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EVALUATING THE RELATIONSHIP BETWEEN TECHNICAL EFFICIENCY AND THE FACTORS OF CORPORATE GOVERNANCE, SOCIAL RESPONSIBILITY, AND FINANCIAL PERFORMANCE OF COMPANIES: A COMBINED APPROACH TO NETWORK DATA ENVELOPMENT ANALYSIS AND REGRESSION

Avaliação da relação entre eficiência técnica e os fatores de governança corporativa, responsabilidade social e desempenho financeiro das empresas: uma abordagem combinada para análise envoltória e regressão de dados de rede

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ABSTRACT

This paper utilized the network data envelopment analysis model (a mathematical technique) to calculate the technical efficiency aimed at evaluating its relationship with the factors of corporate governance, social responsibility, and financial performance of companies operating in the cement, plaster, and lime industry listed on Tehran Stock Exchange from 2013 to 2022. A two-step data analysis process was used in the research. In the first stage, the technical efficiency of companies was calculated by applying the mathematical technique of network data envelopment analysis. The second stage was focused on using statistical methods to examine the relationship of technical efficiency with the factors of corporate governance, social responsibility, and financial performance of the studied companies. In this research, the variables of the dual role of the CEO, board of directors' compensation, replacement of the CEO, audit quality, and risk management were regarded as corporate governance factors, and the variables of return on assets, Tobin’s Q, and shareholders' equity were considered as financial performance factors. The results demonstrated A significant relationship between technical efficiency and indices of return on assets, equity, the dual role of the CEO, board of directors' compensation, CEO replacement, audit quality, and social responsibility. It was found that companies' adherence to the mechanisms of corporate governance and social responsibility can improve their technical efficiency. Furthermore, these factors have the potential to enhance the company's processes and improve the performance of companies.

Keywords: Technical efficiency, Corporate Governance, Social responsibility, Financial performance

JEL Classification: M2, G3, C1.

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AVALIANDO A RELAÇÃO ENTRE EFICIÊNCIA TÉCNICA E OS FATORES DE GOVERNANÇA CORPORATIVA, RESPONSABILIDADE SOCIAL E DESEMPENHO FINANCEIRO DAS EMPRESAS: UMA ABORDAGEM COMBINADA PARA ANÁLISE E REGRESSÃO ENVOLTÓRIA DE DADOS DE REDE

Evaluating the relationship between technical efficiency and the factors of corporate governance, social responsibility, and financial performance of companies: a combined approach to network data envelopment analysis and regression

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RESUMO

Este artigo utilizou o modelo de análise envoltória de dados de rede (uma técnica matemática) para calcular a eficiência técnica com o objetivo de avaliar sua relação com os fatores de governança corporativa, responsabilidade social e desempenho financeiro de empresas que operam na indústria de cimento, gesso e cal listadas na Bolsa de Valores de Teerã de 2013 a 2022. Um processo de análise de dados em duas etapas foi utilizado na pesquisa. Na primeira etapa, a eficiência técnica das empresas foi calculada por meio da aplicação da técnica matemática de análise envoltória de dados de rede. A segunda etapa foi focada no uso de métodos estatísticos para examinar a relação da eficiência técnica com os fatores de governança corporativa, responsabilidade social e desempenho financeiro das empresas estudadas. Nesta pesquisa, as variáveis duplo papel do CEO, remuneração do conselho de administração, substituição do CEO, qualidade da auditoria e gerenciamento de riscos foram consideradas como fatores de governança corporativa, e as variáveis retorno sobre ativos, Q de Tobin e patrimônio líquido foram consideradas como fatores de desempenho financeiro. Os resultados demonstraram uma relação significativa entre eficiência técnica e índices de retorno sobre ativos, patrimônio líquido, duplo papel do CEO, remuneração do conselho de administração, substituição do CEO, qualidade da auditoria e responsabilidade social. Verificou-se que a adesão das empresas aos mecanismos de governança corporativa e responsabilidade social pode melhorar sua eficiência técnica. Além disso, esses fatores têm o potencial de aprimorar os processos da empresa e melhorar o desempenho das empresas.

Palavras-chave: Eficiência técnica, Governança Corporativa, Responsabilidade social, Desempenho financeiro

INTRODUCTION

How to calculate and evaluate efficiency in all the processes performed by them has been one of the concerns of humanity for a long time. Efficiency evaluation aims to recognize the status quo and change it with the goal of improving and enhancing performance. The performance status of organizations and companies has come to the focus of attention in today's societies; thus, numerous methods and tools have been suggested for performance evaluation. Productivity, technical efficiency, and effectiveness are some instances of these evaluation tools (Huang, 2016). By developing the idea of Farrell (1957) in 1978, Charnes et al. presented a new technique known as Data Envelopment Analysis (DEA) to evaluate relative efficiency, especially technical efficiency for the first time. Their technique was a non-parametric method, which utilizes operations research techniques. This technique has always drawn the attention of researchers for evaluating technical efficiency in recent years (Silva et al., 2022). A weakness found in the data envelopment analysis models is their failure to consider internal processes in efficiency evaluation. The structure of examining internal processes in evaluating technical efficiency can appear useful in evaluating the performance of internal subsystems and identifying the source of system inefficiency. As a result, the network data envelopment analysis technique was developed (Kao, 2020). Corporate governance may act as an effective factor in obtaining optimal performance. Effective corporate governance serves as a control mechanism for the company resources management. The board of directors and CEO are responsible for the implementation of policies related to cash management, accounts receivable, purchase and inventory management, accounts payable, and all financial policies of the company, and they can play a major role as one of the corporate governance mechanisms (Mallin, 2016). Therefore, by attracting and optimally allocating resources, enhancing efficiency, fulfilling the rights of shareholders, and increasing sustainable investment, corporate governance attains the trust of investors (Naciti et al., 2022). Social responsibility emphasizes the organization's relationship with its stakeholders. Corporate social responsibility has a positive impact on society, improves relations with stakeholders and the company's management, and enhances the company's financial performance by providing public trust and cheaper resources compared to other competitors (Coelho et al., 2023).

The core problem discussed in this research covered the two following questions:

1. How is the technical efficiency of companies calculated using the network data envelopment analysis technique?
2. How much does this technical efficiency affect the factors of corporate governance, social responsibility, and financial performance of these companies?

1 THE RESEARCH LITERATURE AND HYPOTHESES

1.1 Technical efficiency

Theoretically, technical efficiency was first defined by Koopmans (1951) as an input/output ratio. Debreu (1951) and Farrell (1957) developed the input-based technical efficiency index. Thereafter, Färe and Lovell (1978) and Lovell (1993) expanded this concept. By expanding Farrell's idea (1957), Charnes et al. (1978) propounded a new technique, recognized as Data Envelopment Analysis (DEA), to assess technical efficiency. This technique has become popular in evaluating technical efficiency since it controls multiple outputs easily, is nonparametric, and does not need input price data (Ruggiero, 2000). Data envelopment analysis (DEA) has always served as a useful tool for calculating technical efficiency over recent years. For instance, Assaf et al. (2011) utilized a data envelopment analysis technique to compute the technical efficiency of Saudi Arabian banks. Using the data envelopment analysis technique, Jing et al. (2020) evaluated the technical efficiency of private and public hospitals in Beijing, China. By utilizing DEA models, Silva et al. (2022) calculated technical efficiency and examined the impact of social and economic factors on technical efficiency in entrepreneurial activities. Konca and Top (2023) used DEA models to calculate the technical efficiency of healthcare systems in OECD countries. Also, Akdeniz et al. (2023) performed a comprehensive review of 305 studies about the use of technical efficiency measurement techniques in both Islamic and traditional banking sectors from 1989 to 2019. Likewise, Tayebi et al. (2024) applied DEA models to measure the efficiency of 20 Algerian insurance companies. A literature review in the field of data

envelopment analysis shows that this technique is the main tool for calculating technical efficiency (Camanho et al., 2023). Several models have been proposed in data envelopment analysis for performance evaluation. The variety of models in this field comes from their generalizability to real-world examples and solving the problems of previous models as well as the ever-introduction of new models in this field (Tsaples & Papathanasiou, 2021; Emrouznejad et al., 2023).

1.1 Corporate governance

Corporate governance includes a set of relationships between the company's management, shareholders, board of directors, and other beneficiaries, based on which, some structures are developed that the goals of a company, the means of achieving them, and how to supervise the company's performance are determined accordingly (Mallin, 2016). Corporate governance is seen as a powerful tool with the potential to improve other financial indices of firms (Kyere & Ausloos, 2021). Shahwan (2015) examined the relationship between corporate governance, financial performance, and financial distress for Egyptian companies. Anginer et al. (2018) demonstrated a significant relationship between the financial health of banks and the corporate governance index. Li et al. (2021) focused on the prediction of financial distress risk using corporate governance. Singh & Rastogi (2023) evaluated the relationship between corporate governance and financial performance in Indian companies. Ben Fatma, H., & Chouaibi (2023) stated that they found a significant relationship between corporate governance indices such as board gender diversity, CEO ownership, board size, and ownership concentration with the company’s value. All the issues mentioned in this subsection suggest the possible relationship between corporate governance and indicators related to the company's performance. As a result, a hypothesis derived to test is as follows:

Hypothesis 1: There is a significant relationship between technical efficiency and corporate governance factors of companies listed on the Tehran Stock Exchange.

1.2 Corporate social responsibility

The social responsibility of companies involves the obligations of economic enterprises and commercial companies towards society (Schwartz & Cragg, 2017). This index can be related to a variety of financial indices. For example, Luo & Du (2015) studied the relationship between social responsibility and innovation of a company. Ruwanti et al. (2018) suggested a relationship between social responsibility and the variables of company size and profit management and stated that corporate governance affects this relationship. Hou (2019) and Awaysheh et al. (2020) individually examined the relationship between corporate social responsibility and its financial performance and concluded identical results. Liu et al. (2021) evaluated the relationship between corporate social responsibility and financial performance with the mediating role of fintech technology. In another study, Al-Shammari et al. (2022) examined the relationship between corporate social responsibility and financial performance based on the theory of dual responsibility.

Based on the abovementioned, one may come to the conclusion that there is a significant relationship between the social responsibility of the company and its financial performance. Since technical efficiency is seen as a kind of performance index for firms, the following hypothesis can be made:

Hypothesis 2: There is a significant relationship between technical efficiency and social responsibility of companies listed on the Tehran Stock Exchange.

1.3 Financial performance

Financial performance can be measured according to the performance in financial indies, including capital adequacy, liquidity, debt solvency, leverage, and profitability (Fatihudin, 2018). According to Zainuddin et al. (2017), return on assets can be considered as a performance evaluation criterion of companies. As suggested before, financial performance is associated with social responsibility (Maqbool & Zameer, 2018). Some studies have

focused on the relationship between financial performance and other financial indices in this context. For instance, Uyar et al. (2020) studied the features of the board of directors and financial performance in the tourism industry. According to Kyere et al. (2021), a significant relationship was found between the company's financial performance and corporate governance. Also, Butt et al. (2023) suggested that Tobin's Q is a measure of the company's performance.

Based on the above, the financial performance of companies is related to many financial indices, leading to the evaluation of the relationship between financial performance and efficiency index. Thus, another hypothesis is defined as follows.

Hypothesis 3: There is a significant relationship between technical efficiency and the financial performance of companies listed on the Tehran Stock Exchange.

2 METHODOLOGY

Since we sought to use mathematical and statistical models for accounting topics in this paper, the research type can be categorized as applied research based on the objective. Also, given the fact that the research data was collected from the past to conduct the research without the direct involvement of the researcher, the data is historical or retrospective. The research can be seen as a descriptive-causal study from the perspective of the nature of its implementation. The data envelopment analysis technique was utilized to calculate the technical efficiency variable. Also, inferential statistics, especially regression, were used for examining the relationships between variables.

The research statistical population included all the companies listed on the Tehran Stock Exchange from 2013 to 2022. Moreover, the companies needed to be homogeneous due to the use of data envelopment analysis techniques. Hence, merely the listed companies in one industry should be chosen, and thus in this research, cement, plaster, and lime industry companies were selected as the statistical sample. 46 companies are operating in the cement, plaster, and lime industry on the Tehran Stock Exchange and the data of all of them were used in this research.

The required data were collected by the following two methods:

1. Library method: The information related to the theoretical foundations and the research background was gathered by the library method. Thus, basic information needed for performing the research and writing the theoretical foundations as well as the research background were collected by searching in library and internet sources.
2. Document mining method: This method is used to collect information related to the research data. In fact, the data was collected from the Codal website*.

This research was done in two stages; hence, its variables are listed below according to the stages:

3. Stage 1: Calculating the technical efficiency of companies

A series of evaluation indices should be considered at this stage to calculate the technical efficiency of companies. To do so and to provide a complete assessment of the technical efficiency of companies, the most important and most widely used evaluation criteria of the company efficiency were chosen by studying the research literature on the topic of efficiency evaluation, and accordingly, a checklist was prepared. Then, the final indices were obtained using interviews with financial experts as follows:

1. Assets
2. Debts
3. Equity
4. Profit to assets ratio
5. Net profit

* https://www.codal.ir

4. Stage 2: Examining the relationship between technical efficiency and the factors of corporate governance, social responsibility, and financial performance

To this end, the following regression model was utilized:

$$y = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + a_5x_5 + a_6x_6 + a_7x_7 + a_8x_8 + a_9x_9$$

Whose variables are as follows:

a. The dependent variable

Y = The efficiency of companies obtained in the previous stage

b. The independent variable

X_1 = Return on assets

The return on assets (ROA) is obtained by dividing net profit by total assets (Chaharmahali et al., 2018).

X_2 = Tobin's Q Ratio

The following relation was used to calculate Tobin's Q Ratio (Iraj Rad & Eslamdoost Keleydbari, 2014):

Q Tobin= (MEV+TD)/TA

Where,

MEV: Market value

TD: Total debt

TA: Total assets

X_3 = Equity

Return on equity (ROE): This index can be obtained by dividing the company's net profit by the total equity (Chaharmahali et al., 2018).

X_4 = The dual role of the CEO

This variable is considered equal to 1, in case the CEO is also a member of the board of directors; but it would be considered equal to zero if the CEO is not a member of the board of directors.

X_5 = Board of directors' compensation

The natural logarithm of the board's compensation is in millions of Rials (which is a positive real number).

X_6 = Replacement of the CEO

This variable is considered equal to 1 if the CEO changes in the studied financial year. Otherwise, the value of the variable is considered equal to zero.

X_7 = Audit quality

Here, the size of the audit firm that audits the company is used to determine audit quality.

X_8 = Risk management

This variable is put equal to 1 if the company has a risk committee. Otherwise, the value of this variable is equal to zero (Galati et al., 2019).

X_9 = Corporate social responsibility

The formula below is used to compute the corporate social responsibility (Ashrafi et al., 2019):

$$CSRDI_j = \sum_{i=1}^{n_j} \frac{x_{ij}}{n_j}$$

Where,

x_{ij}: The items checklist that is put equal to 1 in case it is disclosed, otherwise equal to zero (not disclosed).

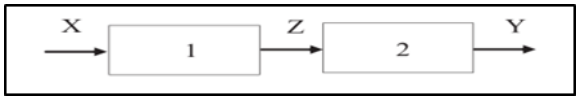
n_j: The total number of the checklist items that the jth company is required to disclose.

Mathematical and statistical models in this research as data analysis methods. The network data envelopment analysis model was used as the mathematical model in the study, which is known as a new model in the field of data envelopment analysis and evaluation of technical efficiency in companies. On the other hand, the econometric

model and multivariate regression model were used to examine the relationship between technical efficiency and factors of corporate governance, social responsibility, and financial performance in companies. Moreover, Excel 2013, Lingo11, and Eviews software were applied to analyze the collected data.

As stated before, a network data envelopment analysis model was used to measure technical efficiency. The model is described below. Each decision-making unit is denoted by DMU. As can be seen in Figure (1), a DMU generates inputs X and outputs Y using intermediate products (capacities) Z.

Figure 1 - The studied two-stage network process



The following data envelopment analysis models were used to calculate the efficiency of stages 1 and 2 demonstrated in Figure (1):

$$
\begin{aligned}
&E_{jo}^{1} = \max \varphi Z_{jo} \\
&s.t \\
&\eta X_{jo} = 1 \\
&\varphi Z_j - \eta X_j \le 0, \qquad j = 1, \dots, n \\
&\varphi Z_j - \eta X_j \le 0, \qquad j = 1, \dots, n \\
&E_{jo}^{2} = \max \omega Y_{jo} \\
&s.t \\
&\varphi Z_{jo} = 1 \\
&\omega Y_j - \varphi Z_j \le 0, \qquad j = 1, \dots, n \\
&\omega Y_j - \varphi Z_j \le 0, \qquad j = 1, \dots, n \\
&\varphi \ge \varepsilon \quad , \quad \omega \ge \varepsilon
\end{aligned}
\tag{1}
$$

$$\eta \ge \varepsilon \quad , \quad \varphi \ge \varepsilon \tag{2}$$

The two-stage process seeks to maximize the efficiency of the stages and the total efficiency. However, since the total efficiency is obtained by combining the efficiencies of the stages, thus, the efficiency of the whole process would be also maximized by maximizing the efficiency of the stages. Keeping in mind these explanations, the following two-objective model was provided to evaluate the total efficiency and stages of the two-stage network:

$$
\begin{aligned}
&E_{jo}^{1} = \max \varphi Z_{jo} \\
&E_{jo}^{2} = \max \omega Y_{jo} \\
&s.t \\
&\eta X_{jo} = 1 \\
&\varphi Z_{jo} = 1 \\
&\varphi Z_j - \eta X_j \le 0, \qquad j = 1, \dots, n \\
&\varphi Z_j - \eta X_j \le 0, \qquad j = 1, \dots, n \\
&\omega Y_j - \varphi Z_j \le 0, \qquad j = 1, \dots, n \omega Y_j - \varphi Z_j \le 0, \qquad j = 1, \dots, n \\
&\eta \ge \varepsilon \quad , \quad \varphi \ge \varepsilon \ , \quad \omega \ge \varepsilon
\end{aligned}
\tag{3}
$$

Model (3) is a two-objective model. Many techniques have been developed to solve this two-objective model (Ehrgott, 2005). Here, the weighted method was applied to solve the model as follows:

$$
\begin{aligned}
&E_{jo} = \max \frac{1}{2}(\varphi Z_{jo} + \omega Y_{jo}) \\
&s.t \\
&\eta X_{jo} = 1
\end{aligned}
$$

$$\begin{aligned}
&\varphi Z_{jo} = 1 \\
&\varphi Z_j - \eta X_j \le 0, \qquad j = 1, \dots, n \\
&\varphi Z_j - \eta X_j \le 0, \qquad j = 1, \dots, n \\
&\omega Y_j - \varphi Z_j \le 0, \qquad j = 1, \dots, n \omega Y_j - \varphi Z_j \le 0, \qquad j = 1, \dots, n \\
&\eta \ge \varepsilon \quad , \quad \varphi \ge \varepsilon \ , \quad \omega \ge \varepsilon
\end{aligned} \tag{4}$$

Solving the above model calculates the total efficiency "$E_{jo}E_{jo}$" and the efficiency of stages 1 and 2, i.e., "$E_{jo}^{1}E_{jo}^{1}$ &$E_{jo}^{2}E_{jo}^{2}$", as follows, in which, ($\eta^*, \varphi^*, \omega^*\eta^*, \varphi^*, \omega^*$) is the optimal solution obtained for model (4). This research considered the value E_{jo} as the technical efficiency score of companies.

$$\begin{aligned}
&E_{jo} = \max \frac{1}{2}(\varphi Z_{jo} + \omega Y_{jo}) \\
&s.t \\
&\eta X_{jo} = 1 \\
&\varphi Z_{jo} = 1 \\
&\varphi Z_j - \eta X_j \le 0, \qquad j = 1, \dots, n \\
&\varphi Z_j - \eta X_j \le 0, \qquad j = 1, \dots, n \\
&\omega Y_j - \varphi Z_j \le 0, \qquad j = 1, \dots, n \omega Y_j - \varphi Z_j \le 0, \qquad j = 1, \dots, n \\
&\eta \ge \varepsilon \quad , \quad \varphi \ge \varepsilon \ , \quad \omega \ge \varepsilon
\end{aligned} \tag{4}$$

3 RESULTS

The core goal of this study was to examine the relationship between technical efficiency and the factors of corporate governance, social responsibility, and financial performance in the studied companies. To this end, first, the technical efficiency of the companies was calculated using the network data envelopment analysis model. Then, the factors of corporate governance and social responsibility index of companies were evaluated in another model associated with the variables of return on assets, Tobin's Q, equity, and company size as independent variables, and their relationship with the variable of technical efficiency of companies. The process is described below.

a. Evaluating the technical efficiency of companies

The network data envelopment analysis model was utilized to calculate the technical efficiency of companies. Therefore, efficiency evaluation indices had to be divided into three input, intermediate, and output categories to use this model. Based on the classification procedure, the input index includes the criteria that their lower values for the company indicate higher efficiency of the company. The output index is opposite to the input index, while the intermediate index is exactly the intermediate point between these two, i.e., it indicates a kind of reduction on the one hand and an increase on the other hand for the efficiency of the company. Accordingly, the research variables were classified into the following three categories.

1. Input variable: Debts
2. Intermediate variable: Assets
3. Output variable: Equity, profit to assets ratio, net profit.

The Tehran Stock Exchange Technology Management website and the Codal website (Codal.ir) were used to extract the primary data related to the research variables. Excel software was also utilized for preparing the data related to the studied variables. Table (1) provides the descriptive statistics of input and output data for the period from 2013 to 2022.

Table 1 - Descriptive statistics related to input, intermediate, and output indices for calculating the technical efficiency

Variable Name	Assets	Liabilities (Debts)	Equity	ROA	Net Profit	Number of Observations
Mean	278115188	55625545	10130	41/66	4155	460

Median	174512282	32674521	9297	72	6103	
Maximum	1390575940	109768146	26662	429	33274	
Minimum	125151834	9894376	1274	2	38	
Standard Deviation	214895786	4896521	4482	18/961	489/6521	
Skewness	29/786323	764382	479	21/65	764/382	
Kurtosis	067/489084	589461	174/1	5/86	589/461	

As mentioned earlier, the research covered a 10-year period study on 46 companies. Thus, multiplying these two numbers provided us with 460 year-company data for doing our research.

The data envelopment analysis model introduced in the previous section was then used to calculate the technical efficiency of the companies. To do so, the linear programming model (4) was first solved followed by using relations (5) to calculate the technical efficiency. Lingo 11 software was applied in this research to solve the linear programming model. Table (2) presents the results of the technical efficiency evaluation using the network data envelopment analysis model.

Table 2 - Descriptive statistics of technical efficiency of cement, plaster, and lime industry companies

Statistical Index		Mean	Median	Maximum	Minimum	Standard Deviation	Skewness	Kurtosis	Number of Observations
Technical Efficiency		0.7	0.68	1.00	0.42	0.13	0.15	-0.42	460

Table (2) provides the technical efficiency scores for companies. As seen, the obtained technical efficiency score ranges between zero and one. A closer number to one indicates a better technical efficiency score obtained by the company, suggesting the technical efficiency of the company. The technical efficiency scores for the companies have been calculated so far. The next part examined the relationship between the obtained technical efficiency and the social responsibility and financial performance indices of the companies.

b. The relationship between the technical efficiency of companies with the factors of corporate governance, social responsibility, and financial performance

The first task here was to gather information on research variables for the studied statistical sample. Once the information was gathered, descriptive statistics were used for analysis. A summary of research variable information is given in Table 3.

Table 3 - Descriptive statistics of the research variables

	Variable	Range	Minimum	Maximum	Mean	Standard Deviation	Number of Observations
X1	Return on assets	1.185	0.83	2.015	1.483	1.84	460
X2	Tobin's Q	7.719	0.724	8.443	1.873	0.733	
X3	Equity	25388	1274	26662	10130	4482	
X4	The dual role of the CEO	1	0	1	0.222	0.355	
X5	Board of Directors' compensation	9.556	9.942	19.498	13.773	1.704	
X6	CEO replacement	1	0	1	0.162	0.430	
X7	Audit quality	8.978	10.173	19.151	14.113	1.567	
X8	Risk management	1	0	1	0.266	0.187	
X9	Social Responsibility	0.473	0.168	0.641	0.225	0.362	
Y	Technical efficiency	0.48	0.49	0.97	0.730	0.133	

The normality of the dependent variable was first examined. Then the hypotheses were tested.

The Jarque-Bera test was utilized to determine the normality of the dependent variable in the regression model. According to the results given in Table (4), since the significance of this test is greater than 0.05, one may conclude that the dependent variable of the research enjoys a normal distribution.

Table 4 - Examining the normality of the research dependent variables

Variable	Y
Jarque-Bera statistic	4341
Significance level	0.0945
Compared to 0.05	Higher
Test result	Normal

Source: The researcher's findings

Hadri's unit root test, one of the unit root tests, was applied to examine the reliability of the variables used in the models related to testing the research hypothesis. The following table shows the results of this test:

Table 5 - Examining the reliability of the research variables (Hadri's unit root test)

Variable	Symbol	Z statistic	Significance level	Comparison with 5%	Result
Return on assets	X1	13.8	0.00	Smaller	Reliable (Durable)
Tobin's Q	X2	16.9	0.00	Smaller	Reliable (Durable)
Equity	X3	15.5	0.00	Smaller	Reliable (Durable)
The duality of the CEO's role	X4	16.7	0.00	Smaller	Reliable (Durable)
Board's compensation	X5	14.6	0.00	Smaller	Reliable (Durable)
CEO replacement	X6	19.7	0.00	Smaller	Reliable (Durable)
Audit quality	X7	17.9	0.00	Smaller	Reliable (Durable)
Risk management	X8	22.4	0.00	Smaller	Reliable (Durable)
Social responsibility	X9	15.7	0.00	Smaller	Reliable (Durable)

As can be seen in the table above, the significance level of Hadri's Z-statistic is lower than 5% for all the research variables, suggesting no unit root problem for any of the research variables. Nevertheless, one may conclude that all the variables in the regression model are reliable and there is no false regression problem.

3. Testing the research hypotheses

Given the fact that the data related to the research variables are quantitative and continuous, the multiple linear regression model was utilized to examine the relationship between the research variables as follows.

$$y = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + a_5x_5 + a_6x_6 + a_7x_7 + a_8x_8 + a_9x_9 \qquad (6)$$

Thus, the presuppositions of linear regression were first examined.

Moreover, the VIF (variance inflation factor) test was used to evaluate another assumption of the regression model, i.e. examining the absence of collinearity between the independent and control variables. The results of this test are given in the table below.

Table 6 - The results of the VIF test

Variable	Symbol	Variance coefficient	Variance inflation factor
Return on assets	X1	0,00	1,11
Tobin's Q	X2	0,00	1,01
Equity	X3	0,00	1,11
The duality of the CEO's role	X4	0,00	1,07
Board's compensation	X5	0,00	1,07
CEO replacement	X6	0,00	1,27
Audit quality	X7	0,00	1,06
Risk management	X8	0,00	1,26
Social responsibility	X9	0,00	1,02

Given the fact that the variance inflation factor is lower than 10 for all variables, the assumption of non-collinearity of the regression variables is confirmed. According to the results shown in Table (6), Since the variance inflation factor for all descriptive variables (independent and control variables) does not exceed 10, then, one may conclude that the assumption of collinearity between research variables is not confirmed.

The F-Limer and Hausman's test was used to estimate the research models. The results of these tests are given in Table 7.

Table 7 - The results of the F-Limer and Hausman's test

Model/Test	Model (6)
F-Limer test statistic	1.51
Significance level	0.01
Result (model estimation method)	Panel (combined)
Hausman statistic	61
Significance level	0.02
Result (model estimation method)	Panel-Fixed effects

The significance level of the F-Limer's test is estimated equal to 0.01 in this table. Since this value is lower than 5%, then, the panel (combined) method was chosen out of the two choices of pooled (combined) and panel (combined) methods for estimating the research model (6). Also, based on the output of the Hausman test with a significance level lower than 5%, one may conclude to use the fixed effects method to estimate the model (6). Thus, the regression model used here is the panel-fixed-effects regression model.

4. Estimating the model (6) aimed at testing the hypotheses

The estimation results of the model (6) are provided in Table (8). This model is estimated by the GLS approach and fixed effects panel method.

Table 8 - The results obtained from estimating the model (6)

Variable	Symbol	Coefficients of variables	Standard deviation	T-statistic	Significance level	Compared with 10%	Result
Y-intercept	(a)	-0,227	0,054	-4,227	0,000		
Return on assets	(a)	0,021	0,009	2,263	0,024	Smaller	Has an impact
Tobin's Q	X1	-0,100	0,002	-0,177	0,859	Larger	Has no impact
Equity	X2	0,102	0,038	2,690	0,007	Smaller	Has an impact
The duality of the CEO's role	X3	0,402	0,003	0,925	0,045	Smaller	Has an impact
Board's compensation	X4	-0,015	0,005	2,936-	0,003	Smaller	Has an impact
CEO replacement	X5	0,038	0,005	7,011	0,000	Smaller	Has an impact
Audit quality	X6	-0,049	0,014	-3,554	0,000	Smaller	Has an impact
Risk management	X7	0,006-	0,005	1,271-	0,204	Larger	Has no impact
Social responsibility	X8	0,079	0,014	5,759	0,000	Smaller	Has an impact
Durbin-Watson statistic	X9	2.3	Fisher statistic		F-stat		5.69
Model Coefficient Of Determination	DW-stat	0.61	Model significance level		p-Value		0.00

One may conclude according to the results obtained in Table (8):

The relationship between the efficiency variable and two financial performance indices, i.e., return on assets and equity is positive and significant (The significance level is lower than 0.05). However, the relationship is not significant for Tobin's Q financial performance index (The significance level is higher than 0.05).

In the case of the relationship between the efficiency variable and corporate governance factors, a positive and significant relationship was found between the efficiency variable and the variables of CEO role duality and CEO replacement, while a negative and significant relationship was seen between the efficiency variable and the variables of board compensation and audit quality. Also, the relationship was not significant in the case of the risk management variable.

Given that the coefficient of the social responsibility variable is 0.079 and its significance is lower than 0.05, then, one can conclude that the relationship between the two variables of companies' efficiency and social responsibility of companies is direct and significant. On the other hand, enhancing one unit in the social responsibility of companies will increase their efficiency by 0.079 units. The value of the Durbin-Watson statistic equal to 2.3 suggests the lack of autocorrelation between the error terms. Also, the F-statistic indicates the high validity of the model. Furthermore, Also, the value of the estimated coefficient of determination is equal to 0.61. Finally, the regression model is as follows:

$$y = -0{,}227 + 0{,}021x_1 + 0{,}102x_3 + 0{,}402x_4 - 0{,}015x_5 + 0{,}038x_6 - 0{,}049x_7 + 0{,}079x_9 \quad (7)$$

CONCLUSION AND SUGGESTIONS

This research was designed to calculate the technical efficiency using the network data envelopment analysis model and its relationship with the factors of corporate governance, social responsibility, and financial performance of companies operating in the cement, plaster, and lime industry listed on the Tehran Stock Exchange from 2013 to 2022. The obtained results were as follows:

Table 9 - The results obtained from data analysis

Row	Obtained results
1	There is a positive and significant relationship between technical efficiency and the financial performance index of return on assets.
2	There is no significant relationship between technical efficiency and Tobin's Q financial performance index.
3	There is a positive and significant relationship between technical efficiency and the financial performance index of equity.
4	There is a positive and significant relationship between technical efficiency and the corporate governance factor of the duality of the CEO's role.
5	There is a negative and significant relationship between technical efficiency and the corporate governance factor of the board of directors' compensation.
6	There is a positive and significant relationship between technical efficiency and the corporate governance factor of the duality of changing the CEO.
7	There is a negative and significant relationship between technical efficiency and the corporate governance factor of audit quality.
8	There is no significant relationship between technical efficiency and the corporate governance factor of risk management.
9	There is a positive and significant relationship between technical efficiency and social responsibility.

Pak Maram and Lotfi (2016) demonstrated a positive and significant relationship between the composition of the board of directors and the factors of return on assets and equity. Asaadi and Abri (2020) suggested that the dimensions of the corporate governance system have a direct and significant impact on the financial performance of banks. The results of a study by Dadashi et al (2022) revealed that according to the moderating variable of financial limitation, the social responsibility variable significantly affects the performance variable. However, no significant relationship was found between the risk-taking variable and the performance variable. According to Forgione et al. (2020), all corporate social responsibility (CSR) activities showed a positive effect on the bank's technical efficiency in 22 countries during the period 2013-2017. The results of Tucker et al. research (2021) suggested that the characteristics of board size, board independence, and the CEO's role duality have a positive impact on technical efficiency. Also, according to the research results of Peng et al. (2021), there is a positive linear relationship between technical efficiency, corporate governance, and financial performance.

According to the research results, the following suggestions are made:

1. Managers and decision-makers of the stock market are suggested to implement the corporate governance system in listed companies aimed at enhancing efficiency. Such requirements can make the CEO a member of the board of directors. Also, the companies can be made to form audit and risk management committees. The companies can be made to use the performance in the financial year besides the rules of the commercial law concerning the board of directors' compensation.
2. Forming committees and involving them in the company's issues to give consultation to the CEO of the company paves the road for the company to reach the realistic goals set by the board of directors more easily, which will lead to the increased technical efficiency of the company.

3. The company managers are recommended to provide the highest possible number of disclosures according to the available checklists so that shareholders would have complete information about the company's status.

4. Investors in the stock market are suggested to choose companies for investment with high assets, net profit, and low debt according to the companies operating in the studied industry since these companies benefit from high technical efficiency and will bring good returns.

5. The shareholders of the companies are recommended to especially pay attention to the financial indices of return on assets, Tobin's Q, and equity for evaluating the performance of the joint stock company and consider these indicators in making decisions.

The following are also suggested for future research:

6. It is suggested to do research on the relationship between technical efficiency and competition and financial stability in banks.

7. It is suggested to conduct research on the impact of independence of board members on the relationship between ownership structure and disclosure of social, environmental, and corporate governance performance in companies.

8. It is suggested to do research on the impact of financial performance on profit management with the moderating role of corporate governance.

9. It is suggested to examine the impact of social responsibility on financial performance with the mediating role of technical efficiency in companies.

10. It is suggested to do research on examining the impact of social responsibility on employees' job satisfaction with the moderating role of technical efficiency and corporate governance.

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