

**استعمال التوجه الادخالي في نموذج (CRS) لتقييم
وتقويم الكفاءة الفنية في الشركة العامة للسمنت العراقية**

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Using the input approach
in the (CRS) model to evaluate and assess
technical efficiency

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المستخلص:

تهدف هذه الدراسة إلى توضيح وإبراز أهمية تقييم وتقويم أداء المنظمات والمنشآت الإنتاجية (المصانع) بشكل خاص، إذ تمثل هذه العملية وسيلة لمعرفة كفاءة (المصانع) في إنجاز أنشطتها وكفاءتها في تحقيق أهدافها. واعتمد الباحث على المنهج الكمي باستخدام إحدى أساليب البرمجة الخطية المتمثلة بمنهجية تحليل مغلف البيانات (DEA) مع التوجه بالمدخلات ووفقاً لعوائد الحجم الثابتة (CRS) بالإضافة إلى ذلك استخدم أسلوب تحليل مغلف البيانات (DEA) الذي يعد من أهم الأساليب الكمية في تقييم أداء مجموعة من الوحدات المتشابهة، بناءً على تحديد مستوى كفاءتها باستخدام مجموعة من المدخلات كمتغيرات مستقلة متمثلة بـ (راس المال، قيمة المواد الأولية، الطاقة والوقود) والمخرجات كمتغيرات تابعة متمثلة بـ (الأرباح). وقد تم تطبيق هذه الدراسة في الشركة العامة للسمنت العراقية، وقد تم استخدام البرنامج الإلكتروني Deap 2.1 لتقييم وقياس الكفاءة الفنية لمصانع الشركة خلال عام 2023، وقد أظهرت النتائج أنه من بين 13 مصنعاً تمكنت ثلاثة (3) مصانع فقط من الوصول إلى مستوى الكفاءة الكاملة 100% وهي مصنع كربلاء ومصنع كركوك ومصنع سنجان أي بنسبة 23% وتعتبر نسبة منخفضة، وبما يؤهل بقية المصانع الغير كفوءة للاقتداء بها كمرجع لتحسين مستوى الأداء واستغلال الموارد بأفضل طريقة وأن متوسط الكفاءة الفنية لمصانع الاسمنت وفقاً لعائدات الحجم الثابتة (CRS) لنموذج التوجه الادخالي قد بلغت 0.582 % وتعتبر نسبة منخفضة جداً.

الكلمات المفتاحية: الكفاءة الفنية (TE)، تحليل مغلف البيانات (DEA)، عوائد الحجم الثابت (CRS)، الأداء، الإنتاج، البرمجة الخطية (L.P)، صناعة الاسمنت.

بحث مستل من رسالة ماجستير

Abstract

This study aims to clarify and highlight the importance of evaluating and assessing the performance of organizations and production facilities (factories) in particular, as this process represents a means of knowing the efficiency of (factories) in completing their activities and their efficiency in achieving their goals. The researcher relied on the quantitative approach using one of the linear programming methods represented by the Data Envelopment Analysis (DEA) methodology with an orientation to the inputs and according to the constant returns to scale (CRS). In addition, he used the Data Envelopment Analysis (DEA) method, which is one of the most important quantitative methods in evaluating the performance of a group of similar units, based on determining their level of efficiency using a set of inputs as independent variables represented by (capital, value of raw materials, energy and fuel) and outputs as dependent variables represented by (profits). This study was applied in the Iraqi General Cement Company, and the electronic program Deap 2.1 was used to evaluate and measure the technical efficiency of the company's factories during the year 2023. The results showed that out of 13 factories, only three (3) factories were able to reach the full efficiency level of 100%, namely Karbala Factory, Kirkuk Factory and Sinjar Factory, i.e. 23%, which is considered a low percentage, which qualifies the rest of the inefficient factories to follow them as a reference to improve the level of performance and utilize resources in the best way, and that the average technical efficiency of cement factories according to the constant returns to scale (CRS) of the input orientation model reached 0.582%, which is considered a very low percentage.

Keywords: Technical Efficiency (TE), Data Envelopment Analysis (DEA), Constant Returns to Scale (CRS), Performance, Production, Linear Programming (L.P), Cement Industry.

1-Introduction:

The role of industrial institutions, especially the cement industry, is prominent in the economies of all countries of the world. As these institutions are considered important institutions that contribute effectively to the gross domestic product, hence, paying attention to industrial institutions and raising the level of existing industries should be among the basic goals of any comprehensive development policy, especially since this institution has a large relative weight among economic institutions. Accordingly, focusing on these industrial institutions and trying to develop them and identify their branches that suffer from a decline in their efficiency, and trying to avoid such negatives are considered important economic measures that would give an indication of the real situation of such an industrial institution.

The research problem : The research problem lies in measuring the technical efficiency of factories in order to improve their technical and production efficiency, cover production costs and increase profits, as most cement factories have recorded large losses and their revenues no longer cover their expenses due to the great neglect suffered by this sector, as its technical and production efficiency has deteriorated significantly after 2003.

Measuring the efficiency of industrial establishments has been limited for several decades to relying on traditional methods and techniques that have proven their limitations in this, especially when the study extended to knowing the factories that do not operate efficiently and the desire to know the underlying reasons behind this, as well as determining the optimal quantities of inputs and outputs that achieve full efficiency for industrial establishments.

Research objective: Evaluation and assessment of the technical efficiency of the performance of the Iraqi General

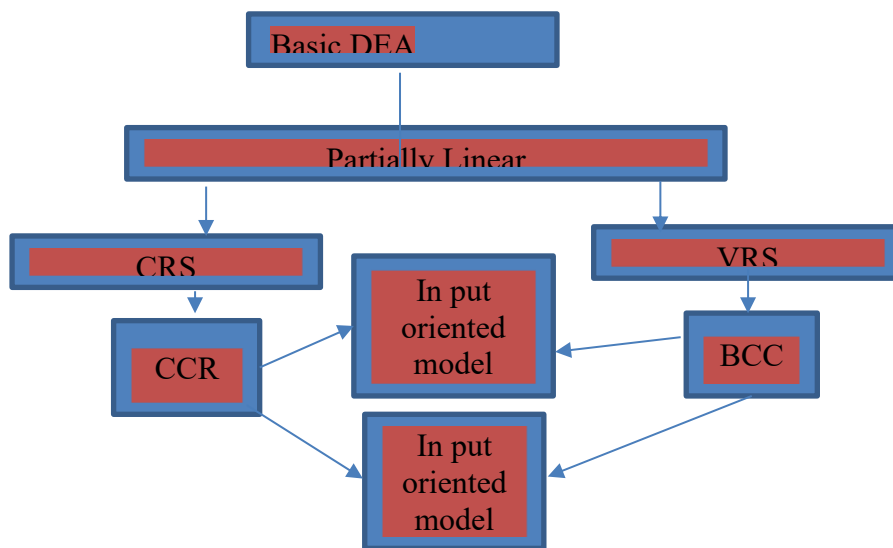
Cement Company factories through the use of the Data Envelopment Analysis (DEA) model with input orientation according to the constant returns to scale of the CRS model.

Importance of research :The topic of evaluating and measuring efficiency is one of the topics that receives great attention in research studies, especially with regard to the company's factories, using data envelopment analysis (DEA) is a non-parametric mathematical method based on linear programming. Therefore, it is a methodology that addresses the limits instead of using measures of central tendency. It is a data-oriented approach to evaluating the performance of a set of evidence units called decision-making units (DMUs) that transform multiple inputs into multiple outputs. The success of any organization depends on making the right decision at the right time.

Research Hypothesis test : The research is based on the hypothesis that: "Companies operating in the cement industry in Iraq rely on the input-output orientation that led to the development of their performance efficiency". Therefore, there is a possibility to evaluate and measure technical efficiency at the level of each factory that can contribute to supporting trends towards expansion in it by creating competition to motivate factories to improve their performance in this field.

The hypothetical chart :Figure 1 shows a hypothetical diagram that illustrates how the researcher's idea can be illustrated by using data envelopment analysis for the input orientation model according to constant returns to scale, taking into account that this description fits his hypotheses to reach the research objectives. It was conceived based on intellectual studies on the research variables.

Figure (1) : hypothetical chart



Source :Prepared by the researcher

Research methodology: The study methodology was adopted in evaluating the performance efficiency measurement of the studied factories, as the descriptive analytical approach was relied upon in the methodology of this study to verify its hypotheses in order to achieve its objectives through:

-Adopting the quantitative mathematical method (nonparametric linear programming method), which is called the data envelopment analysis method (DEA) or what is called data envelopment analysis as one of the quantitative methods of linear programming within operations research

Research structure :The research was divided into two sections. The first section includes the basic concepts of performance evaluation and efficiency, their measurement, types, estimation, and productivity measurement. The second section includes the concept and method of data envelope analysis, the mathematical model, and constant returns to scale. The third section includes the results, discussions, conclusions, and proposals.

1.1 Literature review:

Several local studies have been conducted to evaluate and assess the measurement of technical and relative efficiency of universities using linear programming methods.

- Al-Sufyani (2020) conducted a study that aimed to build a proposed vision for developing the colleges of Umm Al-Qura University according to the results of measuring relative efficiency using the Data Envelope Analysis (DEA) model in light of the standards of the National Center for Academic Evaluation and Accreditation. The study followed a mixed approach (quantitative/qualitative), and was limited to (16) colleges of Umm Al-Qura University from the year (2016-2018). It reached a set of results, the most important of which are: the percentage of efficient colleges reached (37.50%) and their relative efficiency levels reached (76%) or higher, while (3) colleges appeared with a low relative efficiency level ranging between (26%-50%), namely the College of Economics and Islamic Finance, the College of Medicine, and the College of Arabic Language and Literature.
- Al-Shaya and Batal (2013) conducted a study that aimed to estimate and analyze the relative efficiency of colleges at Qassim University using Data Envelope Analysis. The results showed that (10) colleges representing (55.5%) achieved relative efficiency with an average of (88%) according to the return to size variable. The colleges of Qassim University also achieved relative efficiency with an average of (68%), and only three colleges achieved the optimal size .
- Al-Shaya (2008) conducted a study aimed at measuring the relative efficiency of Saudi universities using data envelopment analysis. This study was limited to the colleges of three universities (King Saud, King Abdulaziz, and King Faisal). The most important results were: the presence of (7) efficient colleges out of (13) colleges at King Saud University included in the evaluation process. As for King Abdulaziz University, the number of efficient colleges was (6) colleges out of (12) colleges included in the evaluation process.
- As for King Faisal University, the number of efficient colleges reached (4) colleges out of (8) colleges included in the evaluation process, and the highest average efficiency was (75%), which was obtained by King Saud University, followed by King Abdulaziz University with an average efficiency of (71%), then King Faisal University with an average efficiency of (62%).

- **Qanawi and Al-Faki (2015)** conducted a study aimed at measuring the relative efficiency of private colleges in Sudan using the data encirclement method, and the most prominent results were: (6) colleges out of (19) colleges achieved full relative efficiency according to the CCR model according to the output orientation, while (12) colleges out of (19) colleges achieved full relative efficiency according to the BCC model according to the output orientation. Abdul Qader's study (2012) aimed to measure the efficiency of Saida University in Algeria using the data encirclement analysis (DEA) method. The results showed that the Faculty of Economics was the only one that achieved complete relative efficiency using the constant returns to measurement model with an orientation to inputs and outputs, while using the variable returns to measurement, it was found that the Faculty of Law was the only one that did not achieve complete relative efficiency of 100%.
- **Many foreign studies** were conducted in the same context; Kao and Hong (2008) conducted a study; with the aim of evaluating the relative efficiency of the colleges affiliated with the National Cheng Keng University in Taiwan, and the results showed that the Faculty of Medicine is the most resource-consuming (inputs) relative to outputs, and that the Faculty of Engineering consumes a lot of resources (inputs) but produces a lot of outputs and is therefore the most efficient, and that (13) colleges had low efficiency. Jones (2006) conducted a study; The study aimed to measure the efficiency of higher education in Britain, and the study sample was (109) universities, and the most important results were: The average technical efficiency for all universities was (61.94%), while the average volumetric efficiency was (45.96%), and (62) universities achieved complete efficiency.

1-2- Methods and materials

1-2-1 Data and variables :

Input-oriented Data Envelopment Analysis (DEA) method was used to calculate the technical efficiencies of the company's factories. Primary data were collected by the Production Control Department, Planning and Follow-up Department, Accounts Department and Marketing Department for thirteen factories (13 out of 18 factories of the Iraqi Cement State Company)..

1- 3 Basic Concepts:

Good performance in any institution is represented by the success of a set of strategies adopted by the management of this institution to achieve the specified goals, and this can only be achieved through the ability of factories to make the right decisions at the right times and to the extent of their ability to reduce and minimize inputs and maximize outputs without compromising the essence of the production process .(Ahmed Shaker Mahmoud,2023: 6) Accordingly, performance is considered the best way to accomplish work and achieve the greatest goals and enable the process of evaluating the performance of decision-makers to know the true level of activity carried out by industrial establishments and identify and enhance strengths and discover weaknesses and procrastination, if any, in order to propose solutions and determine the extent of implementation of possible and specific goals and whether they are with the required efficiency. This can only be achieved through the use of mathematical methods that provide accurate quantitative results, which helps rationalize decisions (Al-taee,2024: 17-28)

"Farrell (Farrell,1957:90-253) was the first to propose measuring the efficiency of a complex system based on one input indicator and one output indicator. "

This methodology was developed by "Charnes, Cooper and Rhodes" in 1978 They were able to propose and use linear mathematical programming to solve this type of problem. Then, the formulation of the data envelopment analysis model method was done. Over the years, the method has been widely applied in various fields to calculate both the technical and economic efficiency of the work of institutions as systems that are not simple or complex. (Emrouznejad and Yang,2018: 20-17017) .At this time, the basic models and methods of data analysis method were formulated (El-Shater et al.,2017: 20-1709). These models have subsequently been widely and comprehensively spread in research around the world with practical applications in various fields. Data analysis is a mathematical programming method that can identify relatively useful actions for decision-making units and technical efficiency. Data analysis can enable the use of multiple inputs and outputs in a linear programming model that calculates technical efficiency(Alinsato and Alakonon,2021:66-1055). In 1957, Farrell considered "measuring efficiency in the presence of multiple inputs and outputs by assigning weights to the inputs and outputs In this analysis, the first key point is efficiency, which is generally defined as "the sum of all weighted output parameters divided by the sum of all weighted input factors. In general, the formula is as follows: (Emrouznejad and Yang,2018: 4-8)

$$Te = \sum \text{weighted output parameters} / \sum \text{weighted input parameters} \dots\dots (1)$$

where **Te** is technical efficiency.

Production efficiency has five types; studies have indicated them: (Al-Sofyani, 2021; Al-Mohammadi, 2015; Muhanna, 2014), and they can be summarized as follows:

1-Relative efficiency: It aims to improve the way decision-making units (DMUs) work, which are factories in this study. The relative efficiency index represents one of the most important indicators of measuring efficiency, and it expresses how well decision-making units (factories) use their inputs (capital, raw materials, and fuel energy) to produce their outputs (profits); but taking the efficiency index (inputs over outputs) in an absolute manner does not give a real meaning, so it is compared to other reference bases such as: comparing it to production capacity or comparing it to the maximum limits drawn by good units that have achieved complete efficiency; therefore, it is called relative efficiency (Alsaidi et al., 2014:1-93).

2-Technical Efficiency: It means the ability of the administrative unit to invest the same inputs to obtain the greatest amount of outputs, or to achieve a specific level of outputs using the least possible inputs (Hussien & Abdel Hamid, 2010:160-571)

3. Allocative Efficiency: It means the ability of the administrative unit to optimally invest a mix of inputs, taking into account their costs and available production technologies . (Ciula et al.,2022:56-143)

4. Economic Efficiency: It is called Farell's efficiency; which assumes that the efficiency of the institution consists of two elements: technical efficiency and employment efficiency, and by integrating These two measures can measure economic efficiency (Hawari&Bin El Din , 2019: 182-187).. Economic efficiency is defined as: "The ability of the

institution to use its resources in a way that achieves the highest productivity at the lowest costs or at the same previous costs”

5.Scale Efficiency: It means the ability of the administrative unit to expand according to the size of its operations, or it is the amount of change in production as a result of changing the elements of production at one time and it also means working at the optimal size level; the degree of relative inefficiency obtained for any institution can be attributed to technical inefficiency or to volumetric inefficiency, and the volumetric efficiency of the administrative unit is calculated by dividing the technical efficiency index of the administrative unit under constant (RTS) returns to scale (CRS) by the technical efficiency index of the same administrative unit under variable returns to scale (VRS). (Kenawy & Al-Faki, 2015: 93-102) .

1-4 Measuring productivity:

Total productivity is the arithmetic ratio between the amount of outputs produced during a specific period and the amount of inputs used to achieve that amount of production. Total productivity is expressed by the following relationship: (Salan et al.,2022- 1-13) (Khalaf and Ali,2023: 189-209)

Total productivity = outputs / inputs

It can be said that the terms efficiency and productivity are sometimes used interchangeably;(Saad Ali Mahmoud,2023 : 6) this is due to the significant overlap between the two concepts. If productivity is calculated for a group of administrative units, and the lowest and highest productivity are determined, then efficiency is an indicator used to rank productivity values. Technical and volumetric efficiency also fall under relative efficiency. This is confirmed by (Alsofyani, 2020, p. 22), who pointed out that “relative efficiency includes technical efficiency and volumetric efficiency on the one hand, and total production efficiency on the other hand.”

(Kliment et al., 2020: 41-470) .

1-5 Methods of Estimation :

The pioneering article by Farrell (1957) on “efficiency measurement helped in developing various methods for efficiency analysis” . DEA is mean that mostly used in efficiency research works all over the world. DEA is used to estimate model the efficiency of non-agricultural can sector, for example, **public utilities, banks, hospitals, educational institutions, industrial and production enterprises, etc.** This paper uses DEA methods to estimate the determinants of efficiency and this model method is discussed as follows:(Pokushko, Stupina, Medina-Bulo, Dresvianskii, and Karaseva,2019: 5) .

2- Research variables:

2-1-Data Envelopment Analysis (DEA) Model :

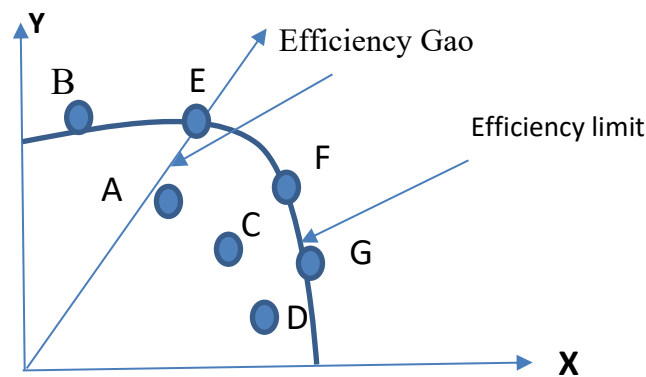
Data envelopment analysis (DEA) is a linear programming (**L.P**) method used to formulate a piecewise linear surface on input and output data points. Linear programming problems are solved for each production or organization firm in the sample to construct the frontier surface and produce the inefficiency level. The inefficiency level is the gap between the frontier and the observed data point. An efficient firm with an efficiency score of one lies on the production frontier, and an inefficient firm with an efficiency score of less than one lies below the frontier. Charnes et

al. (1978)” proposed an input-oriented DEA method that assumes constant returns to scale (CRS) (Boyd and Färe,1984) Further more, Banker et al. (1984)” assumed variable returns to scale (VRS) in their DEA model. (Banker et al.,1984: 1078–1092)Since this study deals with cement industry and one output and three inputs, it chooses the input-oriented model. This model evaluates how much input can be changed proportionally to produce a fixed amount of output.

2-1-1 Data Envelopment Analysis Method :

Data Envelopment Analysis Method is defined as (Zhu, 2003: 85-477) “ the method that uses mathematical programming to find the relative efficiency of a set of decision-making units (DMUs) “, which use a variety of inputs and outputs, by dividing the total outputs by the total inputs for each facility, and this ratio is compared to other facilities, and if a facility obtains the best efficiency ratio, it becomes an "efficient frontier", and the degree of inefficiency of other facilities is measured relative to the efficient frontiers using methods Sports, and the efficiency index of the establishment is limited between the value one (1), which represents complete efficiency, and the index with the value zero (0), which represents complete inefficiency. The reason for calling this method data envelopment analysis is that the administratively efficient units always come at the forefront or start and envelop the inefficient administrative units. Accordingly, the data that envelops the efficient units is then analyzed to differentiate between them, as shown in Figure (2). (Cooper et al.,2006: 1-354)

Figure (2) : Output Orientation packaging Case



Source: Prepared by the researcher

In Figure (1) represents a grup of decision –making units that produce the products (y_1 and y_2) using the input (x , and shows the possible production range between the two axes (y_2/x and y_1/x), and the efficient limits consisting of the units (G-F-E-B), This explains as the latter are considered to have full production efficiency compared to the points D-C-A)) that do not make good use of their available inputs, and the efficiency of the latter is calculated by comparison and the efficient limits, as if we calculate the efficiency of unit ((A by dividing the ray ((OA) \rightarrow) by the ray ((OE) \rightarrow) so the result is 0.75, which means that this The unit can increase its outputs by (25%) without affecting the inputs, and thus the efficiency is measured and improved with respect to (C and (D). The (DEA) method

for the facility whose efficiency is to be measured is called the decision-making unit (DMU), and so in general, (the DMU is every entity responsible for converting inputs into outputs, as its performance can be evaluated, in the specified field) and can include: banks, warehouse departments, central markets, companies, hospitals, universities, ... etc., Accordingly, the concept and meaning of the decision-making unit is broad, provided that each decision-making unit or institution enjoys a certain degree of administrative freedom in implementing decision-making (Cooper et al.,2006: 30)

The DEA method is classified as(DEA) as the best means of benchmarking (Benchmark), due to its distinction in identifying the best efficient units relative to the inefficient units) , And so. based on multiple inputs and outputs, measuring efficiency in this way does not require the availability of information about the prices of inputs or outputs, t is not necessary for the inputs and outputs to be from the same unit of measurement, and more importantly, the focus is on all decision-making units and not on the average of the sample unit, and there is no restriction on using any form of available production functions, and it is possible to achieve objective fairness standards in the relative evaluation of each decision unit. (Cooper et al.,1978) (Sekitani and Zhao,2023:310-1296)

To conduct a successful efficiency evaluation process according to the DEA analysis, a number of conditions must be met: (Xu and Liu,2017:4)

- Selecting similar units: meaning that it includes a group of companies among themselves, or a group of industries among themselves, and the basis of this condition is that each group has factors and laws that determine its activity (Wasilewski and Żurakowska-Sawa,2006:31-322) .
- The model requires relative homogeneity of decision-making units, meaning that all units included in the evaluation have the same inputs and the same outputs with positive values, and does not measure the efficiency of companies with negative values.(Dehnokhalaji et al.,2022:1-32)
- The evaluation should be greater than the product of the number of inputs and the number of outputs (variables), otherwise the model will lose its discriminating power between efficient and inefficient units.
- Some see the existence of the largest number of inputs and outputs involved in the evaluation process, and the second requires a balance between the number of inputs and outputs and the number of units involved in the evaluation. However, this conflict does not exist in reality, as we can start with a large number of inputs and outputs that actually reflect reality and do not deprive any unit of showing its efficiency. (Silberberg,2012:18)

2-1-2 input-oriented DEA analysis:

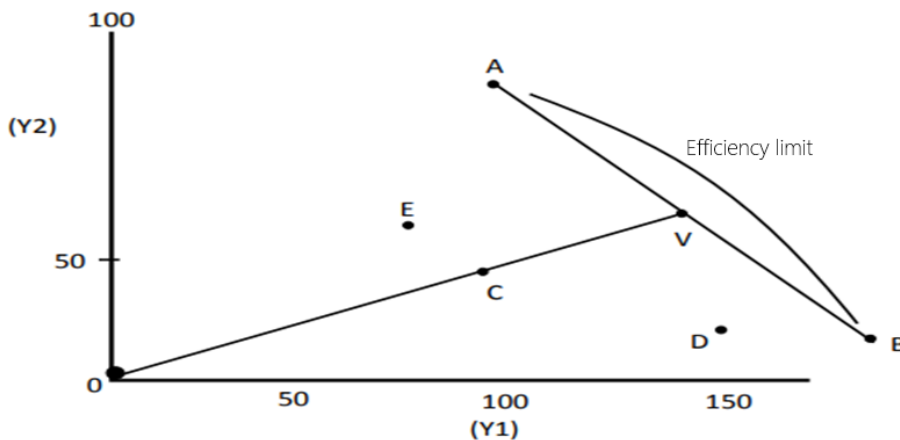
The limits of input-oriented analysis are calculated using CRS. The CRS efficiency ratio is estimated for most plants (23%) that have technical efficiency scores within the 100% efficiency index. The average technical efficiency score for CRS that have constant returns is **582** .(Pokushko et al.,2020)

2-1-3 Objectives of Data Envelopment Analysis:

DEA seeks to describe which decision-making units are on the envelope surface or efficiency frontier and are efficient, and which decision-making units are below the surface and are inefficient. (Yen et al., 2021:5) To find The relative efficiency of each unit is calculated by using the input and output variables of the decision-making units in general. For each inefficient decision-making unit, DEA determines must to the level of inefficiency of both the input and

output, and (suggests that to how those units can be reach the efficiency frontier Possible) (Akay et al.,2012: 75-7763) .Thus, the data envelope analysis approach aims to choose a set of input and output weights that maximize the efficiency of any inefficient decision-making unit relative to all other decision-making units. For example, points (A and B) are efficient; and points (E) (C, D) are not efficient, as they are not at the level of efficiency, as shown in Figure (3).

Figure (3) Efficiency limit in data envelopment analysis input

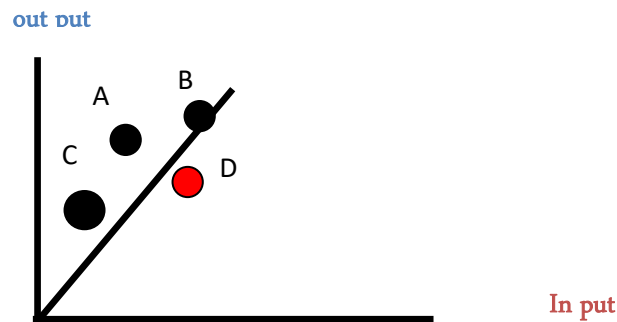


Source: Rieman, Mark W.: "Enhancing the Balance Scorecard with Scale-(DEA)", Unpublished Doctor of Philosophy Dissertation, Washington State University, USA,p30, 2003

2-2-TheCRS (CCR) Model :

The founders of the model are Charnes, Cooper, and Rhodes in 1978 with the model, thus, being called the CCR model, as an abbreviation of the authors' surnames.It was one of the first to be developed, Implement and work on it being considered a basic model in the scientific literature. Based on this model, the DEA method has been supplemented with many new models and has been further developed clearly and understandably.(Gidion,2023:10-1700) .This model has been developed This model was developed by Chakj hrnes, Cooper & Rhodes and is abbreviated as (CCR) which are the first letters of their names in the year (1978). They relied on Farrell's model, also called the Constant Returns to Scale (CRS) model, which means that the change in the amount of inputs used by the unit or company has a constant effect on the amount of outputs it provides when it moves towards the front line of efficiency (CRS). This property It is consideredis only appropriate when all the units being compared are operating at their optimal sizes, but in reality" there are a lot off many obstacles that prevent the units from achieving these sizes" . Such as that competition, financing restrictions, etc. (X. Wang et al.,2023:41-52) If we assume that three companies (A.B.C.) fall on the constant returns curve, then these are efficient companies in the case of constant returns to scale, while company (D) is inefficient, because it falls below the curve, Figure (4). (Janzakov et al.,2024: 53-65)

Figure (4) Efficiency limits and possible production range



Source: Prepared by the researcher

According to Farrell's analysis, there are two ways to calculate efficiency, which he called:

2-2-1 Mathematical model CCR (CRS) :

The CCR model is built on Farrell's method to measure the efficiency of the feasible units considered using production functions. The equation with Farrell's nonlinear program can display a simple production ratio with a single input and output parameter.(El-demerdash et al.,2025:20) (Despotis et al.,2015: 79-370).

In this model, can be multiple input and output parameters of each enterprise are combined into various scalar input and output parameters. In This model is based on a constant return to scale (CRS).It can be described by a formula that represents a solution to the maximization problem:

$$E f = \frac{\sum_{r=1}^s U_r Y_m}{\sum_{i=1}^m V_i X_{im}} \leq 1 \quad \dots\dots\dots 2$$

Under the following restrictions:

$$E f = \frac{\sum_{j=1}^s U_j Y_{jo}}{\sum_{i=1}^r V_i X_{io}} \rightarrow \mathbf{max} \quad \dots\dots\dots 3$$

$m = 1, 2, \dots, n, U_r \geq 0, j = 1, 2, \dots, s, V_i \geq 0, i = 1, 2, \dots, \dots\dots\dots r.$

where:

Ef is the efficiency value of the enterprise.

n is the number of units compared.

r is the number of input factors.Algorithms

Sis the number of output parameters.

xi0 is an observed indicator of the i-th input factor of the enterprise.

Yi0 is an observed indicator of the j-th output parameter of the enterprise.

Xim is the observed indicator of the i-th input factor of the m-th enterprise with

$i = 1, \dots, r$ and $m = 1, \dots, n.$

Yim is the observed indicator of the j-th output parameter of the m-th enterprise with

$i = 1, \dots, r$ and $m = 1, \dots, n$.

U_r is the weighting of output factor i with $I = 1, \dots, r$.

V_i is the weighting of input parameter j with $j = 1, \dots, s$.

When this maximization problem is to be solved, a problem of finding a quotient of two combined linear values must arise. These maximization problems are also called quotient linear programming. There are also many possibilities to transform quotient linear programming into a linear programming (L.P) problem. For this purpose," Charnes, Cooper, and Rhodes" in 1978 formulated what is called the inverse program for the following function:(Boyd and Färe,1984)

$$E f = \frac{\sum_{i=1}^r V_i X_{i0}}{\sum_{j=1}^s U_j Y_{j0}} \rightarrow \min \quad \dots\dots\dots 4$$

Subject to the following conditions:

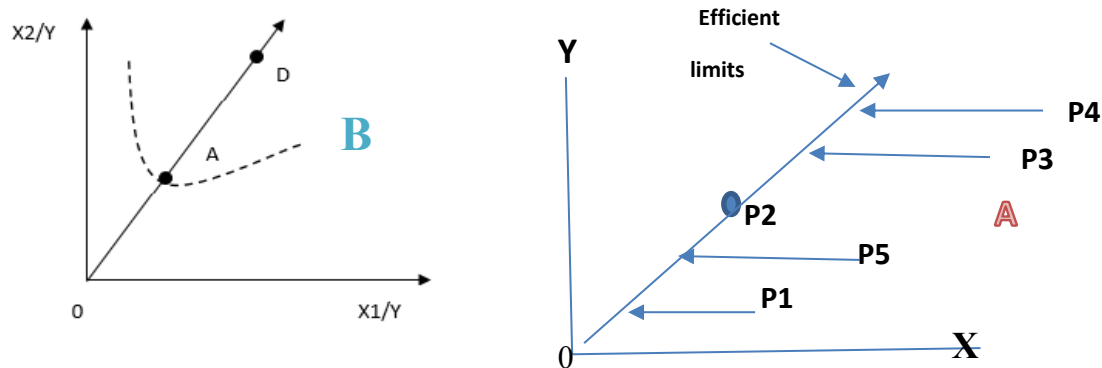
$$E f = \frac{\sum_{i=1}^m v_i X_{im}}{\sum_{r=1}^s U_r Y_{rm}} \leq 1 \quad \dots\dots\dots 5$$

where $m = 1, 2, \dots, n$, $U_r \geq 0$, $j = 1, 2, \dots, s$, $V_i \geq 0$, $i = 1, 2, \dots, r$.

A- Input Orientation Index (CCR-I)

In This method is based on the possibility of reducing the elements of production (inputs) to can be obtain the same level of production (outputs), under that conditions characterized by the stability of returns to scale (Farrell,1957) This measure is can be characterized by comparing the actual combination of inputs and outputs that , i.e. the inputs required for the actual efficient outputs, and can be expressed by the relationship: (Inputs required for the actual efficient outputs / Actual inputs). The efficient unit is the one that has the actual inputs equal to the inputs required for the actual efficient outputs, Therefore, it is possible to achieve and thus the ratio of equality is achieved and is efficient As shown in Figure (5). (Lychev et al.,2023:)

Figure (5) CCR model with input orientation



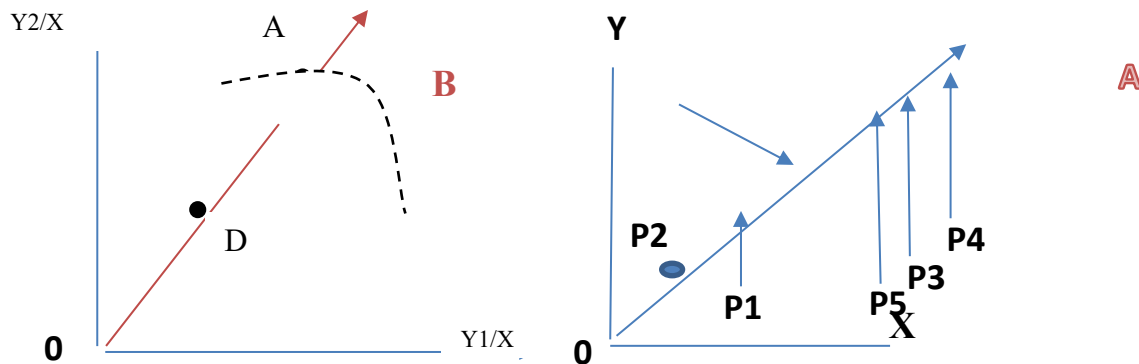
Source : Prepared by the researcher

In Figure A)) "We can notice that (P2) is efficient, and in order for the rest of the units to be efficient, they must take that the horizontal direction, i.e. maintaining the same amount of outputs (Y). In this direction, we can reduce the inputs (X), and the lines heading towards the efficient limit express the percentage of inefficiency for the rest of the units. In Figure B)) If that the two variable inputs (x1, x2) are used to produce one level (y) of production, then the unit or company (D) is less efficient than company (A), and Therefore, the distance (AD) expresses the decrease in technical efficiency, and indicates the amount by which all inputs can be reduced proportionally without reducing production. Therefore, Thus, the technical efficiency (TE) for company D)) is ($0 \leq TE = OA / OD \leq 1$) (Zhang et al.,2020: 82-174)

B- Output Orientation Index (CCR-O)

It is possible that It means achieving maximum outputs Weighted from available resources, and is expressed by the output magnification increase scale. This scale is achieved by comparing the actual combination of inputs Weighted and outputs Weighted, i.e. the efficient outputs for the same inputs, or in other words, the ratio between the actual outputs Weighted and the achievable (potential) outputs at the efficient limit level using the actual inputs(Hussein,2023:1-13). It is measured by the relationship: (actual outputs / potential outputs for the same inputs), and accordingly, the efficient unit is the one that achieves the ratio of one and its actual outputs are equal to the potential outputs of its actual inputs, and Low efficiency means that the inefficient unit is less than one and its actual outputs are less than the potential outputs For its inputs ,(Wang et al.,2023) and Figure (6) shows the output orientation index.

Figure (6) CCR model with orientation to outputs



Source: Prepared by the researcher

We notice that In the right figure (A), unit P2 appears efficient while the other units are inefficient. In order for the units to become efficient, they must increase their output and maintain the amount of inputs, i.e., move vertically to the efficient frontier.

The second figure (B) shows that the company is inefficient (D), as the distance (AD) represents the amount by which production (outputs) can be increased Magnification and multiply without the need for any increase in the elements of production (inputs), and in it is efficiency.(Ratner et al.2023:1-14)

3-Results and Discussions :

3-1 A-Data and Variables

Table 1 : Summary statistics of variables used in this study .

Variable	Minimum	Maximum	Mean	Standard Deviation
Profits	0.28	378.00	26.39	32.24
Capital	0.47	270.00	16.19	19.33
Raw materials	1.20	539.00	40.99	44.51
Energy and fuel	0.43	0.98.00	10.41	12.36

Source : Prepared by the student using the SPSS 24 program

The statistics Below is that in Table (1) show that the average net profits amounted to (26.39) billion dinars and capital (16.19) billion dinars, while the average value of raw materials amounted to ((40.99) billion dinars and energy and fuel ((10.41) billion dinars.

3-2 B-Estimating Efficiency Levels :

In this applied aspect, (efficiency indicators will be calculated for the institutions under study), based on the input approach of the fixed economies of scale model (CRS). For this purpose, we used the Deap2.1 program on the data of the institutions (factories) under study during the year 2023.

3-2-1 Research results:

The company's factories are similar to all production institutions, which among their goals are reducing their discount inputs and rationalizing the use of inputs for each factory. This makes the performance evaluation process necessary and inevitable. For this reason, we applied the encapsulated data analysis method to thirteen factories affiliated with this company in order to determine the level of performance in them.

- 1-The performance evaluation process is considered one of the necessary processes in various institutions because it helps Rationalization of inputs rationalize use and achieve the best goals.
- 2-The encapsulated data analysis method is considered the most appropriate for evaluating performance in similar activity units.
- 3-The Iraqi Cement Company's factories are characterized by a low level of performance because the average technical efficiency was 0.582.
- 4-Out of 13 factories, only three factories achieved the optimal performance level with a technical efficiency index of 100% in the CRS model and are considered efficient institutions.
- 5- The rest of the inefficient factories were characterized by average, if not weak, levels of performance due to their inability to achieve acceptable levels of technical efficiency.
- 6- Inefficient factories can simulate and emulate reference units to improve their performance.
- 7- It is possible the target values shown by the results of the method clarify the amount of expansion or increase that inefficient factories can achieve to reach the optimal level of performance.

3-3 C-Determining the program :

Due to the large and numerous calculations, and the time and effort that they can take, the DEAP2.1 (data envelopment analysis program) program was used as a specialized program in calculating efficiency indicators using the DEA method in solving data envelopment analysis problems, in order to estimate efficiency indicators, economies of scale and reference institutions, and improvements in inputs and outputs. This program uses linear programming to determine the optimal combination of a set of inputs and a set of outputs for production facilities with similar goals, based on the actual performance of these facilities. It is worth noting that each of the factories studied represents a decision-making unit (Dmus), which is a separate unit from other factories (other decision-making units). The variables used in this research, which are represented by one output (profits) and three inputs (capital, value of raw materials, energy and fuel) during the year 2023).

Analysis of the efficiency scores of Iraqi cement factories Research sample:

In this section, the efficiency measurement results will be presented according to each institution (factory), through a table showing the efficiency score for the CCR DEA model - with the input orientation. We will analyze the efficiency

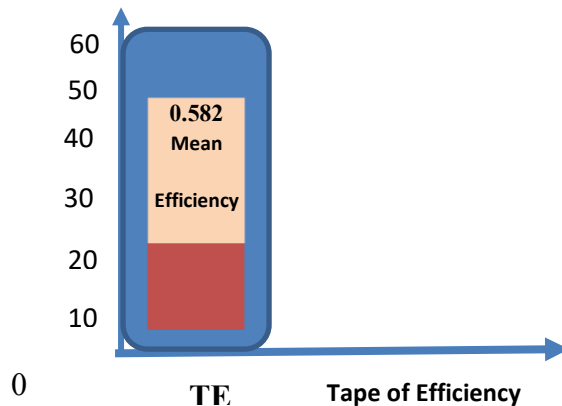
indicators of cement factories by focusing on the efficiency in each model. As for the results of estimating the technical efficiency for the year TE (Technical Efficiency) 2023, they were as follows and according to the table below:

Table (2) Technical efficiency grades for cement factories 2023

Technical Efficiency TE Year (2023)	Cement Factories (Decision Making Units) DMU's	Sequence
0.246	Al Rafidain Factory	1
0.083	Babylon Factory	2
0.299	Najaf Factory	3
0.820	Basra Factory	4
0.145	Kufa Factory	5
0.667	Samawa Factory	6
0.904	Kabisa Factory	7
0.561	BadushExpansion Factory	8
1.000	Karbala Factory	9
0.170	Muthanna Factory	10
1.000	Kirkuk Factory	11
1.000	Sinjar Factory	12
0.667	Al Qaim Factory	13
0.582	Mean	

Source: Researcher's own work based on the results of the Deap ver 2.1 program.

Figure (7) Mean technical efficiency obtained using the DEA method.



Source: Researcher's own work based on the results of the Deap ver 2.1 program.

Through the previous table (efficiency ratios achieved during the years under study for Iraqi cement factories), the results obtained from the application of the CCR model were divided into two types of (factories) that were classified according to **efficiency, which are :**

1-Efficient factories during 2023

Three factories that operate at 100% efficiency constituted **23%** of the sample size under study. It is clear from the efficiency indicators that there is optimal utilization of available resources to achieve the highest level of outputs or products.

2-Inefficient factories in 2023:

Ten factories and included **76 %** of the total sample size.

The impact of the lack of efficiency in these institutions is due to the poor exploitation of available resources, resulting from inefficiency according to the CCR model. As for the inefficient factories in the year (2023), most of them, with the exception of the (Karbala, Kirkuk and Sinjar) factories, were efficient and were able to achieve the highest levels of performance due to their achievement of a complete efficiency level of 100%, which qualifies them to be a reference for the rest of the factories that were unable to achieve high levels of performance.

3-4 Improvements needed for inefficient factories :

One of the advantages of the **DEA** method is that it determines the efficiency levels of the decision-making units involved in the evaluation and provides us with the sources of inefficiency and what are the target values in order to reach the full levels of efficiency and thus the highest levels of performance. Since we used the input-oriented constant

returns to scale model that aims to reduce inputs by using the existing level of outputs, the target values will be for the inputs only, which for our study are capital, the value of raw materials, energy and fuel. The process of determining the target values for each faculty shows us the improvements that must be worked on to reach the optimal levels of performance. This is done by simulating efficient factories and following their example.

4-Conclusions and Suggestions :

4-1 First: Conclusions

From the above, we can reach the following conclusions:

The process of measuring the efficiency and effectiveness of productivity It is considered is one of the most prominent main functions of decision-making units, which requires following very accurate measurement indicators to effectively meet the demand for its products and services, achieve its goals, enhance its market share, and sustain its survival in the fields of production and work.

It is considered the success of any organization depends primarily on the effectiveness of inputs, outputs and the right time, which depends on supporting means and tools, including operations research, which is represented by the decision-making process based on the scientific approach and that relies on quantitative analysis methods in solving administrative problems to reach the best alternative in light of the available capabilities.

(Data envelopment analysis models have become increasingly applied in the analysis of production efficiency, and the number of experimental applications has become many in various fields. Modern theoretical and mathematical research has also contributed to a deeper understanding of these models, which appear simple on the surface but are complex in nature) .

It is considered The research shows that inefficient decision-making units did not benefit from their efficient evidence during the period under study, which means that each production unit operates in isolation from other decision-making units. Inefficient production units were obliged to review the production patterns and methods adopted in efficient units.

It is considered the main source of the low efficiency of the cement manufacturing plants under study, which indicates that the plants studied were less efficient in controlling their costs (resources).

4-2 Second: Proposals

Based on the conclusions reached, we propose the following:

- **1-** Adopting the research results in order to raise the efficiency of the performance of inefficient plants by reducing inputs according to the specified amounts on the one hand and working to increase outputs on the other hand.
- **2-** It is possible that Efficient plants should be taken as a reference unit for the rest of the inefficient plants in order to improve their performance.
- **3-**we should Measuring efficiency at the end of each year and determining the efficient plants and the percentage of reaching full technical efficiency for the inefficient plants. When measuring the efficiency of the performance of cement manufacturing companies is repeated every year and developing and implementing plans, the efficiency of the plants will increase.

Abbreviations :

The following abbreviations are used in this manuscript:

TE technical efficiency

CRS constant returns-to-scale

DEA data envelopment analysis

DMU decision making unit

LP linear programming

RTS returns to scale

(CCR-I) Charnes, Cooper, and Rhodes in put

(CCR-O) Charnes, Cooper, and Rhodes out put

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Conflicts of Interest

The author declares no conflict of interest.

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