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Data Envelopment Analysis Models to Measure the Relative and Scale Efficiency of Educational Institutions (Tikrit University as A Model)

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Abstract

The research dealt with measuring the relative efficiency and scale efficiency of the colleges of Tikrit University for the academic year (2019-2020) using the data envelope analysis (DEA) method, which is one of the linear programming methods to measure the productive efficiency of institutions and economic units. The constant returns to scale (CCR) model and the variable returns to scale (BCC) model were used according to the input-oriented measures and output-oriented measures indicators. In order to achieve the objectives of the study, the 21 colleges of the University of Tikrit were selected, and three inputs were identified: the number of registered students, the number of teaching staff, the number of employees, and two outcomes (the number of graduates and the number of published research, seminars, and conferences). The research reached several results, the most important of which is that (9) colleges achieved relative efficiency in the CCR model and (11) colleges in the BCC model with both internal and external orientations. The research also addressed the necessary procedures and reforms for incompetent colleges for the purpose of reaching competency, and also identified the reference colleges for each incompetent college to imitate and emulate in order to reach full competency.

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1. Introduction

The process of measuring the efficiency of educational institutions is considered an important and vital part of improving educational quality, as this process contributes to providing a comprehensive assessment of the educational institution's performance and achieving its educational and research goals. Colleges within universities are considered independent units that each strive to achieve complete efficiency by optimally utilizing inputs to achieve maximum educational outputs. The way to accomplish this is through the prudent use of available resources and capabilities, which is expressed by the term "efficiency." Efficiency, in its connotation, represents the optimal way to use available resources and capabilities to achieve results and goals at the lowest possible cost. Although this term originated in the production field, it has been widely used in sectors and institutions that do not aim for profit, such as educational institutions. The outputs of education in general, and higher education in particular, in all its types and stages, represent one of the essential factors of production and a workforce that plays an influential role in economic development. Education complements the training process, and both represent one of the fundamental pillars of comprehensive development, contributing to the formation of human capital. By measuring efficiency, useful and necessary information can be obtained for making decisions related to the distribution and optimal use of resources, as well as utilizing modern quantitative methods that are relied upon to measure efficiency. Therefore, we will measure the efficiency of the colleges at Tikrit University using the Data Envelopment Analysis method, which is considered one of the most important quantitative methods used to measure the efficiency of educational

institutions. It is one of the linear programming methods, distinguished by several advantages, the most important of which are determining the degree of inefficiency and its sources, in addition to ease of use.

2. Search Objectives:

The research aims to use the Data Envelopment Analysis method, which is one of the modern quantitative methods for measuring relative efficiency, in order to contribute to the following:

1. Identifying the colleges that achieved full relative efficiency according to the provision of the largest amount of outputs, using the available inputs.
2. Identifying the colleges that did not achieve full relative efficiency.
3. Determining the amount of reduction in the inputs of inefficient colleges and the amount of increase in the outputs of inefficient colleges to achieve full relative efficiency.
4. Determining the reference colleges for each inefficient college.

3. Literature Review

(Fahmy, 2009) submitted a study aims to measure the relative efficiency of Saudi universities using the data envelopment analysis method. The results of the study were that (5) universities out of (11) universities achieved 100% complete relative efficiency.

(Pietrzak et al. 2016) discussed the problem of measuring efficiency in publicly owned higher education institutions using an output-oriented CCR data envelopment analysis model. The study sample consisted of 33 Polish colleges for the academic year 2013/2014. The results showed that the relative efficiency ranges from 0.41 to 1 and the average efficiency is 0.72, and (9) colleges were 100% effective.

(Al-Buraihi et al., 2017) Measured the relative efficiency of the 19 colleges of Anbar University using data envelopment analysis. The results were: only two colleges achieved proficiency in the CCR model and (5) colleges in the BCC model in 2010-2011; in the year 2011-2012, no college achieved proficiency in the CCR model and (3) colleges in the BCC model; and in the year 2012-2013, (6) colleges achieved proficiency in the CCR model and (9) faculties in the BCC model.

(Liu et al,2018) They evaluated the research performance of (19) different schools at Double Top University in China, using Data Envelopment Analysis with the CCR and BCC models in an Output Oriented approach. The study found that (12) schools achieved efficiency in the BCC model and (7) schools in the CCR model. The study concluded that schools that prioritize research output achieve higher efficiency compared to other schools.

(Naderi, 2019) The study examines the measured of performance efficiency of 77 academic departments at a public university in Iran using the Data Envelopment Analysis (DEA) method. The results of the study indicate that the efficiency scores in the BCC model are relatively higher than the efficiency scores in the CCR model, and that the model used affects the efficiency scores.

(Wildani et al.2023)They measured the relative efficiency of (38) academic departments at Sepuluh Nopember Institute of Technology, Indonesia, using Data Envelopment Analysis (DEA). The results indicated that (5) departments were efficient in the CRS model with an average efficiency of (59.7%). In the VRS model, (10) departments were efficient with an average efficiency of (67.9%). The study found that some departments were operating with a high level of inputs while the output values were disproportionate, and the efficiency level of some departments was relatively low.

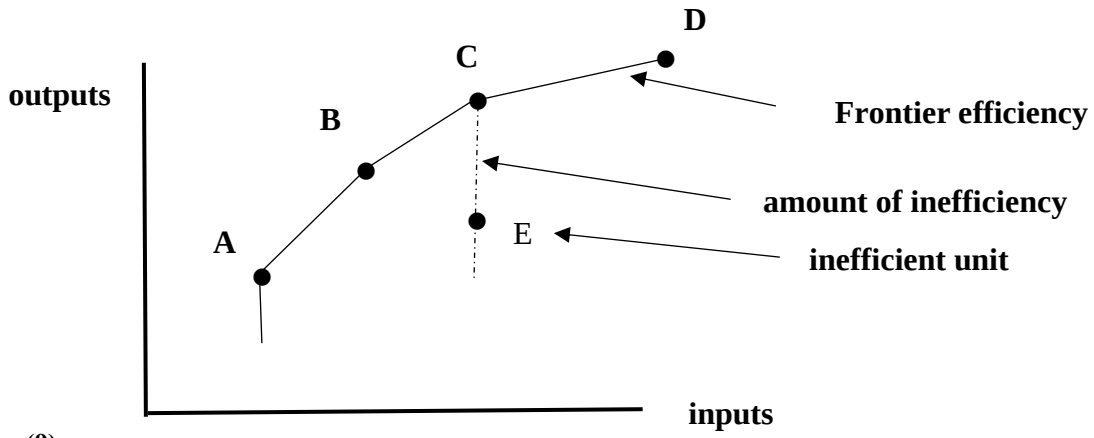
4. Methodology

4.1 Data Envelopment Analysis

The method of analyzing the data envelope is based on the article Farell published in 1957 (6), The beginning of this method's appearance in 1978 is through Charnes, Cooper, and Rhodes (4), Data envelope analysis is a mathematical method used to assess the productive efficiency of a homogeneous group such as schools, hospitals, or banks (10), The method of analyzing the data envelope is based on the optimal weights of input and output (14), DEA is based on the simple fact that any unit that uses fewer inputs than others to produce the same level of output is more efficient. The frontier efficiency curve according to the DEA concept is formed by the efficient units and is the best combination of observations for the ratio of output to input. This curve encapsulates all the observations under study. This technique can be illustrated by the following figure:

From figure 1, we find that units A, B, C, and D are efficient units according to the DEA concept, unit E is inefficient, and the amount of inefficiency can be determined by knowing the horizontal or vertical distance between the efficiency curve

and the E point. The horizontal distance measures the amount that should be reduced from inputs in the case of input orientation, while the vertical distance measures the amount that should be increased from outputs in the case of output orientation to achieve efficiency.



Source: (9)

Figure 1: represents the efficiency curve of data envelopment analysis:

From figure 1 find that the E unit uses more inputs to produce the same output as the other units and assuming that have a set of units, the DEA model is to achieve the highest value (degree of efficiency = 1) through the u_r weight group and v_i as follows (12):

Maximize h_0 (u,v) = $\frac{\sum_{r=1}^{s} y_{r0}\ u_r}{\sum_{i=1}^{m} x_{i0}\ v_i}$ (1)

Subject to $\frac{\sum_{r=1}^{s} y_{rj}\ u_r}{\sum_{i-1}^{m} x_{ij}\ v_i} \leq 1$, (j = 1,2,….,n)

$u_r \geq 0$ (r = 1,2,…,s) $v_i \geq 0$ (i= 1,2,..,m)

Since that:

u_r : Weight set for outputs, v_i : Weight set for inputs, y_r : Outputs for the unit, x_i : inputs for the unit

The unit is efficient if it achieves an efficiency score equal to (1), which means that it falls on the boundary efficiency curve, and there is a compatibility between the actual and targeted performance of the unit. If the unit achieves a level of efficiency below one, it means that it does suffer from a state of inefficiency or relative inefficiency to the corresponding units. The DEA method is solved by converting the previous model into linear software and finding optimal values for ur and vi through the use of standard linear programming methods. According to the DEA concept, each unit's efficiency is assessed by using the optimal weights of that unit.

5. Features and Disadvantages of DEA:

1. Summarizes each unit's performance as a single efficiency indicator (1).
2. The method can use multiple inputs and multiple outputs with different modules in measurement (5).
3. It does not need to set previous weights for inputs and outputs, but rather leaves it to the program that automatically determines them, as it does not require price determination for those inputs and outputs (7).
4. The inability of this method to distinguish between a state of inefficiency and a statistical error, and this method is sensitive to the number of variables entering the model, where the more variables entering the number of units, the more efficient (11).
5. Since the DEA method adopts the concept of weights per unit when maximizing their relative efficiency. This may be one of the disadvantages; the unit may appear to be efficient according to the concept of relative efficiency, but in fact it is not, and this clearly shows when the number of institutions involved in evaluation is small and the number of outputs is large (16).

6. Data Envelopment Analysis Models

Several models have emerged to find efficiency indicators using the method of analysis of the DEA data envelope. Efficiency indicators can be found either by inputs called input-orientation measures or by output indicators called output-oriented measures (18).

6.1 CCR Model

This model was developed by Charnes, Cooper, and Rhodes in 1978 and is considered the foundation of the Data Envelopment Analysis (DEA) approach. This model indicates that the amount of change in inputs has a consistent effect on the quantity of outputs produced, and this property is known as constant returns to scale. To formulate the mathematical model for the CCR model, we assume we have n decision-making units (DMUj) (j = 1, 2, ..., n) that produce several outputs Yrj (r = 1, 2, ..., s) using several inputs Xij (i = 1, 2, ..., m) (17).

Table 1 illustrates the mathematical model of CCR with input and output orientation.

input- oriented	
Envelopment model	Multiplier model
$\min\theta - \varepsilon\ (\sum_{i=1}^{m} S_i^- + \sum_{r=1}^{s} S_r^+)$ Subject to $\sum_{j=1}^{n} x_{ij}\ \lambda_j + S_i^- = \theta x_{io}$ i= 1, 2, …., m $\sum_{j=1}^{n} y_{rj}\ \lambda_j - S_r^+ = y_{ro}$ r= 1, 2, …., s $\lambda_j , S_i^- S_r^+ \geq 0$ j = 1, 2, …., n	Max $\theta = \sum_{r=1}^{s} u_r\ y_{ro}$ Subject to $\sum_{r=1}^{s} u_r\, y_{ro} - \sum_{i=1}^{m} v_i\, x_{ij} \leq 0$ $\sum_{i=1}^{m} v_i\ x_{ij} = 1$ $u_r , v_i \geq 0$
output- oriented	
Envelopment model	Multiplier model
$\max\emptyset + \varepsilon\ (\sum_{i=1}^{m} S_i^- + \sum_{r=1}^{s} S_r^+)$ Subject to $\sum_{j=1}^{n} x_{ij}\ \lambda_j + S_i^- = x_{io}$ i= 1, 2, …., m $\sum_{j=1}^{n} y_{rj}\ \lambda_j - S_r^+ = \emptyset y_{ro}$ r= 1, 2, …., s $\lambda_j , S_i^- S_r^+ \geq 0$ j = 1, 2, …., n	Min $\emptyset = \sum_{i=1}^{m} v_i\ x_{io}$ Subject to $\sum_{i=1}^{m} v_i\, x_{ij} - \sum_{r=1}^{s} u_r\, y_{rj} \geq 0$ $\sum_{r=1}^{s} u_r\, y_{rj} = 1$ $u_r , v_i \geq 0$

6.2 BCC Model

This model was formulated by Cooper Charnes, Banker, and distinguishes between two types of efficiency (technical efficiency and scale efficiency). It differs from the CCR model in that it provides an estimate of technical efficiency based on the operations scale applied in the unit to provide services to beneficiaries at the time of measurement, meaning it gives efficiency related to a specific volume of operations. The model also determines the possibility of a variable return ratio (constant, increasing, or decreasing) on the quantity of services of inefficient units resulting from changing the quantity of their inputs up to the efficiency limit, meaning the model possesses the characteristic of variable return to scale (2).

To formulate the mathematical model, we assume the availability of (n) decision-making units DMUj (j = 1, 2, …, n). These units produce several outputs yrj (r = 1, 2, …, s) using several inputs xij (i = 1, 2, …, m). The mathematical formulation for the BCC model with output orientation is as follows (17). The BCC model takes the same mathematical form as the CCR model with the addition of a size constraint $\sum_{j=1}^{n} \lambda_j = 1$.

Table 2 illustrates the mathematical formula for the BCC model with input and output orientation.

input- oriented	
Envelopment model	Multiplier model
$\min\theta - \varepsilon\ (\sum_{i=1}^{m} S_i^- + \sum_{r=1}^{s} S_r^+)$ Subject to $\sum_{j=1}^{n} x_{ij}\ \lambda_j + S_i^- = \theta x_{io}$ i= 1, 2, …., m $\sum_{j=1}^{n} y_{rj}\ \lambda_j - S_r^+ = y_{ro}$ r= 1, 2, …., s $\sum_{j=1}^{n} \lambda_j = 1$ $\lambda_j , S_i^- S_r^+ \geq 0$ j = 1, 2, …., n ε: It represents a very small positive value that improves the accuracy of the solution.	Max $\theta = \sum_{r=1}^{s} u_r\ y_{ro} + u$ Subject to $\sum_{r=1}^{s} u_r\, y_{ro} - \sum_{i=1}^{m} v_i\, x_{ij} + u \leq 0$ $\sum_{i=1}^{m} v_i\ x_{ij} = 1$ $u_r , v_i \geq 0$

output- oriented	
Envelopment model	Multiplier model
$\max\emptyset + \varepsilon (\sum_{i=1}^{m} S_i^- + \sum_{r=1}^{s} S_r^+)$ Subject to $\sum_{j=1}^{n} x_{ij}\ \lambda_j + S_i^- = x_{io}$ i= 1, 2, …., m $\sum_{j=1}^{n} y_{rj}\ \lambda_j - S_r^+ = \emptyset y_{ro}$ r= 1, 2, …., s $\sum_{j=1}^{n} \lambda_j = 1$ $\lambda_j , S_i^- S_r^+ \geq 0$ j = 1, 2, …., n	Min $\emptyset = \sum_{i=1}^{m} v_i\ x_{io} + u$ Subject to $\sum_{i=1}^{m} v_i\, x_{ij} - \sum_{r=1}^{s} u_r\, y_{rj} + u \leq 0$ $\sum_{r=1}^{s} u_r\, y_{rj} = 1$ $u_r , v_i \geq 0$

7. Data and Sample:

The study included data from 21 colleges at Tikrit University for three inputs (number of students, number of faculty members, number of administrative staff) and two outputs (number of graduates, number of published research and scientific seminars and conferences) for the academic year 2019-2020. The Ver2.1 DEAP program was used to find the efficiency index for all colleges in the CCR and BCC models according to input and output orientation indicators.

Table 3 shows the inputs and outputs of the study.

Inputs	outputs
x_1 Number of accepted students	y_1: Number of graduates
x_2 : Number of teaching staff	y_2: Number of published research, seminars, and conferences
x_3: Number of administrative staff	

8. Results and Discussion:

8.1 Measure efficiency according to the input-orientation indicator.

Table 4 shows the degree of efficiency in the CCR model, the BCC model, and the scale efficiency according to input-orientation indicator.

DMUS	College Name	CCR Effi	BCC Effie	Scale Effi = $\frac{CCR}{BCC}$	Return to scal
DMU1	Computer science and mathematics	0.663	0.749	0.886	Increasing
DMU2	Arts	1.000	1.000	1.000	Constant
DMU3	dministration and Economics	1.000	1.000	1.000	Constant
DMU4	Education for Humanities	1.000	1.000	1.000	Constant
DMU5	Education for Girls	0.517	0.541	0.955	Increasing
DMU6	Education for Pure Sciences	1.000	1.000	1.000	Constant
DMU7	Law	1.000	1.000	1.000	Constant
DMU8	Agriculture	0.760	0.829	0.917	Decreasing
DMU9	Pharmacy	0.403	0.640	0.629	Increasing
DMU10	Medicine	0.592	0.593	0.998	Increasing
DMU11	Dentistry	0.513	0.686	0.748	Increasing

DMU12	Veterinary Medicine	0.908	1.000	0.908	Increasing
DMU13	Nursing	1.000	1.000	1.000	Constant
DMU14	Science	0.890	0.912	0.976	Decreasing
DMU15	Islamic Sciences	1.000	1.000	1.000	Constant
DMU16	Political Sciences	0.901	1.000	0.901	Increasing
DMU17	Engineering	0.463	0.464	0.997	Increasing
DMU18	Petroleum Engineering	1.000	1.000	1.000	Constant
DMU19	Physical Education	1.000	1.000	1.000	Constant
DMU20	Basic Education Shirqat	0.903	0.934	0.967	Increasing
DMU21	Education Tuz Khurmatu	0.816	0.848	0.962	Increasing
DMUS	Average efficiency	0.825	0.866	0.945	

Source: Prepared by researchers based on the results of DEAP Ver2.1

From the results of Table 4, (9) colleges achieved an efficiency score of (100%) in the CCR model and (11) colleges achieved an efficiency score of (100%) in the BCC model, that is, these colleges do not have stagnant resources in their inputs. Thus, the colleges that achieved efficiency in both the CCR and BCC models are volumetrically efficient. Meanwhile, the other colleges were unable to achieve complete efficiency (100%), indicating that these colleges have stagnant resources in their inputs and need to reduce them to reach complete efficiency (100%). The average technical efficiency of the colleges at Tikrit University in the CCR model was (0.825), which means that inefficient colleges need to reduce their inputs by (17.5%) to achieve complete efficiency. In the BCC model, it was (0.866), meaning that inefficient colleges need to reduce their inputs by (13.4%) to achieve complete efficiency. The average volumetric efficiency of the colleges at Tikrit University was (0.945), indicating that there is potential for expansion at the university and its colleges by (5.5%) to reach optimal size. The following figures illustrate the necessary reduction percentage in the inputs of inefficient colleges to achieve complete efficiency:

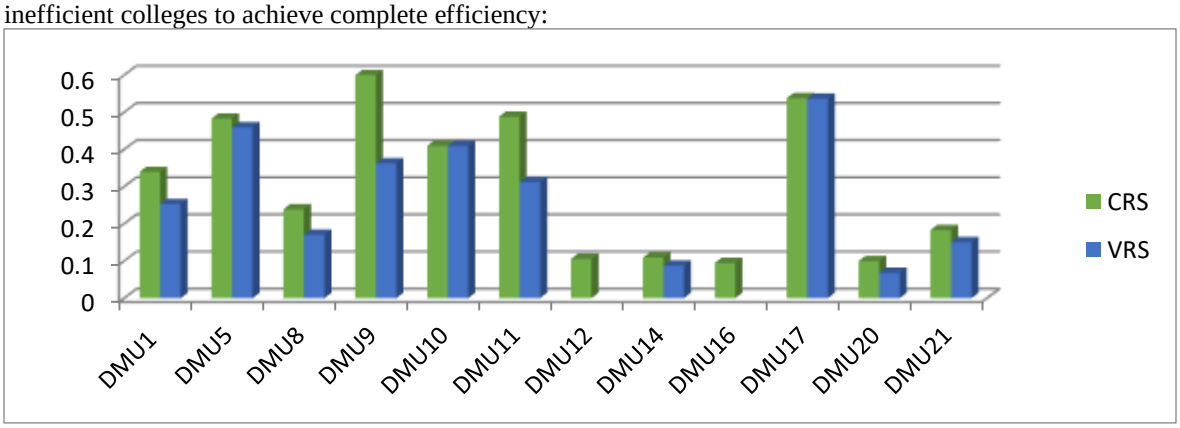


Figure 2 shows the optimal reduction in the number of students admitted to inefficient colleges in CCR and BCC models.

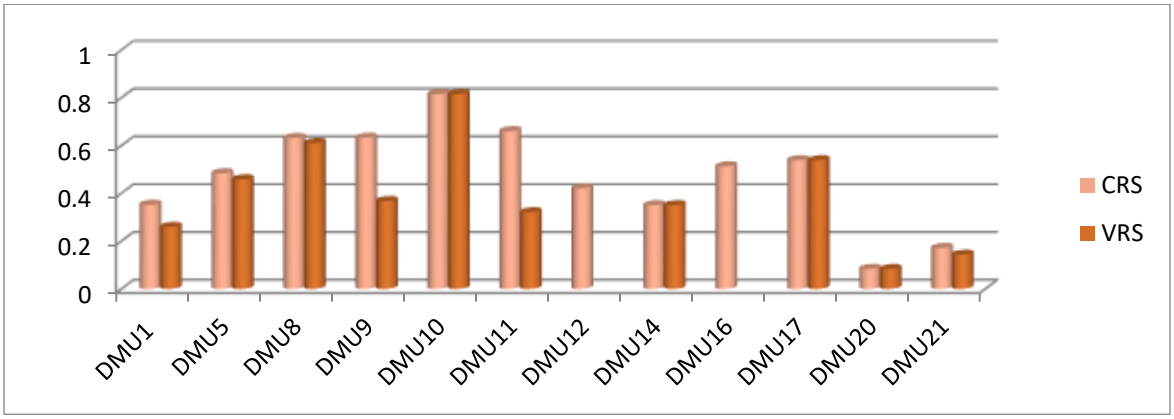


Figure 3 shows the optimal reduction in the number of teachers for inefficient colleges in CCR and BCC models.

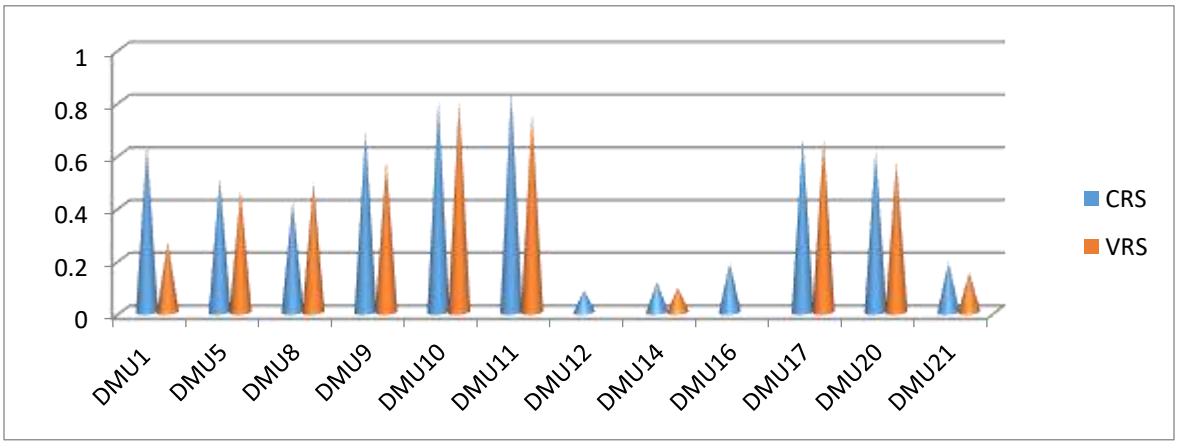


Figure 4 shows the optimum reduction in staff for inefficient colleges in CCR and BCC models.

Table 5 shows the reference colleges for inefficient colleges in both CCR and BCC models.

DMUs	College Name	Reference Colleges in the CCR mod	Reference Colleges in the BCC mod
DMU1	Computer Science and Mathemati	Physical Education – Arts	Administration and Economics - Political Science – Arts – Physical Education
DMU**5**	Education for Girls	Administration and Economics – Nursing	Administration and Economics - Political Science- Veterinary Medicir Nursing
DMU8	Agriculture	Petroleum Physical Education- Engineering	Islamic Sciences- Arts – Physical Education
DMU9	pharmacy	Petroleum Engineering- Physical Education	Nursing- Veterinary Medicine- Political Sciences
DMU10	Medicine	Petroleum Engineering- Physical Education	Physical Education – Petroleum Engineering- Political Science
DMU11	Dentistry	Physical Education - Petroleum Engineering	Nursing - Veterinary Medicine - Political Sciences
DMU12	Veterinary Medicine	Petroleum Engineering	

DMU14	science	Petroleum Engineering- Education fo Administration and -Humanities Economics	Islamic Sciences - Education for Humanities-– Administration and Economics - Petroleum Engineering
DMU16	Political Sciences	Physical Education- Arts	
DMU17	Engineering	Physical Education- Arts - Administration and Economics	Administration and Economics -Arts Physical Education
DMU20	Education Tuz Khurmatu	Physical Education- Nursing Administration and Economics	Nursing – Physical Education – Administration and Economics
DMU21	Basic Education Al-Shirqat	Physical Education- Islamic Science Nursing - Administration and Economics	Petroleum Engineering –Nursing- Veterinary Medicine- Administratio and Economics – Physical Educatio

Source: Prepared by researchers based on the results of DEAP Ver2.1

Reference colleges are those that have achieved full efficiency (100%) using the same resources as inefficient colleges or fewer, under similar conditions. They serve as a reference for inefficient colleges due to the similarity in characteristics and resources. Thus, inefficient colleges can benefit from the methods of reference colleges in resource utilization and how to convert them into outputs. The College of Physical Education was the most reference-worthy for inefficient colleges the CCR model, making its policy the best among efficient colleges. The colleges of physical education and petroleum engineering were the most referenced for the inefficient faculties in the BCC model. The following figure illustrates the number of times efficient colleges appear as reference units in both the CCR and BCC models.

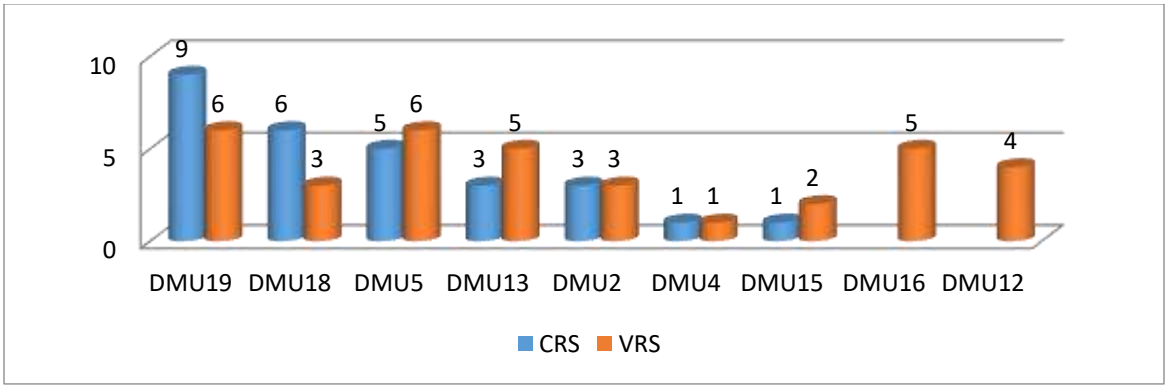


Figure 5 shows how often efficient colleges appear as reference units for inefficient colleges in CCR and BCC models.

8.2 Measure Efficiency According to the Output-Orientation Indicator.

Table 6 shows the degree of efficiency in the CCR model, the BCC model, and the scale efficiency according to input-orientation indicator.

DMUS	College Name	CCR Effie	BCC Effie	Scale Effi = $\frac{CC}{BC}$	Return to scale
DMU1	omputer science and mathematics	0.663	0.665	0.998	Increasing
DMU2	Arts	1.000	1.000	1.000	Constant
DMU3	Administration and Economics	1.000	1.000	1.000	Constant
DMU4	Education for Humanities	1.000	1.000	1.000	Constant
DMU5	Education for Girls	0.517	0.654	0.789	Decreasing
DMU6	Education for Pure Sciences	1.000	1.000	1.000	Constant

DMU7	Law	1.000	1.000	1.000	Constant
DMU8	Agriculture	0.760	0.858	0.886	Decreasing
DMU9	Pharmacy	0.403	0.410	0.981	Decreasing
DMU10	Medicine	0.592	0.621	0.953	Decreasing
DMU11	Dentistry	0.513	0.515	0.996	Increasing
DMU12	Veterinary Medicine	0.908	1.000	0.908	Increasing
DMU13	Nursing	1.000	1.000	1.000	Constant
DMU14	Science	0.890	0.916	0.972	Decreasing
DMU15	Islamic Sciences	1.000	1.000	1.000	Constant
DMU16	Political Sciences	0.901	1.000	0.901	Increasing
DMU17	Engineering	0.463	0.590	0.785	Decreasing
DMU18	Petroleum Engineering	1.000	1.000	1.000	Constant
DMU19	Physical Education	1.000	1.000	1.000	Constant
DMU20	Basic Education Shirqat	0.903	0.910	0.992	Increasing
DMU21	Education Tuz Khurmatu	0.816	0.818	0.997	Decreasing
	Average efficiency	0.825	0.855	0.960	

Source: Prepared by researchers based on the results of DEAP Ver2.1

From the results of Table 6, (9) colleges achieved full efficiency (100%) in the CCR model and (11) colleges achieved efficiency in the BCC model, which means that these colleges have optimally invested all their inputs to achieve the best outputs. The efficient colleges in the CCR model and the BCC model are efficient in terms of size. The average technical efficiency for the CCR model was (0.825), meaning that inefficient colleges need to increase their outputs by (17.5%) to reach full efficiency. In the BCC model, the average technical efficiency was (0.855), meaning that inefficient colleges need to increase their outputs by (14.5 %) to reach full efficiency. The average scale efficiency was (0.960), indicating that there is potential for expansion by (4%) to reach optimal size. The following figures illustrate the percentage increase needed in the outputs of inefficient colleges in both the CCR and BCC models.

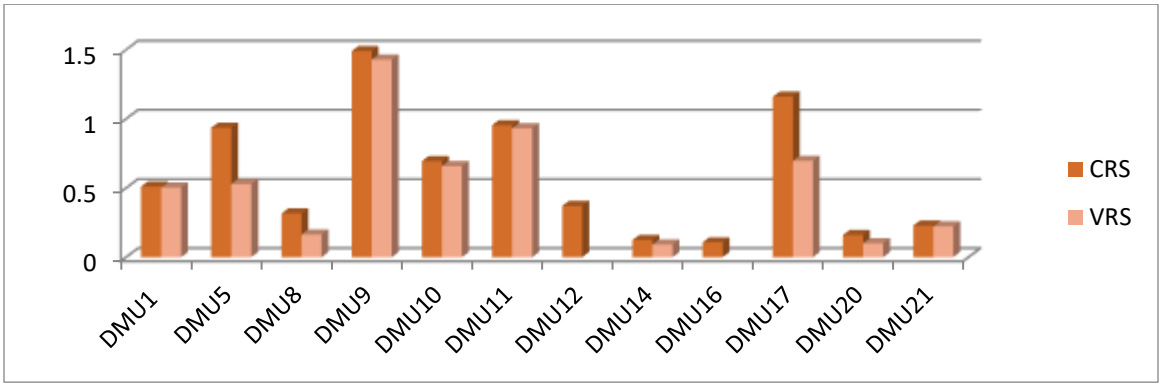


Figure 6 shows the optimal increase in the number of graduates in inefficient colleges in CCR and BCC models.

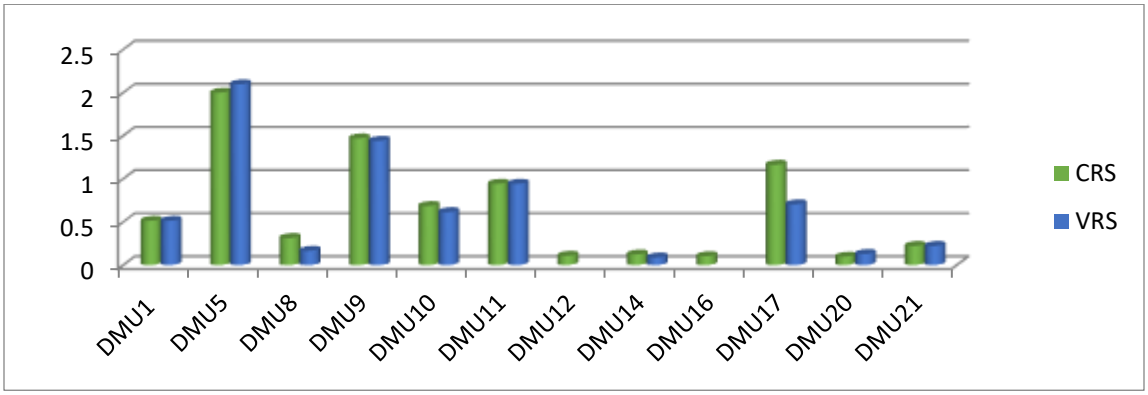


Figure 7 The optimal increase in shows the number of research published, seminars, scientific conferences in inefficient colleges in CCR and BCC models.

Table 7 shows the reference colleges for inefficient colleges in both CCR and BCC models according to the output-orientation indicator.

DMUs	College Name	eference Colleges in the CCR model	eference Colleges in the BCC model
DMU1	ɔmputer Science and Mathematics	Arts – Physical Education	Political Science – Arts – Physical Education
DMU**5**	Education for Girls	Administration and Economics - Nursing	Education for Humanities-– Administration and Economics
DMU8	Agriculture	Physical Education -Petroleum Engineering	dministration and Economics - Arts – Islamic Sciences
DMU9	pharmacy	Petroleum Engineering- Physical Education	Islamic Sciences - Petroleum Engineering - Physical Education
DMU10	Medicine	Petroleum Engineering- Physical Education	Islamic Sciences - Petroleum Engineering
DMU11	Dentistry	Physical Education - Petroleum Engineering	Petroleum Engineering - Political Sciences -Physical Education
DMU12	Veterinary Medicine	Petroleum Engineering	
DMU14	science	etroleum Engineering- Education for Humanities- Administration and Economics	Islamic Sciences - Education for Humanities-– Administration and Economics - Petroleum Engineering
DMU16	Political Sciences	Physical Education- Arts	
DMU17	Engineering	Physical Education- Arts - Administration and Economics	Administration and Economics - Education for Humanities - Islamic Sciences
DMU20	Education Tuz Khurmatu	Physical Education- Nursing Administration and Economics	Nursing – Physical Education – Administration and Economics
DMU21	Basic Education Al-Shirqat	hysical Education- Islamic Sciences- Nursing - Administration and Economics	Islamic Sciences –Nursing- Administration and Economics – Physical Education

Source: Prepared by researchers based on the results of DEAP Ver2.1

From the results of Table 7, find that the Faculty of Physical Education is the most frequently referenced unit for inefficient colleges in the CCR model., and The Colleges of Islamic sciences, Administration and Economics were the most frequently

referenced units in the BCC model for inefficient Colleges. The following figure illustrates the number of times efficient colleges appeared as reference units:

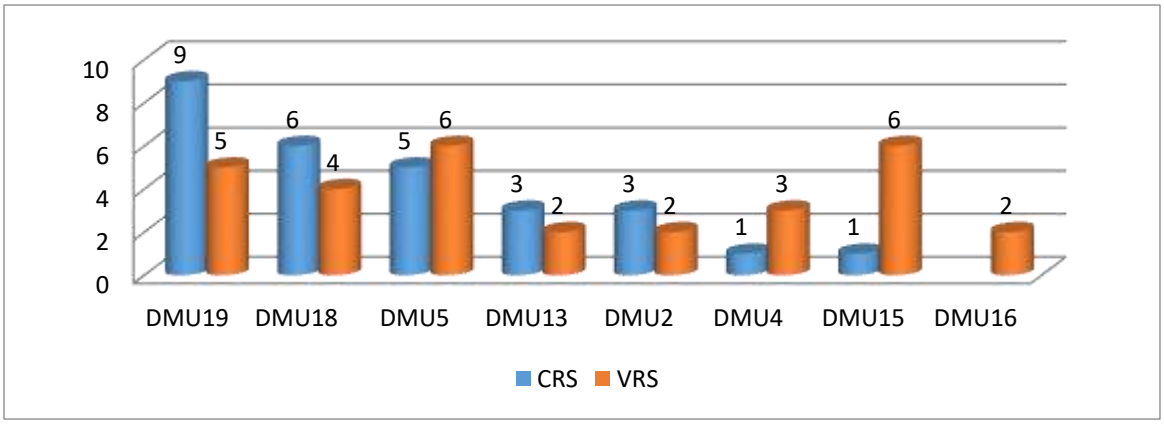


Figure 8 shows how often efficient colleges appear as reference units for inefficient colleges in CCR and BCC models.

9. Conclusions and Future Work

Data Envelopment Analysis (CCR, BCC) models were used to find efficiency indicators in the input and output directions based on data for the academic year 2019-2020 for the colleges of Tikrit University. The following was reached:

Using the CCR model, nine colleges achieved full efficiency (100%) in both input and output directions: (College of Arts, College of Administration and Economics, College of Education for Humanities, College of Education for Pure Sciences, College of Law, College of Nursing, College of Islamic Sciences, College of Petroleum Engineering, College of Physical Education).

Using the BCC model, eleven colleges achieved efficiency, which are the same colleges that achieved efficiency in the CCR model, in addition to the colleges of veterinary medicine and political science.

The colleges (Arts, Administration and Economics, Education for Human Sciences, Education for Pure Sciences, Law, Nursing, Islamic Sciences, Petroleum Engineering, Physical Education) have achieved efficiency in both the CCR and BCC models, thus being scale-efficient and should maintain their current size.

The efficiency results showed that the College of pharmacy is the least efficient college in CCR model in input and output directions That is, it is more comprehensive in needing to reduce its inputs and increase its outputs, it was also the least efficient college in the BCC model in terms of output orientation. While the College of Engineering was the least efficient in the BCC model with input orientation, meaning it is the college that needs the most reduction in its inputs to achieve efficiency.

The necessary reductions and increases in the inputs and outputs of the colleges that did not achieve efficiency were identified to reach efficiency.

Reference colleges for each college that did not achieve efficiency were identified; these reference colleges managed to achieve full efficiency despite operating in the same environment and conditions as the inefficient colleges.

The necessity of benefiting from efficiency indicators and improvement levels in the outputs of inefficient colleges in order to enhance their performance and achieve complete efficiency of 100%.

The necessity of having a unified database specific to each college and at the departmental level, as the main problem facing those who wish to apply data envelope analysis models is the availability and comprehensiveness of data.

It is important to conduct further studies using super-efficiency models to differentiate between efficient colleges and identify the most efficient ones.

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نماذج تحليل مغلف البيانات لقياس الكفاءة النسبية والحجمية للمؤسسات التعليمية (جامعة تكريت انموذجا)

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الخلاصة: تناول البحث قياس الكفاءة النسبية والحجمية لكليات جامعة تكريت للعام الدراسي (2019– 2020) باستخدام اسلوب تحليل مغلف البيانات Data Envelopment Analysis وهو أحد اساليب البرمجة الخطية لقياس الكفاءة الانتاجية للمؤسسات والوحدات الاقتصادية. تم استخدام نموذج عوائد الحجم الثابتة CCR ونموذج عوائد الحجم المتغيرة BCC وفق مؤشرات التوجيه الادخالي Input Oriented Measures ومؤشرات التوجيه الإخراجي Output Oriented Measures ، ومن اجل تحقيق اهداف الدراسة تم اختيار كليات جامعة تكريت البالغة 21 كلية، وتم تحديد ثلاث مدخلات هم (عدد الطلبة المسجلين و عدد التدريسيين وعدد الموظفين) ، ومخرجان هما (عدد الخريجين و عدد البحوث المنشورة والندوات و المؤتمرات) ، وتوصل البحث الى عدة نتائج اهمها ان (9) كليات حققت الكفاءة النسبية في نموذج CCR و(11) كلية في نموذج BCC بالتوجيهين الادخالي والإخراجي. كما تناول البحث الاجراءات والاصلاحات اللازمة للكليات غير الكفؤة لغرض وصولها الى الكفاءة، وكذلك حددت الكليات المرجعية لكل كلية غير كفؤة للاقتداء بها ومحاكاتها للوصول الى الكفاءة التامة.

الكلمات المفتاحية: نموذج BCC، نموذج CCR، تحليل مغلف البيانات، الكفاءة النسبية.