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Evaluation of green supply chain performance using balanced scorecard and data envelopment analysis

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Abstract

Environmental pollution and the deterioration of natural resources are now considered significant challenges in human societies. In fact, environmental pollution is mainly caused by manufacturing industries. Most industries (e.g., the cement industry) employ the green supply chain to overcome ecological problems, a goal that requires various techniques for quantifying the environmental impacts on the supply chain to improve processes. This study aimed to evaluate the green supply chain performance at 11 cement manufacturing factories through the hybrid BSC–DEA approach within the 2018–2020 period. After the principal indices were identified and placed in each perspective of the balanced scorecard (BSC), the DEMATEL technique was adopted to determine the relationships of perspectives. The multistage data envelopment analysis (DEA) model was then employed to measure the efficiency of each BSC perspective and the total network efficiency. Finally, reference units were introduced to improve the inefficient units. According to the results, managers focus mainly on the financial section and customers but pay less attention to growth and learning. The organization yielded the best efficiency in 2020 by following an upward trend. The energy consumption rate, clinker–cement ratio, and CO2 emission rate were analyzed in this study to better investigate the environmental problems in the cement industry. Most of the units followed upward trends in both CO2 emission and energy consumption but experienced a downward trend in clinker production.

Keywords: Performance evaluation; Balanced scorecard (BSC); Data envelopment analysis (DEA); DEMATEL; green supply chain.

Paper Type: Original Research

1. Introduction

Environmental concerns are inextricably linked to supply chains. These issues are reflected in business environments and government resolutions (Wang & Gupta, 2011). Green supply chain is a new industrial development trend. Today, the diversity of standards has compelled many sectors to consider environmental considerations in their supply chain management. Various methodologies should be used to measure environmental issues in a supply chain and suggest areas for improvement (Kim et al., 2021; Wang & Gupta, 2011). A current source of concern is the rise of greenhouse gases, which is causing global warming (Panja & Mondal, 2019). Carbon dioxide is one of the primary culprits, and more restrictions have been implemented in recent years to limit its emissions. The cement business is one of the manufacturing industries that greatly contributes to greenhouse gas emissions (8%) (Andrew, 2018). Cement output should be maintained while demand for infrastructures such as housing, schools, roads, and dams rises. It is impossible to imagine modern life without cement. Furthermore, cement production is a critical component of both national and international economies.

Because the chemistry of the process cannot be modified, carbon dioxide is always emitted during cement manufacture. This is actually an energy-intensive process that cannot be considered environmentally friendly at all. Furthermore, substantial amounts of nonrenewable resources are used in this process, generating a remarkable amount of CO2 and particulate matter. This raises the following issues: To what extent may cement production be considered sustainable? What are the most cutting-edge technologies for long-term industry improvement? What are the expected future contributions?

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The cement industry should undoubtedly adopt sustainable practices and take many innovative measures to mitigate the impact of all of the aforementioned concerns. As a result, an intriguing area of research is to investigate the green cement supply chain in order to improve environmental performance. In recent years, much emphasis has been placed on the importance of green supply chains in improving organizational environmental performance. Greening a supply chain increases competitiveness and economic performance. Furthermore, analyzing the overall performance of a supply chain is crucial for establishing an effective green supply chain management (GSCM).

Because greening a supply chain cannot be accomplished overnight, performance metrics at each stage will reflect how much a firm has invested in its environmental supply chain project (Balon, 2020; Cazeri et al., 2017). External reporting (economic rate), internal control (better business management), and internal analysis (better understanding of business and continuous improvement) are the primary goals of GSCM performance evaluation. These are the core challenges that comprise a framework influencing the long-term performance by making judgments about selecting and developing suppliers, selecting the carrier, routing vehicles, making spatial decisions, specifying packaging alternatives, and so on (Cazeri et al., 2017). As a result, performance assessment systems should provide both quantitative and qualitative dimensions in order to match the organization's strategic goals (Shafiee et al., 2014). BSC, developed by Kaplan and Norton in 1992, is a qualitative approach to performance evaluation that includes four dimensions: financial, customer, internal process, and learning and growth. In comparison to previous systems that focus solely on financial measurements, BSC aims to instill consistency in decision-makers attitudes toward the organization's prospect of major operations. It considers both financial and non-financial components, long-term and short-term strategies, as well as internal and external business metrics (Shafiee et al., 2014).

A few studies have dealt with the relationship between the four BSC dimensions. The majority of studies concentrated on the effects of learning and growth on internal processes, the effects of internal processes on customers, and the effects of customers on financial dimensions. It should be emphasized that, in addition to the ones listed, other essential correlations can be utilized to rigorously analyze performance. Because BSC cannot assess efficiency, a quantitative method should be utilized. To evaluate GSC performance, this study employed DEA to calculate the efficiency score of each of the four BSC dimensions. DEA is a non-parametric method for assessing efficiency developed by Charnes et al. (1978).

DEA can provide a complete picture of an organization's performance. Therefore, conventional methods such as the DEA fail to properly evaluate efficiency, for they consider each decision-making unit (DMU) a black box without knowing anything about its internal structures. A network-based model can be employed to better analyze the dynamism of processes and sub-processes of production.

Many studies have merged BSC and DEA, the majority of which have either employed standard DEA methods to evaluate performance or have not addressed all relationships between the four BSC dimensions. Using a multi-stage DEA suited for network model evaluation, this study investigated other relationships between the four BSC dimensions. It should be noted that a few studies have previously employed the same methodologies to explore the green cement supply chain. Contrary to the previous studies, independent inputs and outputs were considered in each BSC stage. In addition to calculating the total efficiency in the present model, it is possible to calculate the efficiency of each BSC stage and to determine the source of inefficiency. Moreover, each stage has variable weights indicating the relative importance or performance share of each stage in proportion to the total process performance. In the green supply chain, qualitative data are as important as quantitative data; hence, using a performance evaluation framework by integrating the BSC with the DEA can lead to more accurate evaluation results. The main research objectives were as follows:

1. Determining the performance structure that outlines the performance evaluation parameters and indications.

2. Differentiating between distinct relationships between indicators (the four BSC dimensions) in order to achieve the intended goals.

3. Identifying the efficient and inefficient units and also the source of inefficiency in each unit to improve them.

The study findings can help cement manufacturers in promoting various aspects of their business. The rest of the paper is organized as follows: Section 2 describes the mythology and literature review, Section 3 provides the data and details of the experimental study, Section 4 presents the results, and Section 5 delivers the concluding remarks, limitations, and recommendations for future studies.

2. Literature review

2.1. Green Supply Chian Management

Green consciousness has evolved as a competitive advantage for businesses since the late 1980s and early 1990s (Kazancoglu et al., 2018). In 1996, the Michigan State University Industrial Research Association introduced the concept of GSCM. It integrates supply chain management with environmental requirements at all stages, including designing the product, selecting and supplying raw materials, manufacturing, conducting distribution and shipping processes, delivering to customers, and finally managing product recycling after use to maximize energy and resource consumption efficiency and improve overall supply chain performance. GSCM generally promotes the efficient, effective, and complete implementation of green activities (Achillas et al., 2018). Increasing the public awareness of environmental destruction and strict laws of the state have made organizations execute different sustainability-based green methods (Lin, 2022). To provide higher long-term advantages from GSCM, all supply chain components should work together to reduce the ecological imbalance generated by supply chain operations (Wibowo et al., 2018). Environmental considerations may progressively emerge as another essential component of corporate strategies (Mahmood et al., 2013). Many of the leading organizations in developed countries have acquired competitive advantages through different techniques such as the GSCM (Ghosh et al., 2022; McDougall et al., 2022). Green practices enable enterprises to enter new markets and export to green countries, but unsustainable firms are unable to export to green countries such as the US, Germany, the UK, and Poland (Khan, 2018). Compared with the conventional supply chain, the GSCM execution appears to be complicated in the manufacturing sector; however, it is executable (Lamba & Thareja, 2021). Nonetheless, the success of the GSCM depends completely on the commitments of shareholders. If they are unwilling to execute GSCM methods in their facilities, then organizational efforts will be very ineffective in the GSCM (Ghosh et al., 2022).

2.2. Balanced Scorecard

Harvard Business School professor Robert Kaplan and a prominent management consultant David Norton introduced BSC in 1996 (Kaplan & Norton, 1996; Tawse & Tabesh, 2022). It is a performance management tool that combines financial and non-financial measurements to link an organization's mission, fundamental values, and vision with plans, goals, and activities aimed at sustainable development (Beard, 2009; Cullen et al., 2003; Robert, 1992; Taylor & Baines, 2012; Umashankar & Dutta, 2007; Wu et al., 2011). Because BSC and its four dimensions have a vast scope embracing all covert aspects of the organization, they are employed to assess the performance of organizations (Bostan et al., 2019; López-Ospina et al., 2017). BSC applications, in particular, necessitate clarity in predicted short-, mid-, and long-term outcomes. The BSC development requires a strategy map (Kaplan et al., 2004). The BSC technique evaluates the corporate performance from four perspectives: financial, customer, internal processes, and learning & growth (Sarraf & Nejad, 2020).

Financial, customer, internal process, and learning and growth are the four dimensions with a causal relationship. This relationship begins with a learning and growth dimension as the cause, then moves on to internal process and customer dimensions, and finally to a financial dimension as the result (Acuña-Carvajal et al., 2019). The four BSC dimensions are described below in detail:

Financial dimension: It is linked to the firm's profitability, reflecting its previous standing (Sarraf & Nejad, 2020). This dimension's measures reflect what financial outcomes are obtained when the objectives of the other three dimensions are accomplished. By linking financial data, BSC offers managers an accurate picture of the economic effects of operations completed (Kaplan & Norton, 2015).

Customer dimension: It takes into account customer targeting indicators as well as market share (Sarraf & Nejad, 2020). The primary goal is to ensure that customers are satisfied with the company's products and services.

Internal process dimension: Managers should concentrate on essential internal procedures that allow them to meet the needs of their consumers. Internal BSC indicators should be based on processes with the greatest effects on customer and shareholder satisfaction (Kaplan & Norton, 2015).

Learning and growth dimension: It is divided into three sections: personnel, systems, and organizational procedures. Setting financial, customer, and internal process goals in BSC reveals the gaps between present staff competencies, systems, procedures, and all other important needs for successful performance (Kaplan & Norton, 2015). The learning and growth dimension is particularly relevant to firms that are committed to enhancing their employees' knowledge and intellectual capital (Bratianu, 2018; Bratianu & Bejinaru, 2019).

Nonfinancial indices are so interconnected that their improvement will enhance the financial performance. Accordingly, organizations can spend time and energy on tangible and nontangible resources (e.g., employees, technology, and processes) to turn them into competitive advantages (Elbanna et al., 2022).

2.3. Data Envelopment Analysis

Charnes et al. developed DEA in 1978 to assess the relative efficiency of units (Charnes et al., 1978; Mardani et al., 2022). It is a non-parametric linear programming-based methodology that measures the efficiency of each decision-making unit (DMU) based on the production possibility set (PPS) determined by all DMUs (Lucas et al., 2021). The primary goal of DEA is to assess the efficiency of each DMU with various inputs and outputs (Amirteimoori & Khoshandam, 2011; Talluri, 2000). The efficiency produced by DEA is relative, and the efficiency boundary is established by a convex combination of efficient units. DMUs on this boundary are thus deemed efficient; otherwise, they are inefficient. The inputs and outputs of an inefficient unit must be changed to make it efficient. It is noteworthy that a reference set is supplied after the implementation of DEA models. This set explains how the inefficient unit should be compared to efficient units to approach the boundaries of efficiency.

2.4. Multi-Stage DEA

One of the characteristics of the conventional DEA structure is that it makes no assumptions about the system's internal structure. These internal structures frequently point to opportunities to improve the manufacturing process (Chen, 2009). As a result, using a multi-stage DEA allows for the examination of internal linkages between distinct phases. This multi-stage DEA is increasingly important in both theoretical research and experimental applications of DEA (Ang & Chen, 2016; Cook et al., 2010; Kao, 2014; Kao & Liu, 2014; Park & Park, 2009; Tone & Sahoo, 2003; Tsutsui & Goto, 2009). There are three distinctions between traditional DEA and multi-stage DEA. First, traditional DEA merely evaluates the system's inputs and outputs, whereas multi-stage DEA also considers middle outputs. Second, in conventional DEA, efficiency score optimization is the weight ratio of starting inputs to final outputs. However, in multi-stage DEA, the overall efficiency score is the sum of the weights of different stages' inputs and outputs. Third, in multi-stage DEA, efficiency for each DMU and stage can be derived, exposing the flaws and strengths. However, only the total efficiency score may be determined in traditional DEA (Ang & Chen, 2016). Multi-stage DEA models have been employed in a variety of industries such as cement production plants (Tone & Sahoo, 2003) ,power plants (Tone & Tsutsui, 2009; Tsutsui & Goto, 2009), airlines (Lee & Johnson, 2012), banking systems (Kao & Liu, 2014; Matthews, 2013), vegetable oil processing industries (Nouri et al., 2013), and TV service operating units (Park & Park, 2009). This research applies multi-stage DEA in GSC.

2.5. DEMATEL

DEMATEL (Decision Making Trial and Evaluation Laboratory) is a paired comparison decision-making technique developed by Gabus and Fontela in 1976, primarily for studying complex worldwide problems in scientific, political, economic, and social fields (Drumond et al., 2022; Thakkar, 2021). It can be used to study the primary relationships between important objectives in a strategy map by learning about the causal relationships between strategic criteria (Acuña-Carvajal et al., 2019). DEMATEL works as follows:

1. If multiple opinions are used, the average is determined, and the direct impact matrix, known as M, is created. It is a square matrix with the same number of rows and columns as the number of criteria.

2. Normalizing the matrix M: After summing up the row elements, the matrix M̃ is normalized by dividing all elements by the maximum value of rows. It is called matrix M.

$$M = \frac{1}{max \sum_{j=1}^{x} a_{ij}} \tag{1}$$

3. Computing the total relation matrix: Calculation of the infinite matrix of direct and indirect effects of matrix T is indicative of the relative intensity of direct and indirect relations.

$$T = M + M^2 + M^3 + \cdots + M^t = \frac{M(1-M^t)}{I-M} = \frac{M}{I-M} = M(I-M)^{-1}$$
$$\lim_{t \to 0} M^t = 0 \tag{2}$$

4. Setting the threshold value: After computing M (I-M)-1, the mean value of matrix T and the threshold value (average value of elements of matrix T) are calculated. Values of matrix T smaller than the threshold value are given a score of 0 (i.e., that causal relationship is ignored), and greater values are given a score of 1.

5. Building a cause-and-effect relationship diagram:

- The sum of each row (D) for each factor shows the extent to which that factor affects other factors of the system.
- The sum of each column's elements (R) for each factor shows the extent to which that factor is affected by other factors of the system.
- Horizontal vector (D+R) shows the extent to which that factor exerts an effect on the system. In other words, the higher the value of D+R, the more interaction the factor has with other factors of the system.
- Vertical vector (D-R) shows the extent to which that factor is affected. Generally, if D-R is positive, the variable is considered a cause, and if it is negative, the variable is considered an effect.
- Finally, a Cartesian coordinate system is drawn, in which the X-axis is D+R and the Y-axis is D-R. The position of each factor is specified by a point with coordinates (D+R, D-R).

2.6. Integration of BSC and DEA

To boost productivity, both of its key characteristics — efficiency and effectiveness — must be enhanced at the same time. If a company has high efficiency but no effectiveness, it will fail to pursue its strategies, increase its productivity, and achieve its objectives. On the other hand, if an organization works efficiently but not effectively, it will take longer to achieve long-term goals. Because BSC measures the effectiveness and success of a strategy and DEA measures the efficiency of an organization, the two productivity factors (effectiveness and efficiency) can be examined concurrently by merging these two models (Najafi et al., 2009). BSC is used to construct performance assessment indicators in the integrated BSC-DEA model, while DEA is utilized as a tool to evaluate performance. When a perfect organization competes with others, it will achieve the highest degree of productivity.

Less-efficient companies compare their productivity to that of top-level organizations and seek to approach an ideal level by changing the processes, updating the procedures, and implementing other methods to boost their outputs (Najafi et al., 2009). The simultaneous use of BSC and DEA — two distinct methodologies — may improve the performance evaluation process of enterprises (Basso & Funari, 2020).

Many studies have dealt with the use of BSC-DEA in various industries. Vitezić et al. (2019), for example, suggested a new approach to measuring the efficiency of public health services using DEA-BSC. Tan et al. (2017) assessed the performance of ten auto sales representatives using BSC-DEA. This integrative model was used by Amado et al. (2012) to assess organizational performance. Hsu et al. (2013) developed a new model of recognizing routes to improve shipping services by integrating BSC and DEA. Chen et al. (2008) used DEA-BSC to assess Huelin Bank's performance efficiency. García-Valderrama et al. (2009) used BSC-DEA to assess the performance of 90 enterprises in order to demonstrate their innovations. Wang et al. (2013) proposed a comprehensive framework for analyzing the performance of enterprises in Thailand's tourism industry using the BSC-DEA and Boston Consulting Group (BCG) matrices. Bošković and Krstić (2020) applied BSC-DEA in the banking industry. Horváthová et al. (2019) employed BSC-DEA to analyze 295 heating equipment manufacturers in the Slovak Republic. Based on BSC-DEA, Asosheh et al. (2010) offered a new approach to selecting IT projects, in which BSC is used as a comprehensive framework for defining the IT project evaluation indicators, and DEA is used as a non-parametric method to rank IT projects. However, a few studies examined the efficiency and performance of green supply chains in the cement industry using BSC-DEA. This study hence aims to be the first one in this field.

3. Methodology

3.1. multi-stage DEA model for GSC evaluation

Measuring GSC performance by only considering the initial inputs and final outputs is insufficient because the relationships between sections are disregarded. To accomplish this, a multi-stage input-driven DEA with three sorts of input is used: inputs from outside the process, inputs from the previous stage, and inputs from another stage (Z_2^2,Z_5^2). It also has three types of output: one that does not enter another stage, one that enters the next stage as an input, and one that enters any other stage as an input.

- Z_{pr}^{j1}: r-th element of (r=1,…,RP) from dimensional output vector RP for DMUj, which quits the stage P and does not enter the stage P+1 as an input.

- Z_{pk}^{j2}: k-th element of (k=1,…,SP) from dimensional output vector SP for DMUj, which quits the stage P and enters the stage P+1 as part of the input.

- Z_{pi}^{j3}: i-th element of (i=1,…,IP) from dimensional input vector IP for DMUj, which enters the stage P+1.

Note that at the final stage P, all outputs are considered as Z_{pr}^{j1}, and quit the process.

U_{pr}: Output coefficient of Z_{pr}^{j1} which quits Stage P and does not enter any other stage.

η_{pk}: Output coefficient of Z_{pk}^{j2} which quits Stage P and enters Stage P+1.

V_{pi}: Input coefficient of Z_{pi}^{j3} which enters Stage P+1.

Therefore, when p=2, 3, …, the efficiency of DMUj will be as follows:

$$\theta_P = \frac{\left(\sum_{r=1}^{R_p} u_{pr} z_{pr}^{j1} + \sum_{k=1}^{S_P} \eta_{pk} z_{pk}^{j2}\right)}{\left(\sum_{k=1}^{S_{p-1}} \eta_{p-1k} z_{p-1k}^{j2} + \sum_{i=1}^{I_p} v_{p-1i} z_{p-1i}^{j3}\right)} \quad (3)$$

Note that no output enters the stage 1; thus, the efficiency of Stage 1 for DMUj will be as follows:

$$\theta_1 = \frac{\left(\sum_{r=1}^{R_1} u_{1r} Z_{1r}^{j1} + \sum_{k=1}^{S_1} \eta_{1k} Z_{1k}^{j2}\right)}{\sum_{k=1}^{I_0} v_{0i} Z_{0i}^{j}} \quad (4)$$

Since Z_{0i}^{j} is the only input entering the stage 1, it is shown by the input vector Z_0. The overall efficiency of the multi-stage process can be considered as a convex linear combination of efficiency P of that stage, indicated as follows:

$$\theta = \sum_{p=1}^{p} w_p \theta_p \quad where \quad \sum_{p=1}^{p} w_p = 1 \quad (5)$$

Note that weights WP are the relative importance or the portion of the stage P performance in the overall performance of the process. A logical choice for weights WP is the ratio of all resources allocated to Stage P to the resources allocated to the entire process. The number of resources allocated to the entire process equals:

$$\sum_{i=1}^{I_0} V_{0i} Z_{0i}^{j} + \sum_{p=2}^{p} \left(\sum_{k=1}^{S_{p-1}} \eta_{p-1} Z_{p-1k}^{j2} + \sum_{i=1}^{I_p} V_{p-1i} Z_{p-1i}^{j3} \right) \quad (6)$$

Therefore, the weights of each stage are obtained as follows:

$$w_1 = \frac{\sum_{i=1}^{I_0} V_{0i} Z_{0i}^{j}}{\left\{\sum_{i=1}^{I_0} V_{0i} Z_{0i}^{j} + \sum_{p=2}^{p}\left(\sum_{k=1}^{S_{p-1}} \eta_{p-1k} Z_{p-1k}^{j2} + \sum_{i=1}^{I_p} V_{p-1i} Z_{p-1i}^{j3}\right)\right\}} \tag{7}$$

$$w_p = \frac{\left(\sum_{k=1}^{S_{p-1}} \eta_{p-1k} Z_{p-1k}^{j2} + \sum_{i=1}^{I_p} V_{p-1i} Z_{p-1i}^{j3}\right)}{\left\{\sum_{i=1}^{I_0} V_{0i} Z_{oi}^{j} + \sum_{p=2}^{p}\left(\sum_{k=1}^{S_{p-1}} \eta_{p-1k} Z_{p-1k}^{j2} + \sum_{i=1}^{I_p} V_{p-1i} Z_{p-1i}^{j3}\right)\right\}} \quad p > 1 \tag{8}$$

The linear programming model used to calculate coefficients and weights is as follows:

$$\begin{aligned}
& max \sum_{p=1}^{p}\left(\sum_{r=1}^{R_p} u_{pr} Z_{pr}^{01} + \sum_{k=1}^{S_p} \eta_{pk} Z_{pk}^{02}\right) \\
& s\ t. \sum_{i=1}^{I_0} V_{Oi} Z_{0i}^{0} + \sum_{p=2}^{p}\left(\sum_{k=1}^{S_{p-1}} \eta_{p-1} Z_{p-1k}^{02} + \sum_{i=1}^{I_p} V_{p-1i} Z_{p-1i}^{03}\right) = 1 \\
& \sum_{k=1}^{S_1} \eta_{1k} Z_{1k}^{j2} \leq \sum_{k=1}^{I_0} v_{0i} Z_{0i}^{j} \qquad j = 1 \ldots\ldots n \\
& \left(\sum_{r=1}^{R_1} u_{1r} Z_{1r}^{j1} + \sum_{k=1}^{S_1} \eta_{1k} Z_{1k}^{j2}\right) \leq \left(\sum_{k=1}^{S_{p-1}} \eta_{p-1k} Z_{p-1k}^{j2} + \sum_{i=1}^{I_P} V_{p-1i} Z_{p-1i}^{j3}\right) \\
& \sum_{r=1}^{R_1} u_{1r} Z_{1r}^{j1} \leq \left(\sum_{k=1}^{S_{p-1}} \eta_{p-1k} Z_{p-1k}^{j2} + \sum_{i=1}^{I_P} V_{p-1i} Z_{p-1i}^{j3}\right) \\
& \qquad u_{pr}, \eta_{pk}, v_{pi}, v_{0i} > 0. \qquad w_p \geq \beta
\end{aligned} \tag{9}$$

4. Result

4.1. Case study

This experimental study focused on a group of DMUs owned by Fars and Khuzestan Cement Co. The following are summaries of the analyses done in this study: Because BSC is founded on causal relationships, DEMATEL was utilized to build these relationships in the following stage. Since they organize a network structure, multi-stage DEA was used to determine the GSC performance. The efficiency of each unit was then identified. It should be noted that this study was inspired by a study conducted by Shafiee et al. (2014). The difference is that this study included independent inputs and outputs as well as the DEA model. It also considers three consecutive years (2018, 2019, and 2020). Each stage is elaborated in the following.

4.2. BSC Model

Examining GSC-related areas led to the identification of the efficient indicators of the cement industry. Then a questionnaire was distributed among the cement industry experts, including managers and professionals, in order to choose the final indicators. After interviewing the managers and considering the chosen methods and indicators, they were grouped into four BSC dimensions, as shown in table (1). The indicators proposed were chosen based on the availability of credible data.

Table 1:Key indicators of green cement supply chain in balanced scorecard dimensions

Dimensions	criteria	objectives
Finance	- Logistics costs. - Percentage of operating profit. - The cost of goods sold. -	- Reduce the cost of the product. - Reduce environmental costs. - Increase revenue. - Value creation for stakeholders
Customer	- Market share. - The number of returned products. - Percentage of timely delivery. - Average shipping time. -	- Create value for the customer. - Create a competitive advantage - Increase customer loyalty.
Internal Processes	- electrical energy consumption. - fuel consumption. - the amount of clinker produced. - the amount of cement produced. - the amount of co2 produced. - Incentive percentage received. - Number of raw materials consumed. - Waste reduction rate. -	- Reduce production costs. - Reduce co2 emissions. - Waste management. - Reduce energy consumption. - Increase product quality. - - -
Learning and growth	- Customer attraction rate. - Ratio of training cost to total income. - The cost of teaching and learning. - Employee productivity.	- Increase employee safety. - Reduce crash rates. - Sales increase. - Increase the ability and capabilities of employees. -

4.3. Determining network relations among BSC dimensions using DEMATEL

Another questionnaire scored based on a 7-point Likert scale was used in this step to ask the firm managers to explain the relationships between the four BSC dimensions. DEMATEL was implemented as follows after analyzing the relationships between the dimensions based on the opinions of managers and professionals:

1. Generating direct-relation matrix (M)

2. Normalizing the matrix M (model 2)

Table 2:The intensity of the relative effect of direct relations

- M	- Learning and growth	- Internal processes	- Customer	- Finance
- Learning and growth	- 0	- 0.333333333	- 0.333333333	- 0.333333333
- Internal processes	- 0.273224044	- 0	- 0.273224044	- 0.303278689
- Customer	- 0.273224044	- 0.273224044	- 0	- 0.303278689
- Finance	- 0.242258652	- 0.212204007	- 0.242258652	- 0

3. Computing the total relation matrix

Table 3: Intensity of the existing relative effect of direct and indirect relationships

- M*(I-M) ^-1	- Learning and growth	- Internal processes	- Customer	- Finance
- Learning and growth	- 1.285068339	- 1.566834434	- 1.607539377	- 1.724409373
- Internal processes	- 1.345152850	- 1.157948351	- 1.408657920	- 1.530059956
- Customer	- 1.345152850	- 1.372540625	- 1.194065646	- 1.530059956
- Finance	- 1.164899317	- 1.170014328	- 1.219894564	- 1.113108207

4. Setting the threshold value

Table 4:Influence of elements on each other

- T	- Learning and growth	- Internal processes	- Customer	- Finance
- Learning and growth	- 0	- 1	- 1	- 1
- Internal processes	- 0	- 0	- 1	- 1
- Customer	- 0	- 1	- 0	- 1
- Finance	- 0	- 0	- 0	- 0

5. Building a cause and effect relationship diagram

Table 5:The efficiency and effectiveness of each of the BSC dimensions

- T	- Learning and growth	- Internal processes	- Customer	- Finance
- R+J	- 11.32412488	- 10.70915682	- 10.87197658	- 10.56555391
- R-J	- 1.043578166	- 0.174481339	- 0.01166157	- -1.229721075

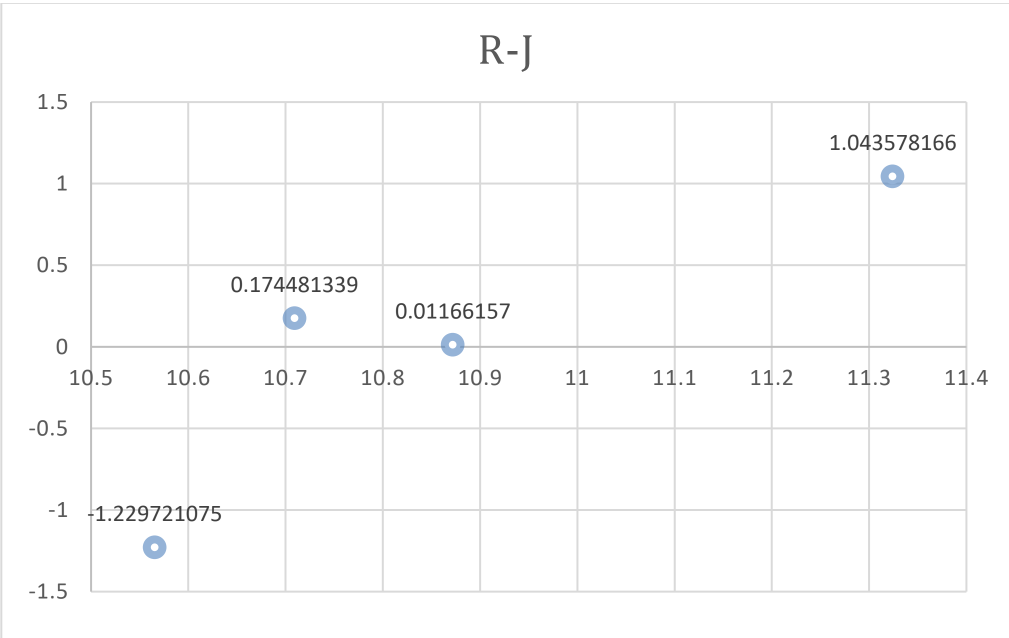

Figure.1: Diagram of the impact and effectiveness of each of the BSC dimensions

The results indicated that the most influencing aspect was the learning and growth viewpoint, whereas the most affected factor was the financial dimension. According to the research network structure, there were four stages, each with its own inputs and outputs, and the relationships between them. Table (6) shows the inputs and outputs of each stage.

Table 6: Inputs and outputs of four dimensions of BSC

Dimensions	Learning and growth		Internal processes		Customer		Finance	
	input	output	input	output	input	output	input	output
Learning and growth	-	✓	✓	-	✓	-	✓	-
Internal processes	-	-	-	✓	✓	-	✓	-
Customer	-	-	✓	-	-	✓	✓	-
Finance	-	-	-	-	-	-	-	-

4.4. multi-stage DEA

After DEMATEL determined the relationships, independent inputs and outputs were added to the intended model at this point. Each stage's indicators were as follows: In terms of learning and growth, the independent input was the cost of staff training, and the middle outputs were staff productivity, new customers, and the training-to-total-revenue ratio. It was assumed that staff training and raising the productivity rate of skilled workers boost staff productivity and ensure the safety of the majority of workers. Moreover, the marketing team will perform better and attract more clients if they are trained.

In the internal process dimension, the middle input was staff productivity and quality index; independent inputs were energy consumption (sum of electricity and thermal energy) and materials (limestone, sand, etc.); the middle output was the amount of cement produced and the bonus percentage†; and the independent output was the reduced rate of wastes and clinkers. Alternative materials and fuels were not considered since it was anticipated that plants that employ alternative materials and fuels are more environmentally friendly. Furthermore, the difference between clinker and finished cement showed that more alternative components were utilized.

In the customer dimension, the middle input was the amount of cement and new customers. One of the middle output indicators was the quality index referring to the mean shipping time, on-time delivery rate, and product return rate. Higher levels of quality were indicative of the fact that no product was returned, no complaint was filed, products were delivered on time, and the mean shipping time was short.

Products are often returned to the process because of poor quality or late delivery. As a result, we assumed it to be a good indicator of quality. Market share is another middle output from the customer's standpoint. Increasing market share, delivering items on time, and improving quality will boost customer happiness, which is the goal of this section.

In terms of finance, the middle input, as the output of the previous stage, was the market share, the training-to-total-revenue ratio, and the received bonus percentage. The total cost of products sold and logistical costs were independent inputs. One of the major indicators in the cement sector was the independent output, which is the operating profit percentage evaluated. The CO_2 emission rate was excluded from this model because it was an unfavorable and unquantifiable output. As a result, a diagram for each plant was drawn to illustrate it. Data for the study were gathered from www.codal.ir and the relevant organization. It should be highlighted that indicators relating to suppliers were not included in this study because cement plants were typically mine owners that supplied their own resources.

Table (7) shows the mean and standard deviation of this model's input and output parameters from 2018 to 2020. According to time series analysis, the volume of cement consistently climbed up to 2019 and reached a peak in 2020. The key reason for this shift was the increased production at Abyek, Bojnurd, Saveh, and Khuzestan plants. Furthermore, the mean clinker-to-cement ratio decreased from 10.44 in 2018 to 0.90 in 2020.

This is due to the increased amount of blended cement and the large volume of alternative raw materials utilized in the clinker production process. The pace of energy use is gradually increasing. According to the research, none of the plants use alternative fuels like waste or biomass, and all are powered by natural gas. Nonetheless, the use of fuel oil, which emits more CO_2 than gas, has been reduced. Reduced energy use and clinker production will reduce CO_2 emissions over time (Oggioni et al., 2011).

† The received bonus percentage shows how much energy the firm has saved. This affects cost reduction and financial affairs.

Table 7: Input and output indicators used to evaluate the performance of cement plants

variables	2018		2019		2020	
	mean	Std.dev.	mean	Std.dev.	Mean	Std.dev.
The cost of teaching and learning (MI)	313	50	303	43	291	41
Ratio of training Cost to total income (%)	323.54	357.6	218.76	251.51	3264	1031
New customer (N)	9.091	5.775	11.090	6.126	1243.45	1094.28
Employee Productivity (MI)	1.303	0.822	1.767	0.989	2.623	1.978
Energy (fuel, electrical) (TWH)	1.223	0.674	1.321	0.785	1.450	0.731
Raw materials (MI t)	1845	8519	2,243	1,622	2,191	1,213
Clinker (MI t)	1139	575	1,239	683	1,269	686
Cement (MI t)	1039	484	1,133	552	9,640	26,476
Waste reduction rate (%)	19.055	16.426	17.836	22.029	17.86	7.678
Incentive percentage received (%)	45122	86562	15199	14137	15452	26152
Market share (%)	1.979	0.912	1.954	0.963	1.871	0.985
Quality index (%)	0.932	0.111	0.909	0.120	0.840	0.192
Logistics costs (MI)	208	117	365	255	623	423
The cost of goods sold (MI)	91471	428	1,261	623	1,831	936
Percentage of operating profit (%)	0.202	0.091	0.224	0.115	0.634	0.082
Clinker/cement	10.441		0.9573		0.9029	

The quality index includes product return rate, timely delivery percentage, and mean shipping time. The first index has a score of 0.5 and the other two indicators have a score of 0.25.

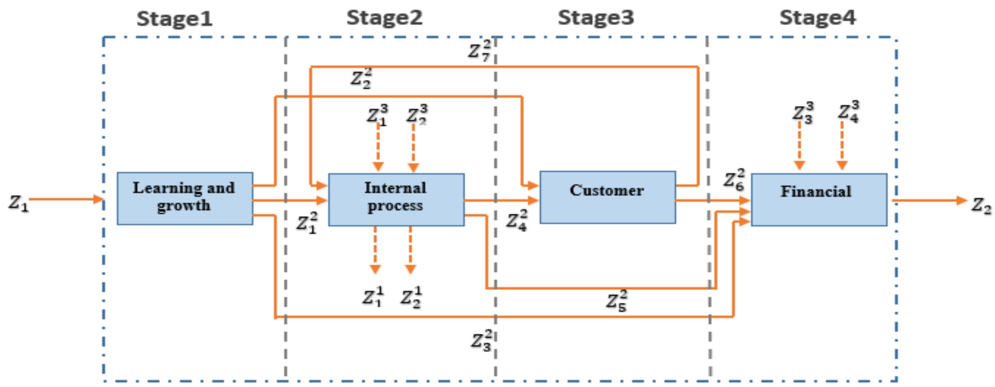

Figure. 2: Network data envelopment analysis of cement

Table 8: Input and output indicators used in evaluating the performance of cement plants

Dimensions	Inputs (independent)		outputs (independent)		Intermediate indicators	
Learning and growth	The cost of teaching and learning (MI)	Z_1			Ratio of training Cost to total income (%)	Z_3^2
					Employee Productivity (MI)	Z_1^2
					New customer (N)	Z_2^2
Internal processes	Energy (fuel, electrical) (TWH)	Z_1^3	linker (MI t)	Z_1^1	Cement (MI t)	Z_4^2
					Incentive percentage received (%)	Z_5^2
	Raw materialS (MI t)	Z_2^3	Waste reduction rate (%)	Z_2^1	Employee Productivity (MI)	Z_1^2
					Quality index (%)	Z_7^2

Customer					Market share (%)	Z_6^2
					Quality index (%)	Z_7^2
					Cement (MI t)	Z_4^2
					New customer (N)	Z_2^2
Finance	Logistics costs (MI)	Z_2^2	Percentage of operating profit (%)	Z_2	The cost of teaching and learning (MI)	Z_1
	The cost of goods sold (MI)	Z_3^3			Incentive percentage received (%)	Z_5^2
					Market share (%)	Z_6^2

4.5. Numerical Result

This study combined BSC and DEA models to determine the relative efficiency of 11 Iranian cement plants affiliated with the Fars and Khuzestan Cement Holding. The model was solved using the General Algebraic Modeling System (Version 33). Table (9) displays the performance ratings achieved for various parts of the organization.
These scores were then shown on a radar graph (Figure. 3) to help visualize the scores received in each of the BSC dimensions. Table (10) presents the benchmarks for each representative. The data acquired for each DMU reveal their progress or regression in efficiency over time.
DMU3 exhibited the best performance in terms of growth and learning, with a full performance score every three years. DMUs 4 and 9 progressed and attained full performance in 2020. In all three years, DMU10 had the worst performance. Furthermore, most factories (DMUs 1, 2, 3, 10, and11) had their lowest efficiency and exhibited downward growth in 2020. These units should focus more on personnel, training, and skill development because this dimension can greatly affect other dimensions.
In terms of internal processes, the majority of factories (DMUs 1, 3, 6, 10, and 11) achieved the highest efficiency score every three years. DMUs 7 and 9 likewise showed an upward tendency over the last three years. By contrast, DMUs 2 and 8 exhibited a declining trend, indicating that they need to pay more attention to some aspects of their internal processes.
On the customer side, most factories' efficiency increased between 2018 and 2020 (DMUs 1, 9, 10, and 11). DMU 4 outperformed the others in all three years. DMUs 6 and 8 were also able to improve and achieve the highest performance. DMU 10 showed the worst overall performance throughout all three years. The DMU 5 was declining, with the lowest performance in 2020. As a result, these units should devote greater attention to customer satisfaction, marketing, retention, and new client acquisition.
Most factories enjoyed financial growth, and most units were on track to attain full efficiency by 2020 (DMUs 2, 3, 4, 5, 6, 7, 8, 9, and 10). DMUs 3, 6, and 10 showed the best performance, receiving a complete performance score for all three years, while DMUs 1 and 11 exhibited the poorest performance but still improved over previous years.
According to the mean score acquired for each component of the organization, the whole organization could raise its efficiency every year in the financial and customer dimensions, indicating that managers primarily focus on these two dimensions. Furthermore, a downward trend in the efficiency in the area of growth and learning demonstrates that managers placed less emphasis on this area. This is one of the crucial components in the cement industry that should be examined as part of its internal process (most environmental issues are in the cement production process). It is noteworthy that efficiency decreased in 2020 when compared to 2019.
A review of this part reveals that factories performed best in "finance" and then "customer", and showed the poorest performed in "growth and learning" and then "internal process". Employee performance substantially affects other areas, according to the growth and learning dimension. Furthermore, the decline in performance in terms of development and learning, as well as the internal process, is a warning sign of possible weakening financial performance in the future.
According to the mean score collected for each factory from all dimensions, most factories experienced their maximum efficiency in 2020 and improved themselves. DMU 2 has been declining from 2018 to 2020, indicating that it needs greater attention. Additionally, other factories with a declining trend in 2020 efficiency compared to 2019

(DMUs 3, 5, 8, and 10) recorded their lowest efficiency in 2018. The reason for each of these units' decreased efficiency may be traced back to the efficiency gained in each of the dimensions. As a result, inefficiencies can be recognized and corrected.

The study results also demonstrated that the whole organization experienced the highest efficiency in 2020 (0.84) and the lowest efficiency in 2018. This represents an improvement for the organization, although it still needs to take a long way to achieve the desired performance. None of the units were able to attain the highest performance in all dimensions in 2018. Nevertheless, DMU 8 in 2019 and DMU4 in 2019 managed to achieve this goal. Based on the data of the last year, it can be stated that Behbahan Factory (DMU4) was the most efficient unit in the studied organization (Table 9, Figure.3)

Table 9:The efficiency of each unit 2018-2020

	2018					2019					2020				
Units	L	P	C	F	Avg	L	P	C	F	Avg	L	P	C	F	Avg
1	0.72	1.00	0.72	0.37	0.70	0.88	1.00	0.63	0.21	0.68	0.55	1.00	1.00	0.56	0.78
2	1.00	1.00	0.68	1.00	0.92	0.91	0.99	0.96	0.82	0.92	0.66	0.55	0.70	1.00	0.73
3	1.00	1.00	0.68	1.00	0.92	1.00	1.00	0.97	1.00	0.99	1.00	1.00	0.80	1.00	0.95
4	0.94	1.00	1.00	0.89	0.96	1.00	0.91	1.00	0.30	0.80	1.00	1.00	1.00	1.00	1.00
5	1.00	0.45	0.97	0.10	0.63	1.00	1.00	0.93	0.59	0.88	0.54	0.51	0.71	1.00	0.69
6	1.00	1.00	0.57	1.00	0.89	0.65	1.00	1.00	1.00	0.91	0.69	1.00	1.00	1.00	0.92
7	0.54	0.69	1.00	0.52	0.69	0.60	0.94	1.00	1.00	0.88	0.59	1.00	0.97	1.00	0.89
8	0.67	1.00	0.74	0.58	0.75	1.00	1.00	1.00	1.00	1.00	0.71	0.52	1.00	1.00	0.81
9	0.68	0.50	0.57	1.00	0.69	0.68	1.00	0.49	0.13	0.57	1.00	1.00	0.71	1.00	0.93
10	0.43	1.00	0.46	1.00	0.72	0.63	1.00	0.44	1.00	0.77	0.37	1.00	0.57	1.00	0.73
11	0.91	1.00	0.79	0.15	0.71	1.00	1.00	0.46	0.12	0.64	0.48	1.00	0.94	0.65	0.77
Avg	0.81	0.88	0.74	0.69	0.78	0.85	0.98	0.81	0.65	0.82	0.69	0.87	0.86	0.93	0.84
Std.dev	0.20	0.21	0.17	0.34	-	0.17	0.03	0.23	0.37	-	0.21	0.21	0.15	0.15	-
Min	0.43	0.45	0.46	0.10	0.63	0.60	0.91	0.44	0.12	0.57	0.37	0.51	0.57	0.56	0.69
Max	1.00	1.00	1.00	1.00	0.96	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Because the indices' weights were zeroed, the efficiency of all weights more than or equal to the fixed value of 0.005 was calculated.

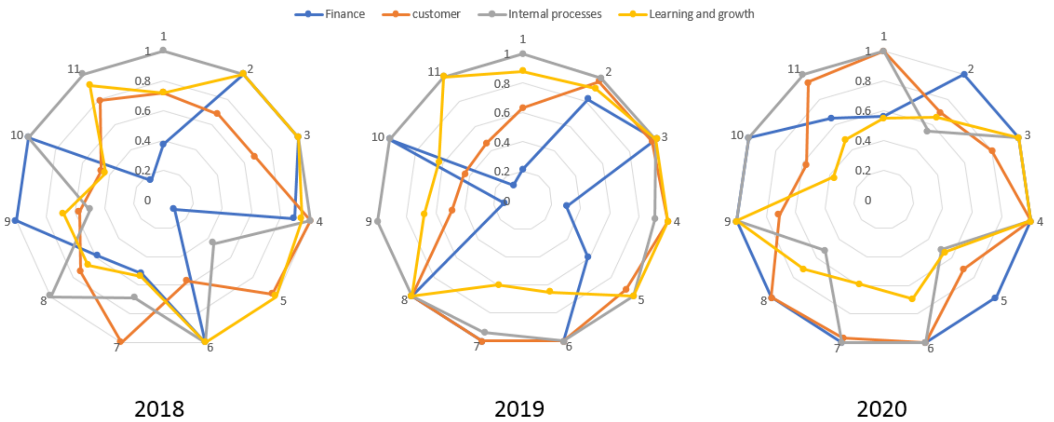

Figure. 3: Radar graph of the efficiency for each unit (2018-2020)

Table 10: Reference units in 2020

DMU	Finance	Customer	Internal processes	Learning and growth
DMU01	DMU03	DMU06, DMU07, DMU 11	DMU08	DMU05
DMU02	DMU03	DMU06, DMU11	DMU01	DMU05, DMU09
DMU03		DMU06, DMU11	DMU01	DMU02, DMU07
DMU04	DMU03	DMU06, DMU11	DMU01	DMU03, DMU05
DMU05	DMU03	DMU06, DMU11	DMU01	DMU03, DMU04
DMU06	DMU04, DMU09	DMU11	DMU01, DMU08	DMU05, DMU08, DMU09
DMU07	DMU03	DMU11	DMU01, DMU04	DMU09
DMU08	DMU04, DMU09	DMU06, DMU11	DMU01, DMU06	DMU05, DMU07, DMU09
DMU09	DMU04	DMU04, DMU06, DMU10	DMU01, DMU08	DMU05, DMU07, DMU08
DMU10	DMU03	DMU04, DMU09	DMU01, DMU08	DMU05, DMU08
DMU11	DMU03	DMU04, DMU06, DMU10	DMU01, DMU08	DMU05

According to Table (10) , each unit can improve its performance by mimicking higher-performing units. A detailed analysis of the results revealed that a DMU can have the highest performance in a dimension relative to other DMUs and be deemed the reference unit, even if it has inferior performance in other dimensions. Fars No Plant, for example, was recognized as the reference unit for Behbahan Plant, despite its poor performance in the other three dimensions. Unit 3 (Fars Plant) is the only unit with no reference unit in terms of learning and growth, and it has been regarded as the reference unit by the majority of DMUs. This implies that Fars Plant outperformed the others in terms of marketing and employee efficiency. In other dimensions, Unit 11 (Dorud) was regarded as the reference unit in terms of internal process, Unit 1 (Gharb) was considered the reference unit in terms of customer, and Unit 5 (Fars No) was considered the reference unit in terms of finance.

Therefore, this study primarily aimed to develop multiple-measure performance evaluation models to identify organizational strengths and weaknesses and to foster learning networks. If only one DEA model was employed or if only the relationship between one dimension and its next dimension was emphasized, some of this priceless information would be lost.

4.6. CO2 emissions

As shown in Fig. (4), most units (Saveh, Bojnourd, Caspian, Fars, Khuzestan, and Dorud) experienced an increase in carbon dioxide emissions. This can be attributed to several reasons, such as increased clinker production rather than cement manufacture, obsolescence of production machinery and factory filters, increased production of type 1 cement, and increased usage of fossil fuels. The most crucial reason, however, is an increase in clinker production. More clinker manufacturing requires more resources, more energy, and emits more carbon dioxide. The Khash plant is the best example of a unit that has seen a decrease in carbon dioxide production compared to previous years. Studies have shown that it is due to an increase in the production of pozzolanic‡ cement (about 15 to 40% of pozzolanic cement is composed of pozzolanic materials, which reduces the amount of clinker for cement production significantly) and a decrease in the production type-I cement (about 95% of Type I cement is clinker). Gharb, Fars No, Abik, and Behbahan industries were among those that improved in 2020 compared to the previous year. Based on the study findings, this is because of an increase in the production of type-II cement (approximately 15% of which is pozzolanic material) and a drop in the production of type-I cement, which resulted in a large decrease in clinker output. As a result, there was a reduction in CO2 emissions.

‡ Pozzolan is a silica-aluminate substance that has no intrinsic value but exhibits cement characteristics when exposed to moisture and calcium hydroxide at normal temperatures. Pozzolans occur naturally as volcanic rocks and artificially as slag from smelting furnace slag, silica fume, fly ash, rice husks, and other materials that can be used to replace clinker in cement production.

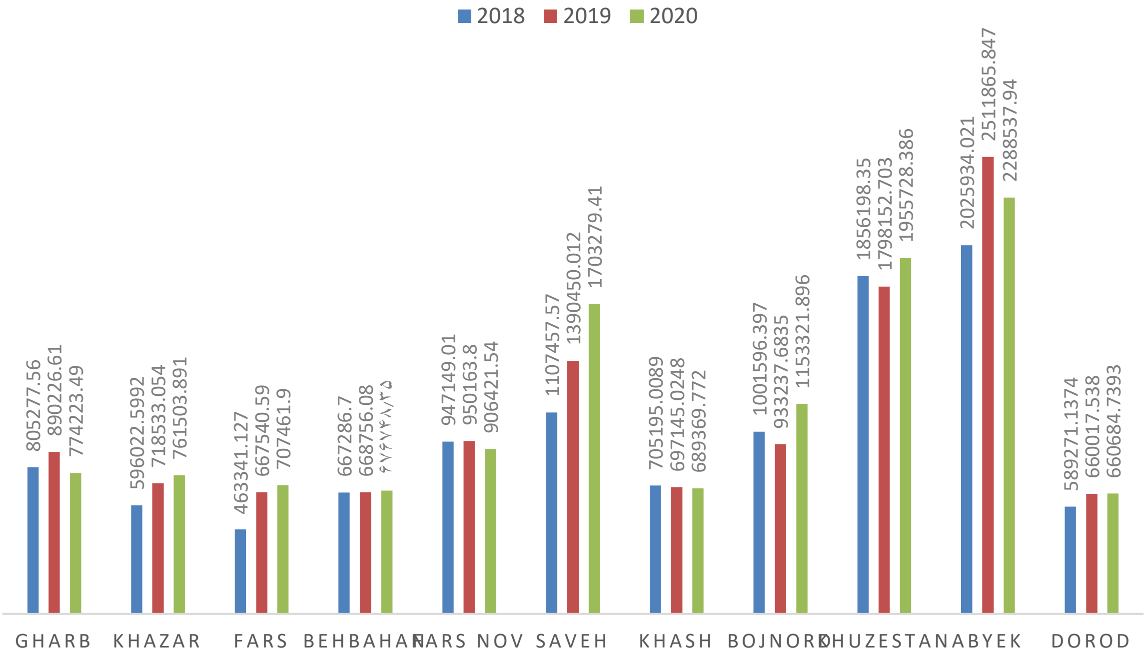

Figure. 4: CO2 emissions of the studied units in the period 2018-2020

5.Discussion and conclusions

This study assessed the performance of 11 cement facilities in Iran (subsidiaries of Fars and Khuzestan Cement Co.). It combined two of the most prominent methodologies of evaluating organizational performance, DEA and BSC. It was concluded that using additional models rather than a single DEA model was beneficial and enhanced performance evaluation. It is vital to analyze the performance of decision-making units from their dimension while evaluating their performance (Sarrico et al., 1997). A single integrated DEA model obscures the complexities of performance evaluation and may miss variables that require attention. The multi-stage DEA model was used in this study because it enables computing efficiency in GSC in multiple BSC viewpoints by taking into account differential weights among stages, fresh (independent) inputs and outputs for stages, as well as the middle inputs and outputs. The BSC-DEA model identifies wasteful resources neglected by organizational managers.

As a result, the unit can troubleshoot its inefficiency and, eventually, emulate the reference units to improve. This method can be used to determine the organization's and each branch's strongest and weakest performance dimensions. On the other hand, such a performance measurement approach considers the multidimensional nature of performance, allows for the demands and expectations of various stakeholders in the organization, and evaluates the organization's performance from the dimensions of employees, customers, and shareholders.

Furthermore, by examining the clinker-to-cement production ratio and the amount of carbon dioxide emissions per year, factories that were using alternative materials and producing their own pozzolanic and replacement cement, including type-II cement, whose properties are similar to those of type-I cement, could reduce clinker production and thus reduce their carbon dioxide emissions. Of course, the availability of these ingredients, their transportation, and the target market for this sort of cement are still critical issues. However, this might be considered among the viable CO2 emission reduction strategies.

According to the adopted methods and study results, researchers can benefit from the following recommendations in future studies:

- Because DEMATEL was employed to determine the causal relationships between BSC dimensions in this study, future studies are recommended to examine other decision-making procedures, such as the analytical network process. It is also recommended that researchers examine the efficiency of cement plants using various DEA models and compare their results to the findings of this study.

- Since the literature review revealed the lack of well-defined indicators to be selected for measuring the efficiency of cement plants in each BSC dimension, future studies are recommended to exclusively employ BSC in the cement industry to determine suitable variables for each BSC dimension and specify the appropriate weights for these variables.

- Future studies are recommended to utilize other DEA methods and compare the results to the findings of this study.

Also, a research limitation was the unavailability of some numbers and figures or their confidentiality from a managerial perspective. All metrics obtained from the BSC technique were not placed in the DEA input, something which may somehow affect the research results.

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Appendix A

Table A1. Weights obtained for inputs and outputs by solving the model using GAMS33

	2018				2019				2020			
DMU	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4
1	0.013	0.964	0.010	0.012	0.012	0.962	0.009	0.014	0.011	0.026	0.950	0.011
2	0.015	0.776	0.179	0.029	0.730	0.213	0.014	0.041	0.011	0.010	0.009	0.967
3	0.013	0.898	0.057	0.033	0.009	0.906	0.005	0.078	0.007	0.042	0.006	0.943
4	0.257	0.050	0.678	0.012	0.014	0.943	0.009	0.033	0.011	0.016	0.017	0.954
5	0.860	0.039	0.090	0.010	0.966	0.017	0.007	0.009	0.010	0.010	0.009	0.969
6	0.014	0.029	0.937	0.018	0.925	0.051	0.013	0.008	0.014	0.010	0.426	0.548
7	0.014	0.045	0.913	0.026	0.011	0.014	0.961	0.012	0.011	0.016	0.109	0.862
8	0.310	0.050	0.604	0.034	0.009	0.972	0.010	0.008	0.011	0.010	0.898	0.079
9	0.015	0.961	0.015	0.007	0.014	0.010	0.013	0.961	0.017	0.029	0.011	0.941
10	0.013	0.945	0.022	0.017	0.011	0.008	0.021	0.958	0.011	0.953	0.017	0.016
11	0.965	0.010	0.011	0.012	0.010	0.967	0.012	0.009	0.009	0.974	0.005	0.010

Appendix B

Table B1. questionnaire

Items	Very Low	Fairly Low	Low	Average	High	Fairly High	Very High
1. The electrical energy consumption rate plays a key role in managing and reducing the energy consumption.							
2.The fuel consumption rate has a crucial role in managing and reducing the energy consumption.							
3.Alternative fuels (from the waste of other industries) have key roles in reducing the energy consumption.							
4.Recycling thermal energy in the process of producing clinker will result in energy consumption reduction and energy efficiency.							
5.The clinker production rate plays a key role in the emission of greenhouse gases.							
6.Using alternative and additive materials (fly ash, natural or artificial Pozzolans, limestone, and melting iron slag) to manufacture clinker will reduce the emission of greenhouse gases.							
7.It is important to analyze the emission of CO2 formed in the process of manufacturing clinker in the green supply chain.							
8.The number of violations against the emission quota plays an important role in analyzing the green supply chain efficiency.							
9.The number of environmentally-friendly suppliers is important in the green supply chain of cement.							
10.The water consumption rate has a key role in managing and reducing waste.							
11.Recycling consumable materials (and using the recycled packaging) will be effective in waste reduction.							
12.Recycling consumable materials (and using the recycled packaging) will be effective in waste reduction.							

13.The fuel consumption rates of vehicles are important in green logistics.
14.The packaging cost is important in green logistics.
15.Outsourcing can be effective in green logistics.
16.The worker training level for the correct use of equipment has a crucial role in optimization.
17.The employee training hours can be effective in improving the employee ability and capability of optimization.
18.The total number of employees should be taken into account to optimize and improve their ability and capability.
19.The number of competent employees plays a key role in an organization (optimization).
20.The cost of training has a central role in improving the employee ability and capability.
21.The dedicated R&D budget plays a key role in developing innovation in processes and technology.
22.The rates of investments in the new green technologies (new assets) will be effective in creating innovation in processes.
23.The number of innovations in the process (for energy reduction) will be effective in organizational improvement.
24.The available capital for the new project execution will be effective in developing innovation in processes.
25.The costs of CO2 emissions should be analyzed to reduce the environmental costs.
26.The cooperation percentage of suppliers are important in designing a new product for developing innovation in processes and technologies.
27.The waste reduction rate should be considered in environmental problems.
28.The total energy cost (electricity-fuel-water) plays a major role in the product cost.
29.The cost of clinker production has a major role in the product cost.
30.The road transportation cost is considered in the product cost.
31.The workforce cost plays an important role in the product cost.
32.The costs of raw materials play a key role in the product cost.
33.The net profit growth rate of green products should be taken into account to increase earnings from green products.
34.The ROA (return on asset) is important in increasing the earnings from green products.
35.The cash flow ratio of an organization has a key role in the earnings from green products.
36.The net earnings from green products play a central role in improving earnings.
37.The export rate indicates customer satisfaction.
38.The timely delivery percentage of products affects customer satisfaction.
39.The market accessibility (market share) affects the acquisition of competitive advantages and value creation for customers.
40.The product return affects customer satisfaction.
41.The superior position to rivals will play an important role in acquiring competitive advantages and creating value.
42.The customer demand rate indicates customer satisfaction and customer value creation in an organization.

43.The number of customers receiving services per day (i.e., the ability to provide services for the maximum number of customers) will be important in organizational flexibility and customer value creation. 44.The rate of offline services for service acceleration will result in value creation. 45.Reducing the average transportation time and delivering products at the right time will enhance customer satisfaction.	

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