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The Use Of Data Envelopment Analysis To Improve The Efficiency Of The Scientific Departments In The Technical Institute Of Al-Suwaira

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ABSTRACT

This research deals with measuring the technical and scale efficiency of the departments of the Suwaira Technical Institute in Iraq utilizing the data envelope analysis method, which is a linear method, not a teacher. The technical and scale efficiency have been computed based on the fixed returns to volume (CCR) model and the variable returns to volume (BCC) model, according to the input and output directions. Furthermore, the mathematical model for evaluation and obtaining results has been designed using the software DEAP.V2.1**.** This work included all 7 departments of the Suwaira Technical Institute in Iraq for one academic year, 2020-2021. Moreover, this research compared the performance efficiency of the departments in the institute during the academic year 2020-2021 to analyze the extent of progress or delay in efficiency. One of the most important results obtained from this research is that the percentage of departments that obtained full technical competence (100%) for the year 2020-2021, according to the CCR model, is 57% of the total departments, and the direct input orientations, while the percentage of departments that obtained full efficiency according to the BCC model, with both output and input approaches, it is 71% of the total sections. Also, this research has shown that the percentage of sections that obtained full-Scale efficiency (100%) is 57%, and the reasons for scale inefficiency for sections that are scale inefficient and that did not obtain full efficiency, whether due to output conditions or input processes, or both.

Furthermore, the research deals with the necessary measures and reforms to improve the performance of the inefficient departments to reach the level of the fully qualified departments by increasing their outputs or reducing their inputs according to certain scientific ratios, as well as the reference departments, which inefficient departments should imitate and simulate as they have the same conditions they are going through. The inefficient departments, however, were able to achieve full efficiency. In other words, these reference departments could produce greater outputs with the same or fewer inputs than the inefficient departments.

Keywords: Ranking of Scientific Departments Efficiency Measurement Data Envelopment Analysis

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1. Introduction

The higher education and scientific research sector is considered one of the important institutions, as developed countries consider it as the gates of economic recovery by providing individuals with material information to facilitate their deal with the problems they face during their work. With the increase in the interest in higher education and the orientation towards the development of this important sector, which in turn is the main pillar for evaluating the sectors, the outputs of higher education are inputs to the rest of the sectors in terms of providing a necessary professional workforce of scientists, engineers, doctors, teachers ... etc. To evaluate the efficiency of educational institutions, in addition to that, many standards measure the efficiency of all educational institutions and evaluate the efficiency of their performance through the optimal use of resources (inputs) and the achievement of goals (outputs) for which these resources were spent.

From this standpoint, we made this study to show the strengths and weaknesses to consolidate the strengths and propose solutions to address the weaknesses. Furthermore, we tried in this research to stand at the level of the scientific departments in the Technical Institute of al-Suwaira and the extent to which they exploit their resources to achieve the maximum output and reduce the input without prejudice to the essence of the process of Educational method through the use of the method of data analysis (data envelopment analysis), which is a relatively new non-parameter mathematical method for evaluating institutions based on linear programming that provides an objective evaluation of several sections as well as additional information that helps to identify the performance of these departments to raise their efficiency.

Since the data envelope analysis (DEA) method was first developed, it has been widely applied to industries as diverse as health institutions, vocational schools, banking, transportation, and much more.

The research problem is represented in measuring the success of any educational institution with the ability of this institution to reduce the inputs and maximize the outputs without compromising the essence of the educational process, as any educational system needs to raise its efficiency to achieve its goals at the lowest costs.

1.1. Literature review

In this part, previous studies and research that dealt with the data envelopment analysis will be reviewed, and we will list here the most important studies related to the subject matter of the research as follows:

- The study (Warning, 2004) aimed to measure the efficiency of German universities, where the researcher applied the data envelope model to (73) governmental universities. The researcher chose the inputs related to the employees and other expenses. The outputs wish to quote from the publications of each university and graduates and used five Models, and (13) universities obtained full efficiency in the fifth model.

- Study (G. Fandel , 2007) aims to measure the efficiency of universities in Germany, and the researcher applied his study to (15) universities and used Ph.D. and bachelor's graduates as outputs. In addition, students and funding from outside the budget and workers as inputs, and the researcher concluded that 10 universities obtained full competence.

- Study of (Chiang k. & Hsi-Tai H., 2008): The data envelopment was used to assess the relative efficiency of departments of Cheng Keng National University in Taiwan, and the two researchers used credit hours, publications, and external grants as outputs, as for the inputs

were individuals, expenses and floor space of the department, and the research aims to help administrators identify weaknesses in their departments.

- As for the study (Lucia B., Antonio G, at all, 2010) aimed to measure the relative efficiency of the departments to evaluate them at the University of Florence in terms of the quality of teaching and research, and several data were used in the outputs, so The academics, administrators, students, researchers, and doctoral students used research grants, and by calculating the correlation coefficient, the researcher used teaching hours, and inputs, the numbers of teachers, and he used the data envelope, and the results varied between departments

- The study (Berna H. ulutas, 2011) aimed at measuring the relative performance of the departments in the College of Engineering at the University of Istanbul. The study was limited to teaching and research, and the numbers of students, employees, and teaching staff were used as inputs. As for the outputs, the percentage of students' rates per semester per year and the average number of students who obtained an average less than medium are outstanding.

1.2. The Research aims

The main objective of the research is to measure the technical and volumetric efficiency of the al-Suwaira Technical Institute's 7 departments for the year 2020-2021 through achieving a set of Sub-objectives, namely: -

1- Using the data envelopment analysis method in identifying the efficient departments according to the presentation of the largest quantity of outputs using the available inputs.

2- Measuring the technical competence of the scientific departments at the Technical Institute of al-Suwaira from 2020-2021.

3- Measuring the volumetric efficiency of the scientific departments at the Technical Institute of al-Suwaira from 2020-2021.

1.3. Research problem

The research problem is summarized in how to raise the efficiency of scientific departments by optimizing the inputs to get the best output through the use of the data envelopment analysis method. Many studies dealt with this aspect but used simple statistical methods. This research is expected to help the officials of the Technical Institute of al-Suwaira know their weaknesses and strengths and make correct decisions on scientific grounds.

The research problem can be summarized through the following question: What is the efficiency level of the scientific departments in the institute according to the results of applying the method of data analysis? Does the efficiency of the departments lead to raising the efficiency of the institute as a whole and the extent of its impact on the educational sector?

2. The concept of data envelope analysis (Chiang K,2008),(Qun W,2022)

The Data Envelopment Analysis method uses linear programming to measure the relative efficiency of Decision Making Units (DMU) to determine the optimal mix of a set of inputs and outputs based on the actual performance of these units (colleges, schools, hospitals, banks). This method began in 1998 with doctoral student Edwardo Rhodes, who was working on an educational program in America to compare the performance of a group of students who had failed in studies in similar educational areas. The challenge he faced represents determining the technical efficiency of these schools, including a set of inputs and outputs, without providing information on their prices. From here, the student, with his supervisor, drafted a Data Envelope Analysis (DEA) form. From the above, we conclude the following:

- Several administrative units (branches) called (DMU) exist. We want to measure the relative efficiency of these branches, as the efficiency of each unit is measured compared to the rest of the group's other units, so it is called relative efficiency.
- The data envelopment analysis method (DEA) depends on the linear programming method in calculating the efficiency of decision-making units and according to what each unit of inputs uses to achieve its outputs.
- Branches use the same group of inputs and outputs.

The general objective of the method is to maximize the amount of output from these units or reduce the amount of input.

The data envelope method is a mathematical method used to evaluate the productive efficiency of a group of homogeneous institutions. It depends on the concept that any institution (department) uses less input than other institutions (departments) to produce the same amount of outputs is more efficient as this method depends on the optimal weights (Optimal weight) for inputs and outputs, which are determined upon solution.

In our research, we find that the border efficiency curve according to the DEA method is the optimal and best limit that can be accessed automatically by the departments, as the sections that fall on this curve are considered efficient sections, while those that fall below the curve are considered inefficient sections. Figure (1) illustrates Proficiency as per the data envelope analysis method (Lucia B.,2010).

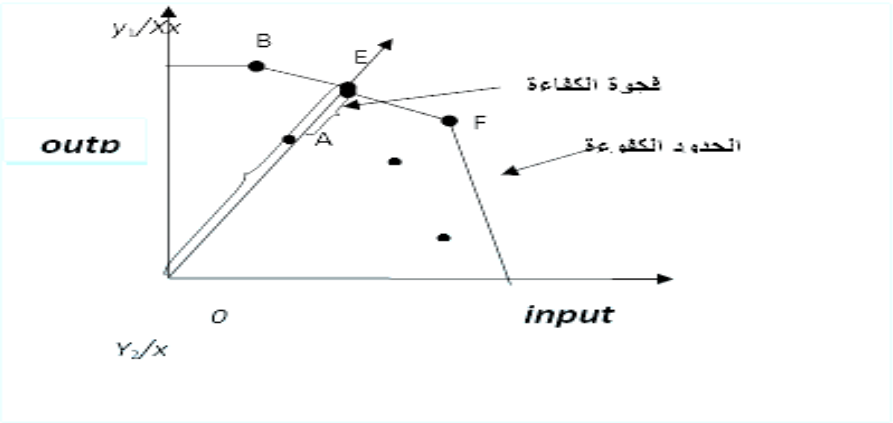

Figure 1: shows the efficient limits according to the data envelopment analysis method

2.1. Efficiency

is defined as fulfilling the largest possible achievement and specific goals to make improvements or developments on it according to need and future vision with the least possible amount of human and material resources and reduce waste in production capacity so that this does not affect the quality of productivity, in other words, producing the largest amount of output with the least amount of input.

Several types of efficiency can be explained as follows:

2.1.Technical Efficiency (TE)

It means the ability of the institution to obtain the largest amount of production or service under a set of available resources. The technical efficiency indicator is a measure of the ability of

the production unit to avoid waste by producing the largest possible amount of outputs that are allowed by the use of inputs or the use of a small amount of the inputs that are allowed by the level of outputs. Technical competence has two aspects(Farrell MJ.,1957)(Coelli,2005) :

The first aspect is called input-oriented efficiency, which aims to achieve a certain amount of output with the lowest possible inputs. Efficiency is measured mathematically through actual outputs/ expected inputs

The second aspect is the efficiency of output-oriented outputs, which aims to achieve the largest possible output using a certain amount of input. Here, efficiency is measured mathematically through the value of the outputs/costs of the inputs.

It is clear to us from these two aspects (W. W. Cooper,2006)

A. **An efficient unit** has the actual inputs equal to the inputs required for the actual efficient output and thus achieves a percentage equal to one and is technically efficient
B. **As for the inefficient unit**, it has inputs that are greater than the required inputs for the efficient actual outputs. Thus, it achieves less than one and is technically inefficient.

2.2.Allocative Efficiency (AE)

It refers to the situation in which we reach the best possible allocation of the available resources in light of the prices and the relative costs of these resources, considering the costs of their use. On the other hand, functional efficiency refers to producing the best combination of goods by using a combination of production elements, i.e. using a combination of inputs at the lowest possible cost(Alex M.,2009), where any decrease in any element of production causes a decrease in production as a whole. Therefore it expresses the technical efficiency, and the production efficiency in the educational institution is achieved when the bank can produce a certain size of output with the lowest possible volume of production elements at the lowest cost. That is when it achieves technical efficiency and specialized efficiency at the same time.

2.3. Scale Efficiency (SE)

It indicates the amount of change in production due to simultaneous changes in the factors of production (Chiang K.,2008)

If the use of inputs and production increases in the same proportion, then here is the case of constant volume return, but if the percentage increase in inputs is greater than production, then we have a case of decreasing volume return, but if the percentage increase in production is greater than the percentage of input, then we have a case of increasing volume return

2.4. The concept of educational efficiency:

The concept of economics has been greatly reflected on educational efficiency by making the education process an investment process required to reduce and rationalize its expenditures to a minimum and raise its internal efficiency (the ability of the educational institution to achieve its goals in light of its specific resources) and external (the ability of the educational institution to achieve the goals of the community for which this institution was found)to the highest level and to reduce the level of educational loss in every way to the least possible. In short, the efficiency of the educational institution is the ability of this institution to achieve its expected objectives.

3. Mathematical form of data envelopment analysis method

The general form that most data envelopment analysis models take is linear rational programming, and this figure can be converted into a liner programming formula using the transformation proposed (Banker, R. D.,1984)

3.1. linear programming

It is one of the most varied, influential, and powerful quantitative techniques for decision-making. It is used to solve optimization problems for a problem; its relationships are in a linear form. It is a mathematical model aimed at achieving the maximum or minimum value of a linear function, known as the objective function, which is restricted by several equations or inequalities called constraints so that the objective function and all the constraints take the form of a linear relationship.

General Formula of Linear Programming Model: (Chiang K ,2008) ,(Berna H. ulutas ,2011)

The general form of the linear programming model is as follows:

$$(\text{Max or Min}) = C_1X_1 + C_2X_2 + \cdots + C_{1n}X_n \ldots (1)$$

S.T

$$a_{11}X_1 + a_{12}X_2 + \cdots + a_{1n}X_n(\geq, =, \leq)b_1$$
$$a_{21}X_1 + a_{22}X_2 + \cdots + a_{2n}X_n(\geq, =, \leq)b_2$$
$$\vdots \qquad \vdots \qquad \vdots \qquad \vdots$$
$$a_{m1}X_1 + a_{m2}X_2 + \cdots + a_{mn}X_n(\geq, =, \leq)b_m$$

And

$$X_1, X_2 \ldots X_n \geq 0$$

Where n is the number of variables and m represents the number of constraints, b_i the available value of the resource, a_{ij} the needs of the product i from the resource j

Where: $X_j \geq 0$ j=1,2,3,…,n، i=1,2,3,…,m

4. The General Format of the data envelope analysis form

4.1.The rational form of the DEA method

Good efficiency should represent fewer inputs and larger outputs. The units of measurement don't need to match either the input or the output.

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}} \qquad \ldots(2)$$

$$\text{Max } \theta_\pi = \frac{\sum_{r=1}^{s} v_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}}$$

s.T:

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \quad j=1, \ldots, n$$

$$r=1, \ldots, s$$

$$u_r, V_i \geq 0 \quad i=1, \ldots, m$$

j: The number of DMUs compared to each other in the DEA method.

m: is the number of entries
s: number of outputs
n: number of units/ DMU
DMU _ j: Decision-making unit number j.
θ: The EFFICIENCY Index for the unit under evaluation by the method (DEA) AND take values from 0 to 1 indicate efficiency.
y_{r0} : the value of the output r produced by the decision–making unit (0).
x_{i0} : the value of the input i used by the decision-making unit (0).
r: the number of outputs produced by each DMU.
i: The number of entries used by each DMU.
u_r : the parameter or weight assigned by (DEA) to the output r to reach the degree of efficiency (100%).
Vi: the parameter or weight assigned by (DEA) to input i to reach the degree of efficiency (100%).

5. Data Analysis Method Models

Several models have emerged to find efficiency indicators using the DEA method, most notably the constant size return CCR model and the BCC model. The efficiency index can be found from either the input side, called input-oriented models, or the output side, called output-oriented models. Data analysis models can be classified into two basic models, namely:

5.1.CCR model constant volume returns model

The CCR model is the basic model in data envelopment analysis, which stands for the initial letters of (Charnels, Cooper, and Rhodes) who introduced this model in 1978, so that name was named. This model is based on the fact that the change in the number of inputs used by the inefficient unit has a constant effect on the amount of output it provides when it moves to the forward of efficiency. This characteristic is known as the constant return on production CRS. This characteristic is appropriate only when all the units are subject to comparison; they operate at the level of their optimum sizes. In reality, many obstacles may prevent units from achieving these sizes, such as imperfect competition, funding restrictions, and others.
There are two basic formulas for the CCR model: the input-based model and the output-based model. In the input-based model, the decision-making units reduce the input ratio while maintaining the same amount of output. In contrast to the output-based model, the decision-making units increase the maximum amount of output given the available input. The model of constant sizes economies can be presented according to the output and input directions as follows:

5.1.1. Liner form of DEA according to the CCR model (Lucia B.,2010)

The mathematical formula for the model of constant size economies is according to the input orientation, as shown in Equation (5), which should be maximized in the objective function and transform the denominator of the previous objective function as a constraint equal to the value 1, which is represented by the following formula: -
The binary program reduces the value 0 under the following restrictions: -

- That the weighted values of the inputs of other units are less than or equal to the values of the inputs of the unit whose efficiency is to be measured
- That the weighted values of the outputs of other units be greater or equal to the values of the outputs of the unit whose efficiency is to be measured

As for the output orientation according to the CCR model, the mathematical formula for the model of constant size economies according to the output orientation is as follows:

Min $\sum_{i=1}^{m} V_i x_{i0}$ ....(3)

s.T

$$\left.\begin{array}{ll} \sum_{r=1}^{s} u_r y_{r0} = 1 & i=1, ..., m \\ \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} V_i x_{ij} \leq 0 & r=1,...,s \\ u_r, V_i \geq 0 & j=1, ..., n \end{array}\right\}$$

5.2.BCC model: Volume Returns Model

(Banker-Charnes-Cooper) (W. W. Cooper,2006) formulated the model of inconstant size economies in 1984 and formulated the inconstant size returns model (BCC) model, which is a development for the model the CCR that uses the CRS hypothesis (except that CRS is appropriate only when all establishments are operating at their optimum size level; otherwise it results from the duality of technical efficiency indicators with volumetric efficiency), and this model is called the change in volume yield (VRS). This model distinguishes between two types of efficiency:

Max. $\sum_{i=1}^{m} u_r y_{r0} - u_0$ ... (4)

s.T

$$\left.\begin{array}{ll} \sum_{r=1}^{s} V_i x_{i0} = 1 & i=1, ..., m \\ \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} V_i x_{ij} - u_0 \leq 0 & r=1,...s \\ u_r, V_i \geq 0 & j=1, ..., n \end{array}\right\}$$

Through the previous Equation, the difference between the CCR model and the BCC model appeared in the variable u0, which is the double variable associated with the constraint in the envelopment model, which also does not appear in the CCR model. The above formula assumes that $x_{ij}, y_{rj} \geq 0$, and all variables are non-negative except for u_0 , which may be positive

Min $\sum_{i=1}^{m} V_i x_{i0} - V_0$ … (5)

s.T

$\sum_{r=1}^{s} u_r y_{r0} = 1$ i=1, ..., m

$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} V_i x_{ij} - V_0 \leq 0$ r=1,..., s

$u_r, V_i \geq 0$ j=1, ..., ***n***

6. The practical side: -

technical efficiency and volumetric efficiency. This model was developed to avoid the assumption of constant volume return in the CCR model, as not all institutions may operate at their optimum size level, mixing technical efficiency indicators with volumetric efficiency. Therefore, the BCC model with its hypothesis VRS was used along with the CCR model to exclude the effect of technical and volume efficiency to measure relative efficiency.

To solve this consideration, Banker, R. D., Charnes, A., & Cooper, W. W. (1984) proposed additional restrictions on the basic fractional CCR model contained in Equation (4), and the constraint is: -

$$\sum_{j=1}^{n} y_j$$

The mathematical formula of the model of inconstant 2020-2021 economics according to the input orientation: -[9]

or negative, or zero, with results that make it possible to use optimal values of this parameter to determine returns to 2020-2021(Chiang K.,2008),(G. Fandel,2007)

For the mathematical formula of the variable economies of the 2020-2021 model according to the direction of the output:

The Technical Institute – al-Suwaira is one of the formations of the Central Technical University in Iraq. It was established in 1987 as an extension of the Agricultural Research Center, and it is a gigantic institute whose facility extends over an area of land of about 265 dunums." The institute includes the administrative specializations represented by the Department of Accounting Techniques and Technologies, computer systems and technological specialties, including techniques Mechanics, electrical technologies, power mechanics techniques, and the medical specialties represented by the Department of Nursing Technologies and Agricultural Specializations represented by the Department of Plant Production Technologies. It includes several academics, including teachers, technicians, and administrators with experience and high competence, and the total number of elementary and evening studies students. It will contribute to reaching solid results for the envelopment data analysis method. The inputs and outputs of the model under discussion were diagnosed based on the annual reports of the Scientific Division, the Student Affairs Department, the Quality Assurance and Performance Rectification Division, and the model inputs and outputs are as follows: -

1. Mathematical model inputs

• The total number of academics with various academic titles for the year of evaluation.

• Total number of 1st- stage students in the evaluation year

2- Mathematical model outputs

• The number of graduate students in the evaluation year.

• The number of scientific research in the year of evaluation.

A table below shows the inputs and outputs of the scientific departments of the Technical Institute of al-Suwaira, one of the formations of the Central Technical University, and for the period 2020-2021, as shown

Table (1)
shows the inputs and outputs of the scientific departments of the Technical Institute of al-Suwaira during the period 2020-2021:

	Inputs		Outputs	
Department	Number of academics	number of students	number of graduates	number of scientific researches
Mechanics techniques	6	46	33	4
Electrical techniques	6	51	44	6
Power Mechanics Techniques	6	29	21	6
Accounting techniques	13	159	125	8
Computer systems techniques	4	50	36	2
Nursing techniques	8	87	30	15
Plant production techniques	6	30	12	6

6.1. The study variables

They are represented in the inputs, which include the number of teachers (X1), the number of primary students (X2), and the outputs, which include the number of graduates (X3), the number of scientific researchers (X4), and it reflects the basic activity of the scientific departments

6.2. Sample and study tools

The study sample was determined and selected based on the data and information available from the universities' quality classification forms, in addition to the quality reports and reports of the Scientific Division and the Student Affairs Division at the Technical Institute of al-Suwaira. It included 7, and the study data was collected during the period (2020-2021).

The data envelope analysis (DEA) method was used, which is a form of linear programming, by applying the CCR model based on the assumption of constant volume returns and the BCC model based on the hypothesis of inconstant 2020-2021 returns.

6.3 Results of the study

As mentioned above, the BCC model with its hypothesis VRS was used along with the CCR model with its CRS hypothesis, which emerged from the data analysis method (DEA) to exclude the effect of technical efficiency and the effect of bulk efficiency to measure the total relative efficiency. The degree of perfect relative efficiency = degree of technical efficiency * Volumetric efficiency degree(Jacob A. Bikker,2008)

First: Measuring efficiency according to the CCR model in the year 2020-2021:

Before starting the process of measuring efficiency, we should verify a correlation between the inputs and the outputs, meaning that any increase in the inputs should be accompanied by an increase in the outputs and vice versa. And the outputs and results are shown in Table (2), where we note through Table (2) that there is a direct correlation between the inputs and outputs of the model despite the varying degrees of correlation.

Table (2)
represents the correlation coefficients between the inputs and the outputs

Outputs Inputs	number of research	number of graduates
number of teachers	0.863	0.491
number of students	0.925	0.430

There are two approaches to measuring efficiency according to the CCR model, which are as follows:

A:- Measuring efficiency in terms of Output Oriented:

Before measuring the efficiency, we should first build the mathematical model for measuring the efficiency.

* **Building the Mathematical Model**: To build the mathematical model for the Department of Mechanics, we use the Linear Programming Model as follows(O. Onder,2021) :

$$Min\ (Z) = 6X_1 + 46X_2 + 0X_3 + 0X_4$$

$\underline{S.t}$

$$6X_1 + 46X_2 - 33X_3 - 4X_4 \geq 0$$

$$6X_1 + 51X_2 - 44X_3 - 6X_4 \geq 0$$

$$6X_1 + 29X_2 - 21X_3 - 6X_4 \geq 0$$

$$13X_1 + 159X_2 - 125X_3 - 8X_4 \geq 0$$

$$4X_1 + 50X_2 - 36X_3 - 2X_4 \geq 0$$

$$8X_1 + 87X_2 - 30X_3 - 15X_4 \geq 0$$

$$6X_1 + 30X_2 - 12X_3 - 6X_4 \geq 0$$

$$33X_3 + 4X_4 = 1$$

$$X_1, X_2, X_3, X_4 \geq 0$$

As X_1 represents the number of teaching staff, X_2 represents the number of primary students, X_3 represents the number of graduates, X_4 represents the number of scientific research, and the objective function represents the efficiency of the Mechanical Techniques Department.

And by using the Dea P 2.1 program and rebuilding the model for the other departments, the results appear in Table (3), which shows the different levels of efficiency for the departments, as well as the amount of increase required in the outputs to modify the path of the inefficient departments and make them efficient departments, as it shows the reference departments for the inefficient departments to simulate, relatively enjoying the same conditions.

Table (3)

which shows the efficiency of the sections, the target outputs, and the reference sections according to the CCR model and according to the output orientation

	Departments	Efficiency	Graduates Real	Graduates Expected	Research Real	Research Expected	Benchmark
1	mechanical techniques	0.832	33	40	4	5	electrical techniques
2	electrical techniques	1.000	44	44	6	6	————
3	Power Mechanics	1.000	21	21	6	6	————
4	Accounting techniques	1.000	125	125	8	8	————
5	computer systems technologies	0.936	36	38	2	2	Accounting techniques
6	Nursing techniques	1.000	30	30	15	15	————
7	plant production techniques	0.976	12	21	6	6	Mechanics of ability techniques, nursing techniques
Total efficiency rate		**0.963**					

The different levels of efficiency can be illustrated in Figure (1). The green color indicates the departments that have achieved full efficiency, the yellow color indicates high efficiency, and the red color indicates the lowest efficiency between the departments, as follows:

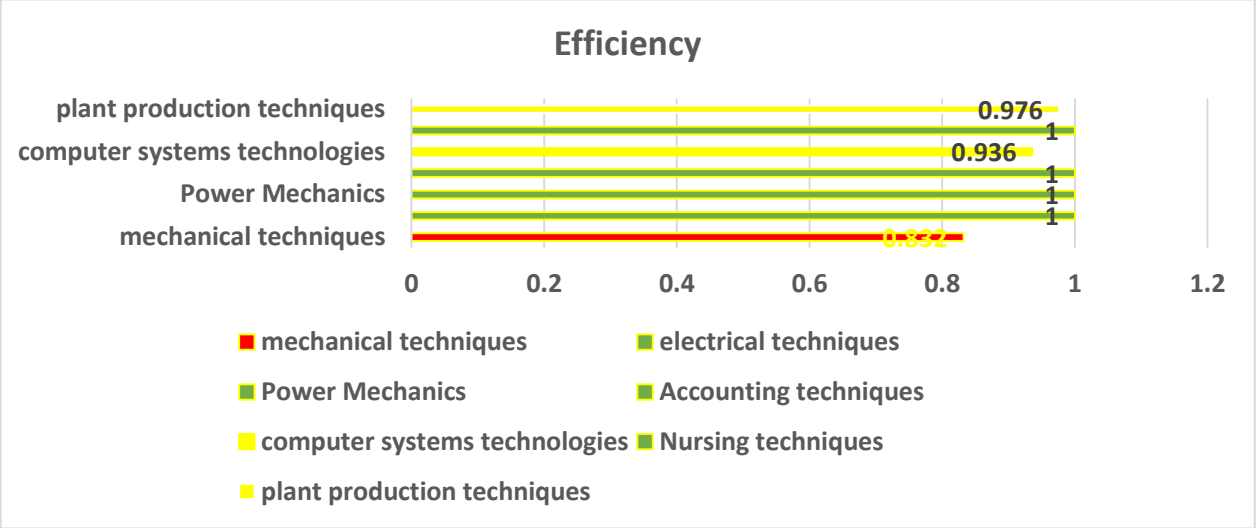

Figure 2: Shows the different levels of efficiency of the departments according to the CCR model and according to the output orientation for the year 2020-2021

B:-Measurement of efficiency in terms of Input Oriented:

Before measuring efficiency, we should first build a mathematical model for measuring efficiency. We will take the mechanics' techniques department, for example, in building the model, and a mathematical model should be built for each department (i.e. 7 mathematical models).

*** Building a mathematical model:**

To build the mathematical model for the Department of Mechanics, we use the linear programming model as follows:

$$Max\ (Z) = 0X_1 + 0X_2 + 33X_3 + 4X_4$$

$\underline{S.t}$

$$-6X_1 - 46X_2 + 33X_3 + 4X_4 \leq 0$$

$$-6X_1 - 51X_2 + 44X_3 + 6X_4 \leq 0$$

$$-6X_1 - 29X_2 + 21X_3 + 6X_4 \leq 0$$

$$-13X_1 - 159X_2 + 125X_3 + 8X_4 \leq 0$$

$$-4X_1 - 50X_2 + 36X_3 + 2X_4 \leq 0$$

$$-8X_1 - 87X_2 + 30X_3 + 15X_4 \leq 0$$

$$-6X_1 - 30X_2 + 12X_3 + 6X_4 \leq 0$$

$$6X_1 + 46X_2 = 1$$

$$X_1, X_2, X_3, X_4 \geq 0$$

Using the Dea P 2.1 program and rebuilding the model for the other sections, the results appear in Table (4), which shows the different efficiency levels for the sections, as well as the optimal amount of reduction in the inputs to modify the path of the inefficient sections and make them efficient sections. It also shows the reference sections for the inefficient sections to simulate relatively enjoying the same conditions.

Table (4)

which shows the efficiency of the sections, the target outputs, and the reference sections according to the CCR model and according to the Input orientation

	Departments	Efficiency	Real teachers	Expected teachers	real students	Expected students	Benchmark
1	mechanical techniques	0.832	6	5	46	38	electrical techniques
2	electrical techniques	1.000	6	6	51	51	————
3	Power Mechanics	1.000	6	6	29	29	————
4	Accounting techniques	1.000	13	13	159	159	————
5	computer systems technologies	0.936	4	4	50	46	Accounting techniques
6	Nursing techniques	1.000	8	8	87	87	————
7	plant production techniques	0.976	6	6	30	29	Mechanics of ability techniques, nursing techniques
Total efficiency rate		**0.963**					

Statistical analysis of the CCR model for the years 2020-2021:

1. By looking at Table (3) and Table (4), we find that the number of departments that have obtained full efficiency (100%) is four departments out of seven departments, whether in the Input orientation (IOM) or the output orientation (OOM). These sections are electrical, power mechanics, accounting, and nursing, meaning that the percentage of departments that got full efficiency out of the total departments is 57%.
2. From the observation of Figure (1), we note that three departments have not achieved full efficiency: the departments of mechanics, computer systems, and plant production techniques, meaning that their percentage is 43%.
3. When looking at Table (3), we find that the Department of Mechanical Techniques, for example, can change from an inefficient department to an efficient department (and according to the Directive Direction (OOM)) if its output increases, which is the number of graduate students by 21% (i.e. from 33 A graduate student to 40 graduate students) and the number of his published research is 25% (from 4 published research to 5 published research). The same applies to the Department of Computer Systems Technologies; it can change from an inefficient department to an efficient department (according to the Directive Directive (OOM)). In contrast, If it increases its output, which is the number of graduate students by 6% (i.e. from 36 graduate students to 38 graduate students), the plant production department can become efficient by increasing the number of graduates by 75% (i.e. from 12 students to 21 students).
4. When we observe Table (4), we find that the Mechanical Techniques Department, if it wants to reach full efficiency (according to the Input

orientation (IOM), has to reduce its inputs, which is the number of teachers by 17% (from 6 teaching to 5 teachings) and also works To reduce the number of students present by 17% (from 46 existing students to 38 existing students), as well as the case for the Department of Computer Systems Technologies. 8% (from 50 students present to 46 students present). The plant production department can reach full efficiency by reducing the number of students present by 3% (ie from 30 to 29 students).

5. When looking at Table (3) and Table (4), we note that the average total efficiency of the departments of the Technical Institute of Suwaira is 96.3% in terms of output orientation (OOM) and terms of input orientation (IOM).

6. When we observe Table (3) and Table (4), we find that the last column is under the name of the reference sections, which represents the efficient sections, which the inefficient sections should follow; for example, in the Mechanical Techniques section, we find that the reference section for it in the incoming and outgoing directions is the Techniques section Electricity As for the Computer Systems Techniques Department, we find that its reference section is the Accounting Techniques Department, and the Plant Production Techniques Department, we find that the reference sections for it in the input and output directions are the Department of Power Mechanics Techniques, and the Nursing Techniques Department.

Secondly: Measuring efficiency according to the BCC model for the years 2020-2021:

There are two approaches to measuring efficiency according to the BCC model, which are as follows:

A:- Measuring efficiency in terms of Output Oriented:

Table (5) shows the different levels of efficiency of the departments, as it shows the amount of increase required in the outputs to modify the course of the inefficient departments and make them efficient colleges, which is the result of dividing the value of technical efficiency according to the CCR model by the value of technical efficiency according to the BCC model.

Table (5)

which shows the efficiency of the sections, the target outputs, and the reference sections according to the CCR model and according to the output orientation

	Departments	Efficiency	Graduates Real	Graduates Expected	Research Real	Research Expected	Benchmark
1	mechanical techniques	0.851	33	39	4	6	Electricity techniques, power mechanics techniques
2	electrical techniques	1.000	44	44	6	6	————
3	Power Mechanics	1.000	21	21	6	6	————
4	Accounting techniques	1.000	125	125	8	8	————
5	computer systems technologies	1.000	36	36	2	2	————
6	Nursing techniques	1.000	30	30	15	15	————
7	plant production techniques	0.990	12	21	6	6	Mechanics of ability techniques, nursing techniques, computer

systems techniques

Total efficiency rate	0.977

Through Table (3) and Table (5), it is possible to view the volume efficiency according to the output orientation (OOM), which is equal to the product of dividing the technical efficiency according to the CCR model and according to the output orientation (OOM) by the technical efficiency according to the BBC model and according to the orientation Output Orientation (OOM) and Scale efficiency according to Output Orientation (OOM) are shown in Table (6).

Table (6)

shows the Scale efficiency according to the output orientation for the academic year 2020-2021

	Departments	Technical competence according to the CCR model	Technical competence according to the BBC model	Scale efficiency	volume yield
1	mechanical techniques	0.832	0.851	0.977	Increasing
2	electrical techniques	1.000	1.000	1.000	———
3	Power Mechanics	1.000	1.000	1.000	———
4	Accounting techniques	1.000	1.000	1.000	———
5	computer systems technologies	0.936	1.000	0.936	Increasing
6	Nursing techniques	1.000	1.000	1.000	———
7	plant production techniques	0.976	0.990	0.987	Increasing

As we note from Table (6) above, all departments are efficient, but three departments are completely inefficient. These reasons are due to Output circumstances, Input processes, or both.

Table (7) shows the different levels of efficiency of the departments, as it shows the amount of reduction in the inputs to modify the course of the inefficient departments and make them efficient department

1. Measurement of efficiency in terms of Input Oriented:

Table (7)

which shows the efficiency of the sections, the target outputs, and the reference sections according to the CCR model and according to the Input orientation

	Departments	Efficiency	Real teachers	Expected teachers	real students	Expected students	Benchmark
1	mechanical techniques	0.916	6	5	46	42	Electrical technologies, power mechanics techniques, computer systems technologies
2	electrical techniques	1.000	6	6	51	51	———
3	Power	1.000	6	6	29	29	———

	Mechanics						
4	Accounting techniques	1.000	13	13	159	159	———
5	computer systems technologies	1.000	4	4	50	50	———
6	Nursing techniques	1.000	8	8	87	87	———
7	plant production techniques	0.996	6	6	30	29	Power mechanics techniques, computer systems techniques, nursing techniques
Total efficiency rate		0.988					

Through Table (6) and Table (7), it is possible to view the scale efficiency according to the input orientation (IOM), which is equal to the division of the technical efficiency according to the CCR model and according to the input orientation (IOM) by the technical efficiency according to the BBC model and according to the orientation The input orientation (IOM) and the Scale efficiency according to the input orientation (IOM) are shown in Table (8).

Table (8)
shows the Scale efficiency according to the output orientation for the academic year 2020-2021

	Departments	Technical competence according to the CCR model	Technical competence according to the BBC model	Scale efficiency	volume yield
1	mechanical techniques	0.832	0.916	0.907	Increasing
2	electrical techniques	1.000	1.000	1.000	———
3	Power Mechanics	1.000	1.000	1.000	———
4	Accounting techniques	1.000	1.000	1.000	———
5	computer systems technologies	0.936	1.000	0.936	Increasing
6	Nursing techniques	1.000	1.000	1.000	———
7	plant production techniques	0.976	0.996	0.980	Increasing

As we note from the above Table (8), all departments are efficient, but three departments are completely inefficient. These reasons are due to Output conditions, Input processes or both

Statistical analysis of the BCC model for the year 2020-2021

1. By looking at Table (5) and Table (7), we find that the number of departments that have achieved full efficiency (100%) is five departments out of seven departments, whether in the Input orientation (IOM) or the output orientation (OOM). These sections are electrical, power mechanics, accounting, computer systems, and nursing, meaning that the percentage of departments that got full efficiency out of the total departments is 71%.
2. From the observation of Table (5) and Table (7), we note that there are only two sections that did not achieve full efficiency, which are the sections of mechanical techniques, and plant production techniques, meaning that their percentage is 29%.
3. When looking at Table (5), we find that the Department of Mechanical Techniques, for example, can change from an inefficient department to an efficient department (and according to the Directive Direction (OOM)) if it increases its output, which is the number of graduate students by 18% (i.e. from 33 A graduate student to 39 graduate students) and the number of his published research is 50% (from 4 published research to 6 published research). The same applies to the Department of Plant Production Techniques if it increases its output, which is the number of graduate students by 75% (i.e. from 12 graduate students to 21 graduate students).
4. When observing Table (7), we find that the Mechanical Techniques Department, if it wants to reach full efficiency (according to the Input orientation ((IOM), has to reduce its inputs, which is the number of teachers by 17% (from 6 teaching to 5 teachings) and also works To reduce the number of students present by 9% (from 46 existing students to 42 existing students), as well as the case for the Department of Plant Production Techniques, which can reach full efficiency by reducing the number of students present by 3% (that is, from 30 students to 29 students).
5. When looking at Table (5) and Table (7), we note that the average overall efficiency of the departments of the Technical Institute of Suwaira is 97.7% in terms of outgoing orientation (OOM) and 98.8% in terms of input orientation (IOM).
6. When we note Table (5) and Table (7), we find that the last column is under the name of the reference sections, which represents the efficient sections, which the inefficient sections should follow; for example, in the Mechanical Techniques Department, we find that the reference section for it in the Input orientation is the Electrical Techniques section Power mechanics techniques, computer systems techniques and in the output orientation department of electrical techniques, power mechanics techniques, as for the plant production techniques department, we find that the reference sections for it in both the input and output orientations are the power mechanics techniques

department, the computer systems technologies department, the nursing techniques department.

7. Conclusion and Recommendation

7.1. Conclusions:

1. The results showed that all departments in the Technical Institute of Suwaira share the same inputs and outputs, which are the most influential inputs and outputs, and this indicates that all these departments are homogeneous, and this supports the first hypothesis of the research hypotheses, which indicates the homogeneity of the departments being evaluated.
2. According to the results for the year 2020-2021 and according to the CCR model, whether in the Input orientation (IOM) or the output orientation (OOM), the percentage of departments that obtained full efficiency (100%) is 57% of the total departments and that 71% of the departments have obtained Full efficiency (100%) according to the BCC model and the two directions of Input (IOM) and output (OOM), and this is an indication that a good amount of departments was able to obtain complete efficiency.
3. The BCC model is better than the CCR model as it takes the effect of volume and measures the Scale efficiency (Scale Efficiency), as using the CCR model alone will not show us the effect of volume, which is one of the important factors in measuring efficiency. The results for the year 2020-2021 showed that 43% of the departments did not achieve full-Scale efficiency (Scale Efficiency), that is, these departments operate below their Scale capacity, that is, they did not use their energies, capabilities, and sizes optimally and could not expand their operations to suit their sizes, and this supports the second hypothesis of the research hypotheses.
4. We noticed the results for the year 2020-2021, according to the CCR model, that the least efficient department according to the CCR model is the Department of Mechanical Technologies with an efficiency of 83.2%, followed by the Department of Computer Systems Technologies with an efficiency of 93.6%, and the least efficient departments according to the IBCC model is the Department of Mechanical Technologies with an efficiency of 91.6% As for the least efficient departments according to the OBCC model, it is the Mechanical Technologies Department with an efficiency of 85.1%. The main reason for this decline in efficiency is due to the presence of many inputs that exceed the department's needs on the one hand and the lack of its outputs compared to these inputs on the other hand. Therefore, the efficiency of these departments and their low percentage have affected the general average of efficiency for the rest of the departments.
5. Through the results obtained for the data for the year 2020-2021 and according to the CCR model, we find that the most departments that need to increase their outputs to become efficient sections of the number of graduate students are the Department of Plant Production Techniques at a rate of 75% and of the number of published scientific research is the Department of Mechanical Techniques at a rate of 25% As for the departments that most need to reduce their inputs, it is the Department of

Mechanical Techniques, in terms of the number of teachers, at a rate of 17%, and the number of students present at a rate of 17% as well.

7.2. Recommendations:

1. Take advantage of efficiency indicators and levels of improvement, whether in the fixed returns to volume model (CCR) or the variable returns to size (BCC) model, whether in the input aspect (IOM) or the output aspect (OOM), and according to the available capabilities for improvement where it is possible to improve in the output aspect Or the Input side, according to the possibility of improvement and according to the conditions of the institute.
2. The need for the improvement process in the inputs or outputs to be in a gradual manner because of the great difficulty, according to my point of view, in applying the improvement process directly, as it is preferable to increase the outputs or gradually reduce the inputs and to measure the improvement process in efficiency.
3. The necessity of applying the data envelope method or other methods in evaluating the performance efficiency annually, as it was found through the results that the performance efficiency decreased in 2021 compared to the previous one in 2020, which will hopefully continue due to the lack of optimal planning that shows how to distribute scarce resources (inputs) to produce the largest amount of the outputs.
4. The need to take advantage of the departments that have proven their full efficiency through analysis and study of their operational and administrative system so that these departments can serve as role models for the inefficient departments to follow their example in increasing their efficiency.
5. The necessity of studying the causes of Scale inefficiency due to Output conditions of its utmost importance in exploiting the optimal section sizes in production.

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