveness and performance of various service-providing units using appropriate methodology. Public policies and initiatives often have an impact on DEA applications for public and government services. More specifically, a variety of organizations deliver public services and are affected by many different parties (Rosenmayer, 2014). DEA may evaluate the most efficient units among the evaluated units and compare them using several parameters for inputs and outputs.

1.1 Study Problem

The number of Saudi universities increased from 12 to 27 in around 10 years due to the enormous rise of educational facilities, particularly in universities. Issues with the funding and the quantity of people served by the universities, including employees and students, have arisen between the universities.

Each institution must increase its capacity by constructing new facilities and hiring frequently new employees with advanced degrees in academic or non-academic fields. In contrast to other universities, certain universities are simultaneously registering a large number of students. In comparison to the other institutions, does each university serve the greatest number of people with the resources allocated to it? This study will make recommendations for how to address the disparities between the budgetary allocations made by Saudi universities and the enrollments at each institution.

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1.2 Study Objective

The purpose of this study is to evaluate the comparative effectiveness of all universities located inside the Saudi Arabian Kingdom. For the purposes of this study, the DEA method will be used. It is anticipated that using DEA will help inefficient universities identify areas for improvement.

2. Literature Review

2.1 Previous Studies

Al-Shayea (2011) used the DEA technique to examine the effectiveness and performance of the various departments of the King Khalid University Hospital. The use of the DEA technique, which enables handling of the multidimensional character of inputs and outputs, can benefit health centers and hospitals. Evaluating the effectiveness and performance of all hospital departments is necessary to achieve hospital goals in terms of meeting the needs of all patient types and providing them with top-notch care. Nine hospital departments were assessed as part of the study, and the findings revealed that only two of them had 100% efficiency during a 12-month period. The departments of psychology and primary care scored highest, whereas others had low efficiency. The main cause was the greatest levels of relative input costs to output levels. These findings may be helpful for the manager of King University Hospital in making decisions and implementing the right corrective measures for these underperforming departments (Al-Shayea, 2011).

In order to evaluate the effectiveness of Saudi banks based on annual data between the years 2003 and 2008, basic DEA models, including CCR and BCR, have been utilized. Saudi banks were, relative to other banks, effective in managing their financial resources. Therefore, the vital information about financial conditions and management performance can be used by bank sector investors, managers, and bank regulators of Saudi banks. A DMU consists of each bank. The need for public policy implications to create a more efficient and competitive financial system is what gives the study its significance. This aids regulatory authorities in determining future plans for more advancements in the banking sector in Saudi Arabia. Out of all banks, NCB Bank was the only one with lower CCR and BCR model efficiency. The majority of Saudi banks managed their financial resources

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effectively, with CCR and BCR percentages of 86% and 93%, respectively (AlKhathlan & Malik, 2010).

The goal was to show how poorly financial resources were managed, which might be used to support the existence of human development scores. Additionally, the research aims to define waste resources using the DEA approach in order to establish the degree of human growth. The degrees of human development and efficiency had a considerable positive relationship. In order to legitimize expenditures that lead to an improvement in overall performance, there was a motivation to disclose high levels of human development along with the effectiveness of resource usage. The paper's major goal was to evaluate how well various nations performed in terms of achieving human development. The findings showed that, given a fixed amount of resources, some countries are more effective than others at achieving human growth. However, when calculating the non-income results, they still need to improve their resource use (Vierstraete, 2012).

a review of the effectiveness of 17 schools in Saudi Arabia, with a focus on the Qassim region. The DEA approach, which employed variable returns from the year 2011 as output, was used to calculate efficiency. The number of students completing school exams, the number of teachers per school, and the annual spending per student were among the factors used to launch the analysis. The findings showed that 6 schools, or 34% of the total number of schools, were entirely efficient, with a 0.96 average. Furthermore, 58% of the institutions have the ideal scale from a size perspective. Three inputs and one output make up the model for the study. The paper's objective was to evaluate the technical proficiency of 17 institutions. The paper's conclusion was that the majority of Qassim secondary schools are of a size that is suitable and suggests that they have room for extra students. Although secondary education in Saudi Arabia is producing results that are close to efficiency, there is still room for improvement (Al-Shayea, 2014).

The distance from the best practice frontier in DEA has been used in the work (Terzi, & Pierini, 2015) to quantify the effectiveness of the performance of economic sample units. The effectiveness of the compound inputs characterized by weighted aggregation, composite indicators, and sub-indicators of the infrastructure was measured using DEA. To

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evaluate the effectiveness of the combination of these factors, DEA produced a tool. Different concepts and outcomes are offered by DEA. It is important to note that DEA is a technique that depends on variables and sub-indicators rather than being the target. The study evaluated the outcomes of many situations in order to identify the key variations in their values and ranks. The difference, though, wasn't very significant (Terzi, & Pierini, 2015).

2.2 Efficiency Measurements

The models in DEA are independent of the size of the data points and lack any preconceived structure. The dependence on DMUs' best practices at a particular output level is the most crucial factor to take into account when calculating relative efficiency. DEA can calculate the efficiency scores under several scale economics hypotheses (Garca & Palomares, 2008). In order to quantify technical efficiency, Constant Return to Scale (CRS) is a model that officially offers linear programming under the assumption of constant returns to scale. In order to approach the production frontier, DMUs in the CRS model change the outputs or inputs. In contrast to using distance to one of the production sides or cost frontier facets to construct efficiency index, the variable returns to scale (VRS) model does not take the assumption of CRS into account (Garca & Palomares, 2008).

There are several DEA technique modifications that allow all factors, whether stochastic or deterministic, to identify the impact on optimization without taking producer control into account. Both allocated and technological efficiency can be produced via DEA. The capacity of DMUs to generate a single point on the production frontier irrespective of input and output values is a feature of technical efficiency (Garca & Palomares, 2008). Technical efficiency metrics should be stated along with a DMU's adjustment plan. Because they can result in lower inputs or higher outputs, it is difficult to distinguish between the consequences of technological inefficiency and technological advancement (Garca & Palomares, 2008). A locative efficiency measure is a component of DMUs that can produce on the production frontier and in an economically efficient way, such as a measure of the level of suboptimal failures in the allocation of inputs to the production process. In other

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words, it may assess how effectively inputs and outputs are allocated so that expenses are kept to a minimum and profits are maximized. DEA can use a variety of analyses depending on the model orientation (Garca & Palomares, 2008).

2.3 Data Envelopment Analysis (DEA)

By transforming a number of inputs into a number of outputs, Data Envelopment Analysis (DEA) is an intriguing technique used to assess the technical effectiveness of a group of entities known as Decision Making Units (DMU). The DMU definition is open-ended and universal. Numerous DEA applications have been utilized to assess the performance of various sorts of entities engaged in various activities in various nations according to the nature of an entity. These DEA apps employ several DMU formats to assess the effectiveness and technical efficiency of the operations carried out by a variety of institutions, including nations, regions, businesses, hospitals, universities, and many more. The minimal assumptions required by DEA allow for usage in a variety of situations and are resistant to other methods that are complex in terms of inputs and outputs (Cooper et al, 2011). The growth of information technology offers scientists in various study domains the opportunity to use novel methodologies in their work (Rosenmayer, 2014). One of the common uses of DEA is the comparison of the effectiveness and performance of various service-providing units using appropriate methodology. Public policies and initiatives often have an impact on DEA applications for public and government services. More specifically, a variety of organizations deliver public services and are affected by many different parties (Rosenmayer, 2014). DEA may evaluate the most efficient units among the evaluated units and compare them using several parameters for inputs and outputs.

3. Methodology

3.1 Data Gathering

According to the goal of the study, the data had been gathered. The availability and dependability of the data were the key challenges in choosing and collecting the data. The study's data set was drawn from six years. Data comes in two different forms—first, the budget, which the Ministry of Finance formally releases each year. Second, the Ministry of Education's website provides information on the student population at universities. The

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Ministry of Education's website last updated its information for the 2015 academic year in February 2016. Consequently, the study's data ranged from 2010 to 2015. The final information compiled is " Annual Budget for each University, the total number of academic staff for each university with the qualification, the total number of non-academic staff for each university with the qualification, the total number of Bachelor's students, total Number of Graduate Studies Students".

3.2 Models Generation

The study's focus is on four different comparisons. First, the general comparison, which compares university-wide generic variables such as the overall number of academic staff without taking qualifications into account. The second is a budget comparison between the budgets for each university and all the factors. Third, compare the number of academic staff members with the necessary qualifications to the number of pupils they served. Fourth, a comparison of non-academic personnel that takes into account their qualifications and the number of pupils they serviced.

The data must be divided into inputs and outputs before using the data envelopment analysis (DEA) tool. The variables that affect or are consumed by the outputs are known as inputs, whilst the variables that benefit or are generated by the system under investigation are known as outputs. The four models employed in this study are as follows:

3.2.1 General Model

Every study about the relative effectiveness of education in public sectors uses the same general model of the variables. The following table displays the data that this model was based on:

Table 3.1 General Model (Show appendix 1)

3.2.2 Budget Model

The number of consumers or beneficiaries who make up the budget is the main emphasis of the budget model. The following table displays the model:

Table 3.2 Budget Model (Show appendix 1)

3.2.3 Academic Staff Model

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The Academic Staff Model emphasizes the quantity and credentials of the academic staff in relation to the quantity of pupils. Listed below is the model:

Table 3.3 Academic Staff Model (Show appendix 1)

3.2.4 Non-Academic Staff Model

The Non-Academic Staff Model emphasizes the ratio of non-academic staff size and competencies to student body size. Listed below is the model:

3.3 Analysis and Results

The numbers make the stark difference between the university inputs and outcomes quite clear. The best number of inputs and outputs for each institution may be found from the relative efficiency using the data envelopment analysis (DEA) tool, which was used to examine this subject by assessing performance relative efficiency for the universities in Saudi Arabia.

DEA is a linear programming-based technique that assesses the effectiveness of decision-making units (DMUs). Data with many inputs and outputs can be described in several units thanks to the use of DEA to assess efficiency. The efficiency frontier developed by DEA also contrasts individual decision-making units with one another and with combinations of DMUs. Information about potential efficiency improvements can be obtained by moving from other DMUs without the DEA efficiency frontier. A relative efficiency calculation is made utilizing the input-oriented DEA model used in this study to estimate how much output may be produced with the fewest quantity of input. The DEA tool actually employs a highly intricate linear programming technique:

Objective function:

$$\text{Min } \theta = \frac{\sum u_m y_m}{\sum v_n x_n}$$

Subject to:

$$\frac{\sum u_m y_m}{\sum v_n x_n} \leq 1$$

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$$\frac{\sum u_m y_m}{\sum v_n x_n} \geq 0$$

$$u_1 + u_2 + \cdots + u_m \leq 1$$

$$v_1 + v_2 + \cdots + v_n \leq 1$$

$$u_1, u_2, \ldots u_m \geq 0$$

$$v_1, v_2, \ldots v_n \geq 0$$

Where:

- θ the relative efficiency score for DMU under study
- m and n: number of output and input respectively
- y and x: value of output and input respectively
- u and v: weight of output and input respectively

This linear programming algorithm was used to determine the relative effectiveness for each university across all models for each model. The results are shown in tables in two different ways. Initially, based on models with different presentations of the outcomes for each model. Second, findings are given separately for each university based on their respective rankings.

3.4 Frontier Analyst

Banxia Software Ltd.'s Frontier Analyst was the program used in this investigation. To compare the effectiveness of business units carrying out comparable tasks, Frontier Analyst uses data envelopment analysis (DEA), also known as a comparative performance assessment or peer-based analysis. It assists the researcher in thoroughly examining the effectiveness of the case being studied and identifies areas for improvement thanks to an intuitive interface. For simple result interpretation and communication, it offers numerical and graphical output. The next two figures show the software interface and results:

Figure 3.1: Frontier Analyst interface (Show appendix 2)

Figure 3.2: Frontier Analyst results (Show appendix 2)

3.5 Ranking

Basically, more than one effective decision making unit DMU might be included in the relative efficiency results obtained by employing the data envelopment analysis tool (a

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university in our study). Therefore, because many DMUs have 100% relative efficiency, we are unable to rank the DMUs (universities) or, put another way, determine which DMU has the highest relative efficiency value. In order to rank the universities based on the study, the average of the results from the four models might be employed.

4. Data Analysis and Results Discussion

4.1 Models Analysis and Results

4.1.1 General Model (Model 1)

The general model variables are common for every study about the relative efficiency of education in public sectors. The annual budget "input," the number of academic staff "input," the number of non-academic staff "input," the number of students "output," and the number of graduate studies students "output" are the elements employed in this model. The analyses' findings for the subsequent table's six-year period are shown.

Table 4.1: General Model Results (Show appendix 1)

Figure 4.1 shows the results for year 2015 (Show appendix 2)

4.1.2 Budget Model (Model 2)

The number of budget beneficiaries or customers is the main emphasis of the budget model. The annual budget "input," the number of academic staff "output," the number of non-academic employees "output," the number of students "output," and the number of graduate students "output" are the elements employed in this model. The analyses' findings for the subsequent table's six-year period are shown.

Table 4.2: Budget Model Results (Show appendix 1)

Figure 4.1: Budget Model 2015 Results (Show appendix 2)

4.1.3 Academic Staff Model (Model 3)

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The Academic Staff model emphasizes the quantity and credentials of the academic staff in relation to the quantity of pupils. The PhD academic staff "input," master academic staff "input," bachelors academic staff "input," other academic staff "input," number of Students "output," and number of graduate studies students "output" are the variables used in the model. The outcomes of the analysis for six years are shown in the following table (Table 4.3).

Table 4. 3: Academic Staff Model Results (Show appendix 1)

Figure 4.2: Academic Staff Model 2015 Results (Show appendix 2)

4.1.4 Non-Academic Staff Model (Model 4)

The Academic Staff model focuses on the numbers and the qualifications for the academic staff to the number of students. The factors used in the model are (Ph.D. non-academic staff "input", master non-academic staff "input", bachelors non-academic staff "input", other non-academic staff "input", number of students "output", number of graduate studies students "output"). The next table presents the results of the analysis for 6 years.

Table 4.4: Non-Academic Staff Model Results (Show appendix 1)

Figure 4.4: Non-Academic Staff Model 2015 Results (Show appendix 2)

4.2 Universities Analysis and Results

For each university, the findings of a performance relative efficiency analysis are presented. Additionally, the 2015 goal values for each factor in each model are shown.

4.2.1 Al Baha University

4.2.1.1 Relative efficiency Results of Al Baha University

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The following table and figure display the Al Baha University's six-year comparative efficiency results for all four models:

Table 4. 5: Relative efficiency Results of Al Baha University (Show appendix 1)

Figure 4.5: Relative efficiency Results of Al Baha University (Show appendix 2)

4.2.1.2 Target Values for Al Baha University

The following two tables, for input orientation and output orientation, show the suggested values for each factor in each model for 2015:

Table 4.6: Input Oriented Target Values for Al Baha University (Show appendix 1)

Table 4.7: Output Oriented Target Values for Al Baha University (Show appendix 1)

4.2.2 Al Jawf University

4.2.2.1 Relative efficiency Results of Al Jawf University

The following table and figure display the Al Jawf University's six-year comparative efficiency results for all four models:

Table 4.8: Relative efficiency Results of Al Jawf University (Show appendix 1)

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Figure 4.3: Relative efficiency Results of Al Jawf University (Show appendix 2)

4.2.2.2 Target Values for Al Jawf University

The following two tables, for input orientation and output orientation, show the suggested values for each factor in each model for 2015:

Table 4.9: Input Oriented Target Values for Al Jawf University (Show appendix 1)

Table 4.10: Output Oriented Target Values for Al Jawf University (Show appendix 1)

4.2.3 Al Majma'ah University

4.2.3.1 Relative efficiency Results of Al Majma'ah University

The following table and graphic display the relative efficiency results of Al Majma'ah University for 5 years (data began in 2011) for all 4 models:

Table 4.11: Relative efficiency Results of Al Majma'ah University (Show appendix 1)

Figure 4.4: Relative efficiency Results of Al Majma'ah University (Show appendix 2)

4.2.3.2 Target Values for Al Majma'ah University

The following two tables, for input orientation and output orientation, show the suggested values for each factor in each model for 2015:

Table 4.12: Input Oriented Target Values for Al Majma'ah University (Show appendix 1)

Table 4.13: Output Oriented Target Values for Al Majma'ah University (Show appendix 1)

4.2.4 Imam Muhammad Ibn Saud University

4.2.4.1 Relative efficiency Results of Imam Muhammad Ibn Saud University

The following table and figure display the Imam Muhammad Ibn Saud University's six-year comparative efficiency results for each of the four models:

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Table 4.14: Relative efficiency Results of Imam Muhammad Ibn Saud University (Show appendix 1)

Figure 4.8: Relative efficiency Results of Imam Muhammad Ibn Saud University (Show appendix 2)

4.2.4.2 Target Values for Imam Muhammad Ibn Saud University

The following two tables, for input orientation and output orientation, show the suggested values for each factor in each model for 2015:

Table 4.15: Input Oriented Target Values for Imam Muhammad Ibn Saud University (Show appendix 1)

Table 4.16: Output Oriented Target Values for Imam Muhammad Ibn Saud University (Show appendix 1)

4.2.5 Islamic University in Madinah

4.2.5.1 Relative efficiency Results of Islamic University in Madinah

The following table and figure display the results of the Islamic University in Madinah's six-year comparative efficiency study for all four models:

Table 4.17: Relative efficiency Results of Islamic University in Madinah (Show appendix 1)

Figure 4.9: Relative efficiency Results of Islamic University in Madinah (Show appendix 2)

4.2.5.2Target Values for Islamic University in Madinah

The following two tables, for input orientation and output orientation, show the suggested values for each factor in each model for 2015:

Table 4.18: Input Oriented Target Values for Islamic University in Madinah (Show appendix 1)

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Table 4.19: Output Oriented Target Values for Imam Muhammad Ibn Saud University (Show appendix 1)

4.2.6 Jizan University

4.2.6.1 Relative efficiency Results of Jizan University

The following table and figure display Jizan University's six-year comparative efficiency statistics for all four models:

Table 4.20: Relative efficiency Results of Jizan University (Show appendix 1)

Figure 4.10: Relative efficiency Results of Jizan University (Show appendix 2)

4.2.6.2 Target Values for Jizan University

The following two tables, for input orientation and output orientation, show the suggested values for each factor in each model for 2015:

Table 4.21: Input Oriented Target Values for Jizan University (Show appendix 1)

Table 4.22: Output Oriented Target Values for Jizan University (Show appendix 1)

4.2.7 King Abdul Aziz University

4.2.7.1 Relative efficiency Results of King Abdul Aziz University

The following table and figure display the King Abdul Aziz University's six-year comparative efficiency results for all four models:

Table 4. 23: Relative efficiency Results of King Abdul Aziz University (Show appendix 1)

4.2.7.2 Target Values for King Abdul Aziz University

The following table and figure display the King Abdul Aziz University's six-year comparative efficiency results for all four models:

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Table 4.24: Input Oriented Target Values for King Abdul Aziz University (Show appendix 1)

Table 4.25: Output Oriented Target Values for King Abdul Aziz University (Show appendix 1)

4.2.8 King Fahd University of Petroleum and Minerals (KFUPM)

4.2.8.1 Relative efficiency Results of KFUPM

The following table and figure display the King Fahd University of Petroleum and Minerals' (KFUPM) six-year comparative efficiency findings for each of the four models:

Table 4.26: Relative efficiency Results of KFUPM (Show appendix 1)

4.2.8.2 Target Values for KFUPM

The following two tables, for input orientation and output orientation, show the suggested values for each factor in each model for 2015:

Table 4.27: Input Oriented Target Values for KFUPM University (Show appendix 1)

Table 4.28: Output Oriented Target Values for KFUPM University (Show appendix 1)

4.2.9 King Faisal University

4.2.9.1 Relative efficiency Results of King Faisal University

The following table and figure display the King Faisal University's six-year comparative efficiency results for all four models:

Table 4.29: Relative efficiency Results of King Faisal Universit (Show appendix 1)

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Figure 4.5: Relative efficiency Results of King Faisal University (Show appendix 2)

4.2.9.2 Target Values for King Faisal University

The following two tables, for input orientation and output orientation, show the suggested values for each factor in each model for 2015:

Table 4.30: Input Oriented Target Values for King Faisal University (Show appendix 1)

Table 4.31: Output Oriented Target Values for King Faisal University (Show appendix 1)

4.2.10 King Khalid University

4.2.10.1 Relative efficiency Results of King Khalid University

The following table and figure display the King Khalid University's six-year comparative efficiency results for all four models:

Table 4.32: Relative efficiency Results of King Khalid University (Show appendix 1)

4.2.10.2 Target Values for King Khalid University

The following two tables, which indicate the suggested values for input orientation and output orientation, respectively, for each factor in each model for 2015:

Table 4.33: Input Oriented Target Values for King Khalid University (Show appendix 1)

Table 4.34: Output Oriented Target Values for King Khalid University (Show appendix 1)

4.2.11 King Saud University

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4.2.11.1 Relative efficiency Results of King Saud University

The following table and figure display the King Saud University's six-year comparative efficiency results for all four models:

Table 4.35: Relative efficiency Results of King Saud University (Show appendix 1)

Figure 4.6: Relative efficiency Results of King Saud University (Show appendix 2)

4.2.11.2 Target Values for King Saud University

The following two tables, for input orientation and output orientation, show the suggested values for each factor in each model for 2015:

Table 4.36: Input Oriented Target Values for King Saud University (Show appendix 1)

Table 4.37: Output Oriented Target Values for King Saud University (Show appendix 1)

4.2.12 Najran University

4.2.12.1 Relative efficiency Results of Najran University

The following table and figure display Najran University's six-year comparative efficiency results for each of the four models:

Table 4.38: Relative efficiency Results of Najran University (Show appendix 1)

Figure 4.7: Relative efficiency Results of Najran University (Show appendix 2)

4.2.12.2 Target Values for Najran University

The following two tables, for input orientation and output orientation, show the suggested values for each factor in each model for 2015:

Table 4.39: Input Oriented Target Values for Najran University (Show appendix 1)

Table 4.40: Output Oriented Target Values for Najran University (Show appendix 1)

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4.2.13 Northern Border University

4.2.13.1 Relative efficiency Results of Northern Border University

The following table and figure display Northern Border University's six-year comparative efficiency results for each of the four models:

Table 4.41: Relative efficiency Results of Northern Border University (Show appendix 1)

Figure 4.8: Relative efficiency Results of Northern Border University (Show appendix 2)

4.2.13.2 Target Values for Northern Border University

The following two tables, for input orientation and output orientation, show the suggested values for each factor in each model for 2015:

Table 4.42: Input Oriented Target Values for Northern Border University (Show appendix 1)

Table 4.43: Output Oriented Target Values for Northern Border University (Show appendix 1)

4.2.14 Prince Sattam bin Abdulaziz University

4.2.14.1 Relative efficiency Results of Prince Sattam bin Abdulaziz University

The following table and figure display the Prince Sattam Bin Abdulaziz University's six-year comparative efficiency results for each of the four models:

Table 4.44: Relative efficiency Results of Prince Sattam bin Abdulaziz University (Show appendix 1)

Figure 4.9: Relative efficiency Results of Prince Sattam bin Abdulaziz University (Show appendix 2)

4.2.14.2 Target Values for Prince Sattam bin Abdulaziz University

The following two tables, for input orientation and output orientation, show the suggested values for each factor in each model for 2015:

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Table 4.45: Input Oriented Target Values for Sattam bin Abdulaziz University (Show appendix 1)

Table 4.46: Output Oriented Target Values for Sattam bin Abdulaziz University (Show appendix 1)

4.2.15 Princess Noura Bint Abdul Rahman University

4.2.15.1 Relative efficiency Results of Princess Noura Bint Abdul Rahman University

The following table and figure display the Prince Princess Noura Bint Abdul Rahman University's six-year comparative efficiency results for all four models:

Table 4.47: Relative efficiency Results of Princess Noura Bint Abdul Rahman University (Show appendix 1)

Figure 4.10: Relative efficiency Results of Princess Noura Bint Abdul Rahman University (Show appendix 2)

4.2.15.2 Target Values for Princess Noura Bint Abdul Rahman University

The following two tables, for input orientation and output orientation, show the suggested values for each factor in each model for 2015:

Table 4.48: Input Oriented Target Values for Noura Bint Abdul Rahman University (Show appendix 1)

Table 4.49: Output Oriented Target Values for Noura Bint Abdul Rahman University (Show appendix 1)

4.2.16 Qassim University

4.2.16.1 Relative efficiency Results of Qassim University

The following table and figure display the Qassim University's six-year comparative efficiency statistics for all four models:

Table 4.50: Relative efficiency Results of Qassim University (Show appendix 1)

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Figure 4.11: Relative efficiency Results of Qassim University (Show appendix 2)

4.2.16.2 Target Values for Qassim University

The following two tables, for input orientation and output orientation, show the suggested values for each factor in each model for 2015:

Table 4.51: Input Oriented Target Values for Qassim University (Show appendix 1)

Table 4.52: Output Oriented Target Values for Qassim University (Show appendix 1)

4.2.17 Saudi Electronic University

4.2.17.1 Relative efficiency Results of Saudi Electronic University

The following table and figure display the Saudi Electronic University's six-year comparative efficiency statistics for all four models:

Table 4.53: Relative efficiency Results of Saudi Electronic University (Show appendix 1)

4.2.17.2 Target Values for Saudi Electronic University

The following two tables, which indicate the suggested values for input orientation and output orientation, respectively, for each factor in each model for 2015:

Table 4.54: Input Oriented Target Values for Saudi Electronic University (Show appendix 1)

Table 4.55: Output Oriented Target Values for Saudi Electronic University (Show appendix 1)

4.2.18 Shaqra University

Table 4.56: Relative efficiency Results of Shaqra University (Show appendix 1)

Figure 4.12: Relative efficiency Results of Shaqra University (Show appendix 2)

4.2.18.2 Target Values for Shaqra University

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The recommended value of each factor in each model for 2015 are shown in the next two tables for input orientation and output orientation respectively:

Table 4.57: Input Oriented Target Values for Shaqra University (Show appendix 1)

Table 4.58: Output Oriented Target Values for Shaqra University (Show appendix 1)

4.2.19 Tabuk University

Table 4.59: Relative efficiency Results of Tabuk University (Show appendix 1)

Figure 4.13: Relative efficiency Results of Tabuk University (Show appendix 2)

4.2.19.2 Target Values for Tabuk University

The recommended value of each factor in each model for 2015 are shown in the next two tables for input orientation and output orientation respectively:

Table 4.60: Input Oriented Target Values for Tabuk University (Show appendix 1)

Table 4.61: Output Oriented Target Values for Tabuk University (Show appendix 1)

4.2.20 Taibah University

4.2.20.1 Relative efficiency Results of Taibah University

The following table and figure display Taibah University's six-year comparative efficiency results for each of the four models:

Table 4.62: Relative efficiency Results of Taibah University (Show appendix 1)

4.2.20.2 Target Values for Taibah University

The following two tables, one for input orientation and the other for output orientation, respectively, show the suggested value of each factor in each model for 2015:

Table 4.63: Input Oriented Target Values for Taibah University (Show appendix 1)

Table 4.64: Output Oriented Target Values for Taibah University (Show appendix 1)

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4.2.21 Taif University

4.2.21.1 Relative efficiency Results of Taif University

The following table and figure display Taif University's six-year comparative efficiency results for each of the four models:

Table 4.65: Relative efficiency Results of Taif University (Show appendix 1)

Figure 4.14**: Relative efficiency Results of Taif University (Show appendix 2)**

4.2.21.2 Target Values for Taif University

The recommended value of each factor in each model for 2015 are shown in the next two tables for input orientation and output orientation respectively:

Table 4.66: Input Oriented Target Values for Taif University (Show appendix 1)

Table 4.67: Output Oriented Target Values for Taif University (Show appendix 1)

4.2.22 Umm Al-Qura University

4.2.22.1 Relative efficiency Results of Umm Al-Qura University

The relative efficiency results of Umm Al-Qura University for 6 years for all 4 models are shown in the next table and figure:

Table 4.68: Relative efficiency Results of Umm Al-Qura University (Show appendix 1)

4.2.22.2 Target Values for Umm Al-Qura University

The following two tables, for input orientation and output orientation, show the suggested values for each factor in each model for 2015:

Table 4.69: Input Oriented Target Values for Umm Al-Qura University (Show appendix 1)

Table 4.70: Output Oriented Target Values for Umm Al-Qura University (Show appendix 1)

4.2.23 University of Bisha

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4.2.23.1 Relative efficiency Results of University of Bisha

The relative efficiency results of Umm University of Bisha for 6 years for all 4 models are shown in the next table and figure:

Table 4.71: Relative efficiency Results of University of Bisha (Show appendix 1)

Figure 4.15: Relative efficiency Results of University of Bisha (Show appendix 2)

4.2.23.2 Target Values for University of Bisha

The recommended value of each factor in each model for 2015 are shown in the next two tables for input orientation and output orientation respectively:

Table 4.72: Input Oriented Target Values for University of Bisha (Show appendix 1)

Table 4.73: Output Oriented Target Values for University of Bisha (Show appendix 1)

4.2.24 University of Dammam

4.2.24.1 Relative efficiency Results of University of Dammam

The relative efficiency results of the University of Dammam for 6 years for all 4 models are shown in the next table and figure:

Table 4.74: Relative efficiency Results of University of Dammam (Show appendix 1)

4.2.24.2 Target Values for University of Dammam

The recommended value of each factor in each model for 2015 are shown in the next two tables for input orientation and output orientation respectively:

Table 4.75: Input Oriented Target Values for University of Dammam (Show appendix 1)

Table 4.75: Output Oriented Target Values for University of Dammam (Show appendix 1)

4.2.25 University of Hafr Al Batin

4.2.25.1 Relative efficiency Results of University of Hafr Al Batin

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The relative efficiency results of University of Hafr Al Batin for 6 years for all 4 models are shown in the next table and figure:

Table 4.76: Relative efficiency Results of University of Hafr Al Batin (Show appendix 1)

Figure 4.16: Relative efficiency Results of University of Hafr Al Batin (Show appendix 2)

4.2.25.2 Target Values for University of Hafr Al Batin

The recommended value of each factor in each model for 2015 are shown in the next two tables for input orientation and output orientation respectively:

Table 4.77: Input Oriented Target Values for University of Hafr Al Batin (Show appendix 1)

Table 4.78: Output Oriented Target Values for University of Hafr Al Batin (Show appendix 1)

4.2.26 University of Hail

4.2.26.1 Relative efficiency Results of University of Hail

The relative efficiency results of University of University of Hail for 6 years for all 4 models are shown in the next table and figure:

Table 4.79: Relative efficiency Results of University of Hail (Show appendix 1)

Figure 4.17: Relative efficiency Results of University of Hail (Show appendix 2)

4.2.26.2 Target Values for University of Hail

The recommended value of each factor in each model for 2015 are shown in the next two tables for input orientation and output orientation respectively:

Table 4.80: Input Oriented Target Values for University of Hail (Show appendix 1)

Table 4.81: Output Oriented Target Values for University of Hail (Show appendix 1)

4.2.27 University of Jeddah

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4.2.27.1 Relative efficiency Results of University of Jeddah

The following table and figure display the University of Hawaii's six-year comparative efficiency results for all four models:

Table 4.82: Relative efficiency Results of University of Jeddah (Show appendix 1)

Figure 4.18: Relative efficiency Results of University of Jeddah (Show appendix 2)

4.2.27.2 Target Values for University of Jeddah

The recommended value of each factor in each model for 2015 are shown in the next two tables for input orientation and output orientation respectively:

Table 4.83: Input Oriented Target Values for University of Jeddah (Show appendix 1)

Table 4.84: Output Oriented Target Values for University of Jeddah (Show appendix 1)

5. Conclusion and Recommendation

5.1 Conclusion

The Kingdom of Saudi Arabia is a developing nation that is on the verge of becoming a developed nation. E-government programs are being created and used in numerous domains. The development's principal goal includes education. Saudi Arabian universities are mainly in charge of preparing students for involvement in a real-world job. Universities also have a responsibility to raise the cultural level of the populace. Therefore, university efficiency should be great because its output determines the future of our society.

Data envelopment investigation The DEA tool is a useful tool for evaluating the relative effectiveness of universities. It is a sophisticated linear programming tool that gauges relative effectiveness using input and output variables. Numerous pieces of software were created to utilize it due to the complexity of the calculations.

Four models—General, Budget, Academic Staff, and Non-Academic Staff—were created to examine the performance relative efficiency for Saudi universities. Over the past six years, each university's efficiency has changed. The relative effectiveness of some colleges

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grew while that of others fell. Additionally, over the past six years, several colleges' relative efficiency increased and dropped in a non-ascending or falling manner.

Regarding the general model's 2015 outcomes, 5 universities—the Islamic University in Madinah, King Faisal University, Tabuk University, Taif University, and University of Hafr Al Batin—were 100% effective. There were 2 universities that scored more than 90% in efficiency: Imam Muhammad Ibn Saud University, and Umm Al-Qura University. In comparison to the other universities, this model shows that these universities effectively used their inputs (budget, number of academic staff, and number of non-academic employees) to produce their respective outputs (number of students, and number of graduate studies students).

In terms of the budget model's 2015 results, Al Majma'ah University, Islamic University in Madinah, Jizan University, King Faisal University, Saudi Electronic University, Umm Al-Qura University, University of Bisha, and the University of Jeddah were the only eight universities to achieve a 100% efficiency rate. Qassim University, Tabuk University, Taibah University, and Taif University were the four institutions with efficiency scores of 90% or higher. In comparison to the other universities, this model shows that these universities made efficient use of their inputs in light of their corresponding outputs.

According to the academic staff model's 2015 findings, 5 universities—Islamic University in Madinah, Imam Muhammad Ibn Saud University, King Khalid University, Qassim University, Saudi Electronic University, Shaqra University, and University of Hafr Al Batin—were 100% effective. Al Jawf University, Taibah University, and the University of Hail were the only three institutions to receive efficiency ratings of greater than 90%. Based on the quantities of these identical parameters at all other institutions, this model shows that the number of academic staff members at these universities and their qualifications are effectively related to the number of students and a number of graduate students.

Al Baha University, Islamic University in Madinah, Jizan University, King Faisal University, Saudi Electronic University, Shaqra University, Tabuk University, Taif University, University of Bisha, University of Hail, and University of Jeddah were the five

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universities that achieved a non-academic staff model efficiency score of 100% in 2015. Imam Muhammad Ibn Saud University and Northern Border University were the only two institutions to receive efficiency scores of higher than 90%. According to this model, based on the numbers of these identical elements at all other institutions, the number of non-academic staff members at these universities who have the appropriate qualifications is effectively correlated with the number of undergraduates and graduate students.

King Saud University has the greatest budget. About 18% of all universities' budget amount. But, the efficiencies for all 4 models are horrible. The university got 31% in general model, 84% in budget model, 55% in academic staff model, and 17% in non-academic staff model. It is recommended for this university to decrease the number of staff and increase the number of students. The budget of King Abdulaziz University is second-best. 11% of the budget for all universities. Based on this budget, the efficiency for all 4 models is terrible. The university received 63% in the general model, 81% in the budget model, 27% in the model for academic employees, and 40% in the model for non-academic workers. It is advised that this university cut back on both employees and budget.

For all 4 models combined, the University of Dammam has the lowest overall relative efficiency %. The university received 14% in the non-academic staff model, 14% in the general model, 52% in the budget model, 53% in the academic staff model. It is advised that this university cut back on its spending and hire fewer academic and non-academic staff members. On the other hand, it is advised to grow the student body.

The first women-only university in the world is Princess Noura Bint Abdul Rahman University. It and Dammam University both have the lowest overall relative efficiency %. 25% in the general model, 71% in the budget model, 17% for academic personnel, and 35% for non-academic staff were received by the institution. It is advised that the Princess Noura Bint Abdul Rahman University cut back on both its funding and non-academic staff. On the other hand, it is advised to grow the student body.

Results from Imam Muhammad Ibn Saud University are excellent. It received 95% in the overall model, 83% in the budget model, 100% in the model for academic employees, and

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92% in the model for non-academic staff. It is advised that Imam Muhammad Ibn Saud University cut the number of non-academic personnel and the budget by just 17%.

The second most effective university is King Faisal University. The college received perfect scores for the general model, budget model, academic staff model (83%), and non-academic staff model (100%). This university should reduce the number of academic staff members, although it can choose to disregard the advice.

One of Saudi Arabia's most recent universities to be founded is the University of Jeddah. In the general model, the university received 73%, in the budget model 100%, in the academic staff model 67%, and in the non-academic staff model 100%. It is advised that this university cut back on its academic staff while modestly increasing the number of pupils.

Of all Saudi Arabian universities, Islamic University in Madinah had the best relative efficiency. In all 4 models, the university scored 100%. It is advised that this university maintain an even ratio of all aspects to maintain efficiency at 100% and concentrate on academic components like courses and curriculum.

For all 4 models, the University of Najran has the third-lowest overall relative efficiency %. The university received 38% in the general model, 50% in the budget model, 18% in the model for academic employees, and 79% in the model for non-academic workers. It is advised that this university cut its budget by roughly 50%, reduce the number of academic and non-academic staff members, and raise the enrollment of students.

In terms of the overall relative efficiency percent for all 4 models, Qassim University is ranked in the middle. In the general model, the university received 77%, in the budget model 100%, in the academic staff model 90%, and in the non-academic staff model 61%. It is advised that this university cut back on its budget and on the number of academic and non-academic employees.

In terms of overall relative efficiency percent for all 4 models, Bisha University is ranked ninth. In the general model, the university received 78%, in the budget model 100%, in the academic staff model 69%, and in the non-academic staff model 100%. It is advised that

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this university reduce its budget, staff size (both academic and non-academic), and number of students while increasing its student body.

5.2 Recommendations

1. The position of the university in the kingdom has to be reviewed by the Ministry of Education.
2. The sums given to each university need to be reviewed by the university budgets.
3. All institutions should receive an equal distribution of academic staff members.
4. Non-academic workers should be divided more evenly among all universities.
5. The distribution of students among the universities should be changed.
6. The study could be improved by using more precise data.
7. The number of scholarly publications from each university may be a useful extra variable in the analysis.
8. The same data could be used for a variety of projects.

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