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RESEARCH ARTICLE

An Expert System to Evaluate the Impacts of Health, Safety, and Environment System Implementation on Firms' Financial Performance Using Analytic Network Process and Promethee Techniques

Ali Asghar Anvary Rostamy[1,*] and Ali Rajabzadeh Ghatari[2]

[1]*Department of Planning and Management, Tarbiat Modares University, Iran*

[2]*Department of Industrial Management, Tarbiat Modares University, Iran*

Abstract: Sustainability involves balancing the environment, equity, and economy, with a focus on the green or low-carbon economy. Four strategic targets for a green economy encompass green management, green production, green lifestyle, and green technologies. Adopting a green economy poses challenges for companies, necessitating innovative systems like green supply chain management, smart homes, and health-safety-environment systems. Companies' concern about financial effectiveness drives the need for investments in these systems, as financial performance is critical for survival and growth. This study investigates the influence of health-safety-environment practices on a firm's financial performance. By determining key health-safety-environment indicators and financial metrics, the research gathered insights through 97 questionnaires, which were completed by experts from four Iranian companies. The collected data were analyzed employing the analytic network process and Promethee techniques, enabling a robust evaluation of the relationship between health, safety, and environment (HSE) practices and financial performance. Finally, an expert system was designed based on decision matrices to provide suitable financial indicators derived from HSE data. Linking HSE practices to financial performance enhances overall effectiveness and sustainability, guiding businesses in making informed decisions while respecting growth, success, environmental issues, and finally low-carbon economy.

Keywords: expert system, health-safety-environment, financial performance, analytic network process, Promethee method

In any organizational activity, including health, safety, and environment (HSE) activities, the efficient utilization of limited resources is crucial to achieving maximum goals. These activities directly or indirectly influence organizational objectives, making it essential to comprehend their impact on financial goals. This study aims to explore precisely this aspect: understanding how HSE activities affect the financial goals of organizations.

1. Introduction

In today's highly competitive business environment, organizations face the obligation to adhere to a range of domestic and international standards and laws, which dictate the specific activities they must perform. These regulations demand compliance in alignment with the organization's field of activity. Examples of such standards include OHSAS, ILO, ISO14001, and HSE standards. As organizations strive to develop empowering strategies centered on health, safety, and the environment, these standards have become a paramount concern for effective management.

It is widely recognized that adhering to these standards and laws, including the HSE standards, can significantly affect the overall performance of organizations. To ensure efficient progress toward their goals and vision, performance measurement plays a crucial role. It provides a clear snapshot of the organization's status at a given time and helps identify both areas of strength and areas that require improvement (López-Alonsoa et al., 2013).

Sharing and implementing these standards and laws allow organizations to establish a set of general performance indicators. By complying with these regulations, organizations must address various financial aspects, such as financing, investment, and liquidity management, which can significantly influence their overall performance, especially their financial performance. Hence, being aware of the financial situation and measuring financial performance offer valuable insights into the consequences of organizational actions.

*Corresponding author: Ali Asghar Anvary Rostamy, Department of Planning and Management, Tarbiat Modares University, Iran. Email: anvary@modares.ac.ir

A healthy organization thrives through steady financial flows that sustain its survival. Consequently, assessing the organization's existing situation from a financial standpoint becomes crucial (Dufera-Meta, 2012). By taking a financial perspective, organizations can better understand their financial well-being and make informed decisions to drive their growth and success amidst fierce competition in the business world.

Several theories are presented in the literature regarding the firms' performance. Some prominent theories are silent trading theory (Preston & O'Bannon, 1997), institutional theory (Roberts et al., 2004), stewardship theory (Hernandez, 2008), agency theory (Chae et al., 2020; Kothari et al., 2009; Rezaee, 2017), stakeholder theory (Campbell & Yeung, 2017; Clarkson et al., 2008; Lozano et al., 2015), legitimacy theory (Tilling, 2004), signaling/disclosure theory (Grinblatt & Hwang, 1989), branding theory (Lys et al., 2015), and managerial opportunism theory (Wang et al., 2020). These theories offer diverse perspectives on the potential influence of expenses on HSE systems on the firms' performance. Silent trade theory, managerial opportunism theory, agency theory, and signaling/disclosure theory are skeptical about the outcomes of investments on HSE, while some other theories such as institutional theory, stewardship theory, stakeholder theory, legitimacy theory, and branding theory are aligned with the outcomes of HSE system.

The primary objective of this research is to develop an expert system that assesses the influence of the HSE system on firms' financial performance. Accordingly, the central issue is "identifying the financial impact of HSE activities on the firms." In essence, this entails determining the most appropriate financial indicators to measure the effects of HSE initiatives and identifying the key indicators that best display these impacts. To achieve the goal of this research, the following three steps have been implemented:

- Identifying appropriate HSE and financial performance indicators
- Assessing the importance of financial performance indicators
- Designing an expert system.

The research aims to offer valuable insights into the interplay between HSE initiatives and financial performance within organizations. The resulting expert system will serve as a valuable decision support tool, enabling firms to make data-driven choices, optimize their HSE practices, and enhance their overall financial performance.

The structure of the article is as follows: the next section provides a brief explanation of the literature and background. Section 3 outlines the data and methodology employed. Section 4 presents the results. Finally, Section 5 concludes the study.

2. Literature Review

Sustainability is balancing the environment, equity, and economy. According to the United Nations World Commission on Environment and Development, sustainable development meets present needs without compromising future generations' ability to meet their own needs. University of California, Los Angeles (UCLA) Sustainability Committee defines it as the integration of environmental health, social equity, and economic vitality to create thriving, healthy, diverse, and resilient communities for current and future generations (UCLA Sustainability, 2012). Central to sustainable development is the concept of a green economy. This shift toward a green and low-carbon economy is essential for global carbon neutrality efforts. The United Nations Environment Program characterized a green economy as being by low carbon, resource efficiency, and social inclusivity. The European Commission identifies four strategic targets for fostering a factual green economy: green management, green production, green lifestyle, and green technology. There are several challenges in the diffusion of the green economy (Organisation for Economic Co-operation and Development, 2011). The challenges and policy options are not the same in developed, developing, and least developed countries. Practicing a green economy requires a systems approach and an understanding of complexity (Litido & Righini, 2013).

Liu et al. (2023a) investigated the influence of carbon-neutral announcements on the market capitalization of Chinese firms. The announcement of carbon neutrality had a positive impact on the value of Chinese firms' stocks. Their findings shed light on the economic value of carbon-neutral initiatives and offer operational guidance to managers in developing economies, helping them enhance their companies' market value through the active implementation of carbon-neutral measures.

Within a green and low-carbon economy framework, economic growth, employment, and income generation are fueled by both public and private investments in activities, infrastructure, and assets that promote reduced carbon emissions and pollution, improved energy and resource efficiency, and the preservation of biodiversity and ecosystem services. Achieving a green and low-carbon economy necessitates the development of innovative systems and approaches. Some strategies include the implementation of sustainable green, digitalized, and smart supply chain systems, the de-carbonization of operational processes to foster climate neutrality in business operations, the advancement of solutions related to climate neutrality and climate change mitigation, and the promotion of research concerning environmental sustainability within the framework of a zero-carbon economy (Nikseresht et al., 2023).

For instance, the green supply chain management (GSCM) progressive approach is gaining prominence as it not only mitigates environmental concerns but also delivers significant economic advantages to manufacturers and society (Lina et al., 2011). Companies have embraced GSCM as a means to mitigate environmental risks, enhance ecological efficiency, drive profitability, and expand their market share (Van Hoek, 1999). GSCM incorporates environmental considerations throughout the supply chain to promote sustainability. GSCM optimizes environmental gains and facilitates a company's pursuit of sustainable development and continual improvement (Shi et al., 2012). GSCM is the incorporation of environmental concerns into supply chain management and encompasses a range of practices, including but not limited to reusing, remanufacturing, and recycling. These practices are integrated into the green design, eco-friendly procurement approaches, total quality environmental management, sustainable packaging and transportation methods, and diverse end-of-life product strategies (Hervani et al., 2005; Xie & Breen, 2012). Anvary Rostamy et al. (2013) devised and implemented an evaluation framework for GSCM specific to the Iranian publishing industry. They employed the fuzzy analytic hierarchy process (AHP) approach, considering five primary criteria: green supplier evaluation criteria, green manufacturing, green strategy alternatives, environmental concerns, and customer environmental concerns. The main criteria encompassed several key sub-criteria, such as green competencies, energy efficiency, resource utilization, hazardous waste management, pollution control initiatives, collaboration with green suppliers, environmental certifications, E-publishing, eco-design, cleaner production techniques, green packaging, and energy conservation. The findings of their study revealed that green supplier evaluation criteria and customer environmental concerns were the most critical factors influencing GSCM.

Implementing smart home systems and promoting a shift in homeowners' attitudes are other innovative solutions for creating a low-carbon economy. In this case, smart home manufacturers and suppliers should focus on making appliances compatible with eco-friendly technologies. A study by Shabha et al. (2023) explores how smart home technology can help the UK achieve climate goals and reduce carbon emissions through better control of water, heating, and energy use.

In the study conducted by Liu and colleagues (2023b), they assessed the repercussions of China's carbon neutrality policies on the Chinese stock market, employing the supply chain. The findings revealed a significant negative stock market reaction. However, customer concentration and the adoption of smart supply chains exerted a substantial mitigating influence on this negative outcome (Liu et al., 2023b).

Another important and effective innovative organizational system in the direction of creating a green and carbon-free economy is the HSE system that we will discuss in this article. HSE exerts both direct and indirect effects on firms' performance. A thorough comprehension of these effects facilitates the establishment of an efficient HSE system, reducing internal negative events and ultimately enhancing overall performance. Additionally, it contributes to a positive external image of the company (Honkasalo, 2000). Significant investment in HSE demonstrates the paramount importance of this field for companies. The funds allocated toward HSE serve to increase employee productivity, ensure workforce well-being, and avoid excessive environmental and labor fines (Miller & Haslam, 2009).

Various studies in the literature have explored the relationship between HSE and performance. For instance, the United Kingdom HSE report has investigated the economic effects of HSE. Andreoni (1986) emphasized the significance and cost of occupational accidents and diseases, while Laufer (1987) discussed construction accident costs and safety management motivation. Brody et al. (1990) focused on incident and work accident costs and their impact on a company's cost structure. Helander and Burri. (1995) assessed the cost-effectiveness of ergonomics and quality improvement in electronic manufacturing, and Abrahamsson (2000) conducted a production economics analysis of investments to enhance the working environment. Guadalupe (2003) examined contract costs related to incidents and accidents. Yeow and Nath Sen (2003) performed a cost-benefit analysis of workspace ergonomics in reducing accidents and diseases, improving employment, cost efficiency, and productivity. Oxenburgh et al. (2004) explored how securing the work environment and reducing financial and non-financial work accidents could lead to increased profit and productivity. Rikhardsson (2004) focused on finding the appropriate accounting method for work incidents' cost, while Oxenburgh and Marlow (2004) provided a computer-based cost-benefit analysis model for evaluating occupational health and safety interventions. Azadeh et al. (2011) also developed an adaptive neural network algorithm for job satisfaction assessment and improvement in a gas refinery's HSE and ergonomics program. Ammar (2011) explored the optimization of time and cost concerning mass constructions and environmental impact. Azadeh et al. (2012) investigated the performance and improvement of the HSE management system in a large conventional power plant manufacturer using a fuzzy multivariate approach under uncertainties and human errors. Sadoughi et al. (2012) proposed intelligent algorithms for evaluating and prioritizing HSE performance indicators using fuzzy TOPSIS. Xu et al. (2012) examined environmental issues in mass construction in relation to financial costs and time. Coquillard et al. (2012) focused on reducing the cost-benefit ratio in environments with plastic waste to clean the environment and facilitate recycling. López-Alonsoa et al. (2013) studied the impact of health and safety investments on construction companies' costs. Azadeh et al. (2013) developed an intelligent algorithm for the performance evaluation of job stress and HSE factors in petrochemical plants with noise and uncertainty. Lastly, Bertram et al. (2014) conducted a cost-benefit analysis within the framework of the European Union's marine environment strategy.

Multi-criteria decision-making (MCDM) techniques find extensive application across various domains, encompassing HSE and finance. The essence of both HSE and financial decisions inherently involves grappling with numerous and often conflicting criteria. Scholars, like Hallerbach and Spronk (2002), have highlighted the relevance of MCDM in financial decisions. In this research, we delve into the interplay and convergence of finance and MCDM techniques, exploring how these two domains are interconnected and utilized together. For instance, Rezaian and Jozi (2011) have conducted research on health, safety, and environmental risk assessment in refineries using a MCDM approach. Additionally, Zheng et al. (2012) have employed a trapezoidal fuzzy AHP method to evaluate work safety and provide early warning ratings for hot and humid environments. Furthermore, Steuer and Na (2003) have integrated MCDM with finance in their studies. This research aims to demonstrate the practical use of MCDM in financial management, emphasizing its versatility and effectiveness in tackling complex financial decisions. By exploring the successful applications of MCDM in both HSE and finance, this study aims to shed light on the immense potential and synergy created when these disciplines are integrated. This synergy can lead to more informed and robust decision-making processes, particularly in situations where multiple criteria need to be considered and balanced effectively.

HSE plans and activities are integral to sustainable performance, encompassing environmental, social, economic, and governance dimensions, all of which affect firm performance. Particularly in industries like oil, gas, petrochemical, and refineries, where activities can have significant environmental and societal consequences, efforts toward sustainability practices hold greater significance. Several studies have shown the positive effects of environmental activities on companies' performance and market reactions. Brockett and Rezaee (2012) argue that corporate features like environmental plans, social responsibility, governance, ethics, and reported earnings improve performance by considering stakeholders' interests. Akrout and Ben Othman (2016) find a positive relationship between environmental disclosure and stock market liquidity in North African companies. Tang and Zhong (2019) highlight that enhancing environmental sustainability reports improves disclosure quality. Harmadji et al. (2020) establish a positive link between environmental sustainability report quality and future stock price crashes. Höck et al. (2020) suggest environmental sustainability impacts credit risk pricing, with stable companies experiencing lower credit risk. However, Alsahlawi et al. (2021) observe a negative impact of environmental sustainability disclosure on stock returns, especially for financially constrained firms. Finally, Pahlavan et al. (2023) outline the impacts of environmentally sustainable performance reporting on Iranian firms' financial performance, showing how environmental disclosure improves their financial performance.

3. Research Methodology

The main purpose of this research is to investigate the impact of the implementation of HSE systems on the firms' financial performance using analytic network process (ANP) and Promethee techniques and develop an expert system based on decision matrices to provide suitable financial indicators derived from HSE data.

To gather data, we follow a two-step process. First, we conduct an extensive review of the literature and background related to HSE systems and their impact on financial performance. Following this, we administer a structured questionnaire.

The study's sample consists all 97 experts who possess substantial knowledge in both HSE and financial domains and are well acquainted with data in these fields, have a minimum of 5 years of relevant work experience, and willing to participate in this research. The qualified experts were from four prominent companies: Exploration Management Company, Gas Engineering Company, Petrochemical Company, and Oil Industry Research Institute.

This research comprises two main stages as below:

Stage 1: Determination of HSE and financial performance indicators
Stage 2: Expert opinion collection and expert system development
Stage 2 is further divided into three following subsections:

2-1 Expert demographic information: This subsection includes data on the experts' work experience, familiarity with financial and HSE topics, and the results of analysis using SPSS software.
2-2 Expert opinion collection: The opinions of experts are gathered through a questionnaire to identify and weight financial indicators. Subsequently, the ANP technique, aided by Super Decision software, is employed to compare and prioritize these indicators. Additionally, the Promethee technique, in conjunction with Visual Promethee software, is utilized for further prioritization.
2-3 Expert system development: In this subsection, an expert system is developed based on the data obtained from the previous section. The system is designed to prioritize indicators effectively, considering expert opinions and relevant information.

Figure 1 illustrates the implementation process of this research.

4. The Results

4.1. Results of stage 1: Determination of HSE and financial performance indicators

Table 1 displays the final HSE indicators identified during the research process.

Table 2 displays the final financial performance indicators identified during the research process (Boyd, 1991; Brealey et al., 2010; Dalton et al., 1998; Kocmanová & Dočekalová, 2012).

4.2. Results of stage 2-1: Expert demographic information

From the 97 returned questionnaires, it was determined that the respondents had an average work experience of 10.08 years, which is considered an acceptable period for the study. The respondents' average level of familiarity with financial topics was 3.89, with a standard deviation of 0.94, indicating a good and acceptable level of familiarity. Similarly, the average level of familiarity with HSE topics was 3.65, with a standard deviation of 1.09, signifying an acceptable level of familiarity based on the 5-point Likert spectrum.

4.3. Results of stage 2-2: Expert opinion collection

To determine the priority and relative importance of financial indicators with the most impact from HSE indicators, a series of

Figure 1
The process of this research

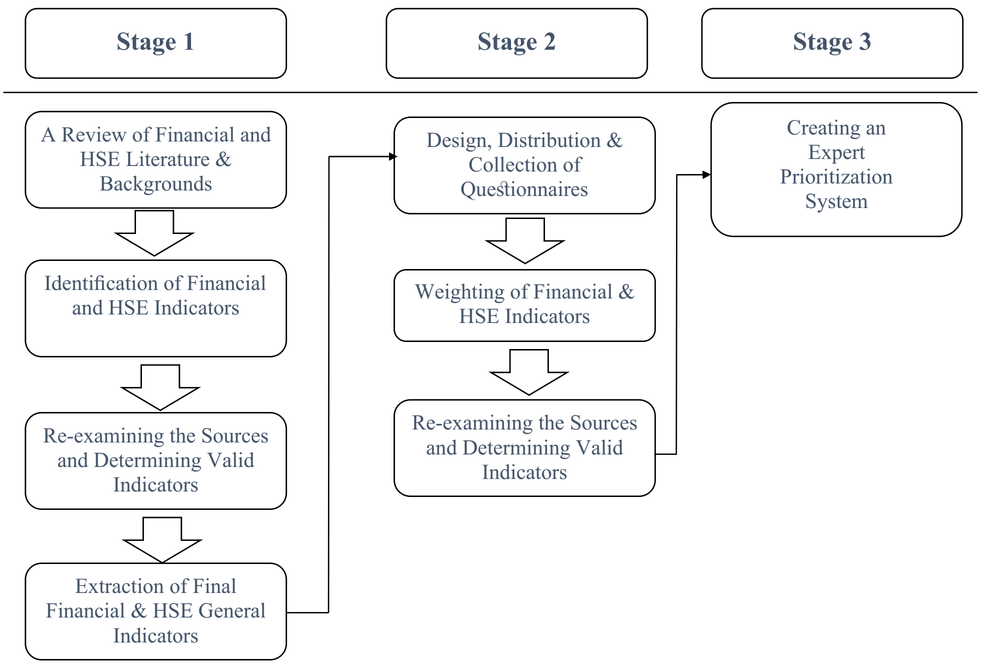


Table 1
Final HSE indicators

Row	Symbols	HSE indicators	Measurements
		A: Health indicators (HSE H)	
1	HSE 1	TRC: Total recordable cases	Total cases of occupational injuries and diseases × 200,000 / Total number of working hours of employees
2	HSE 2	DART: Days away from work, job restriction, or transfer	The number of occupational injuries and illnesses leading to absence from work + the number of occupational injuries or illnesses leading to restrictions or changes in the job × 200,000 / Total number of working hours of employees
3	HSE 3	DAFW: Days away from work	Cases leading to absenteeism × 200,000 / Total number of working hours of employees
4	HSE 4	GAR: Gross absence rate	The total number of work days lost due to absence / The total working days of all employees
5	HSE 5	SAR: Sickness absence rate	The number of days of absence due to illness / The total working days of all employees
6	HSE 6	UAR: Unauthorized absence rate	The number of days of unjustified absence / The total working days of all employees
7	HSE 7	DJRT: Days of job restriction or transfer	Cases leading to job restrictions and job changes × 200,000 / Total number of working hours of employees
8	HSE 8	Percentage of workers exposed to radiation	The number of employees exposed to radiation × 100 / The total number of employees
9	HSE 9	The percentage of employees exposed to inappropriate environmental conditions	The number of employees exposed to inappropriate work environment conditions × 100 / The total number of employees
10	HSE 10	The percentage of employees exposed to whole body vibration	The number of employees exposed to whole body vibration × 100 / The total number of employees
11	HSE 11	The percentage of employees exposed to thermal stress	The number of employees exposed to thermal stress × 100 / The total number of employees
12	HSE 12	The percentage of workers exposed to toxic substances	The number of employees exposed to toxic substances ×100 / The total number of employees
13	HSE 13	The percentage of employees are exposed to organic solvents and corrosive substances	The number of employees are exposed to organic solvents and corrosive substances × 100 / The total number of employees
14	HSE 14	The percentage of employees who are exposed to suspended particles	The number of employees exposed to pathogenic suspended particles × 100 / The total number of employees
15	HSE 15	The percentage of employees who are exposed to bacteria, viruses, pathogenic fungi	The number of employees who are exposed to bacteria, viruses, pathogenic fungi×100 / The total number of employees
16	HSE 16	The percentage of employees who are in harmful positions while performing their duties	The number of employees who are in physically harmful situations while performing their duties × 100 / The total number of employees
17	HSE 17	The percentage of employees who lift/carry more than the allowed load	The number of employees who lift/carry more than the allowed load × 100 / The total number of employees
18	HSE 18	Coverage percentage of job examinations	The number of employees for whom round examinations have been done × 100 / The number of employees who should be examined
19	HSE 19	TROIF: Frequency of reportable occupational illness factor	Total reported occupational illness / Million working hours
20	HSE 20	TLOIF: Frequency rate of time-consuming occupational diseases	Total occupational diseases with medical rest / Million working hours
21	HSE 21	The percentage of employees for whom job restriction rounds have been considered	The number of employees with job restrictions × 100 / The total number of employees examined
22	HSE 22	The percentage of employees who are unsuitable for the current job in round examinations	The number of employees found unsuitable in periodic inspections × 100 / The total number of employees
		B: Safety indicators	
23	HSE 23	Frequency of incidents	The number of disabling incidents × 1,000,000 / Total number of employees working hours
24	HSE 24	Incident severity factor	The number of wasted days × 1,000,000 / Total number of employees working hours

(*Continued*)

Table 1
(*Continued***)**

Row	Symbols	HSE indicators	Measurements
25	HSE 25	Index of frequency of incidents	The number of incidents in a certain period × 1000 The average number of workers at risk during the same period
26	HSE 26	Index of the severity of incidents	The number of days lost due to the accidents in a certain period × 1000 The sum of all useful working hours of the workers in the same period
27	HSE 27	Recordable incidents index	Number of partial accidents + number of incapacitating accidents × 1,000,000 Total number of employees working hours
28	HSE 28	The frequency of incidents leading to financial (non-personnel) damage	Number of incidents leading to financial loss The total number of hours of employees
29	HSE 29	Accident cost factor	Cost of financial, environmental, and personnel damages Total costs
30	HSE 30	Average time interval between incidents	The total number of incidents (financial, environmental, personnel) annually The number of working days of the year
31	HSE 31	The coefficient of the number of safety inspections	The number of safety inspections carried out The number of planned safety audits
32	HSE 32	Safety education indicators	Number of people/hours of safety training The total number of staff training hours
33	HSE 33	Risk assessment indicators	The number of evaluations done The total number of planned evaluations
34	HSE 34	Index of carrying out control actions	Number of corrective/preventive actions Total number of corrective/preventive planned actions
		C: Environmental indicators	
35	HSE 35	Greenhouse gas emissions indicator	Emission of greenhouse gases in kilograms per year
36	HSE 36	Emission rate indicators	Emission of toxic gases (containing compounds of sulfur, phosphorus, nitrogen, chlorine, etc.) in kilograms per year
37	HSE 37		Emission of suspended particles (toxic and non-toxic) in kilograms per year
38	HSE 38	Index of transparency of pollutant distribution	Distribution of toxic substances (liquid and solid) in terms of kilograms and liters per year
39	HSE 39		Distribution of non-toxic substances in kilograms and liters per year
41	HSE 41		Release of toxic substances (solid and liquid) in water in kilograms and liters per year
42	HSE 42	Index of environmental destruction and change	The amount of changes in the environment in square kilometers (these changes include physical changes such as building various facilities, changing the shape of the environment, and soil removal)
43	HSE 43		Index of ambient temperature change based on degrees Celsius per year

questionnaires were prepared in the form of an Excel file and distributed to experts. These questionnaires included assessing the priority of financial indicators in relation to each other and also evaluating the correlation between financial indicators and HSE indicators. Once the results were collected, the information was input into the Super Decision software to build the model, and the process of pairwise comparison analysis commenced.

To ensure robustness, two techniques, namely ANP and Promethee, were utilized for prioritizing the indicators. The final prioritization was then integrated into an intelligent system. Figure 2 illustrates the model designed for data analysis within the Super Decision software.

Table 3 presents the prioritization of financial performance indicators in relation to each other and the set of HSE indicators. Based on the findings from Table 3, the highest priority is attributed to the profitability indicators, while the lowest priority is assigned to the government sector indicators.

Table 4 presents a summary of the comparison between the results obtained from the ANP and Promethee techniques. To combine and use the results from both techniques to arrive at a final priority, the total score method was employed. In this method, prioritized indicators from the two techniques were assigned scores ranging from 30 to 1 based on their respective priorities, and these scores were then summed up for each indicator. Finally, the indicators were prioritized based on the highest total score. The outcome of this prioritization is also presented in Table 4.

4.4. Results of stage 2-3: Expert system development

Matlab and Excel software were utilized to develop an expert system for the selection and prioritization of financial indicators based on the status of HSE indicators. The procedure involves utilizing the existing weight matrix and the weight specified by the user for HSE indicators to generate a new priority for financial indicators. To streamline the process, the system reads the matrix and weights from Excel software and presents the results in its

Table 2
Final indicators of financial performance

Row	Group icon	Type of Indicator	Symbols	Indicator
1	F1	Profitability	F1	ROCE: Return on capital employed
2			F2	Gross profit margin or operating profit margin
3			F3	Net profit margin
4			F4	EBITDA: earnings before interest paid, taxes and depreciation adjustment
5			F5	Assets turnover
6	F2	Liquidity ratios	F6	Current ratio
7			F7	Acid ratio
8			F8	Inventory holding period
9			F9	Debt collection period
10			F10	Debt payment period
11	F3	Leverage ratios	F11	Financial leverage
12			F12	Profit coverage, which is equal to operating profit divided by financing costs
13			F13	EPS or earnings per share
14			F14	Debt ratio
15			F15	Interest cost coverage ratio
16	F4	Investment ratios	F16	Dividend coverage
17			F17	Dividend yield
18			F18	EVA: Economic value added
19			F19	Earnings yield
20	F5	Returns ratios	F20	ROA: Returns to assets
21			F21	ROI: Returns to investments
22			F22	ROE: Returns to equity
23	F6	General indicators	F23	Total sales
24			F24	Total assets
25			F25	Average annual sales growth
26			F26	Average annual profit
27	F7	Governmental sectors indicators	F27	Total financial debts
28			F28	Operational cash surplus or deficit
29			F29	Costs of repair, renovation or replacement of assets
30			F30	Net borrowing and loans given

Figure 2
A model designed for data analysis in Super Decision software

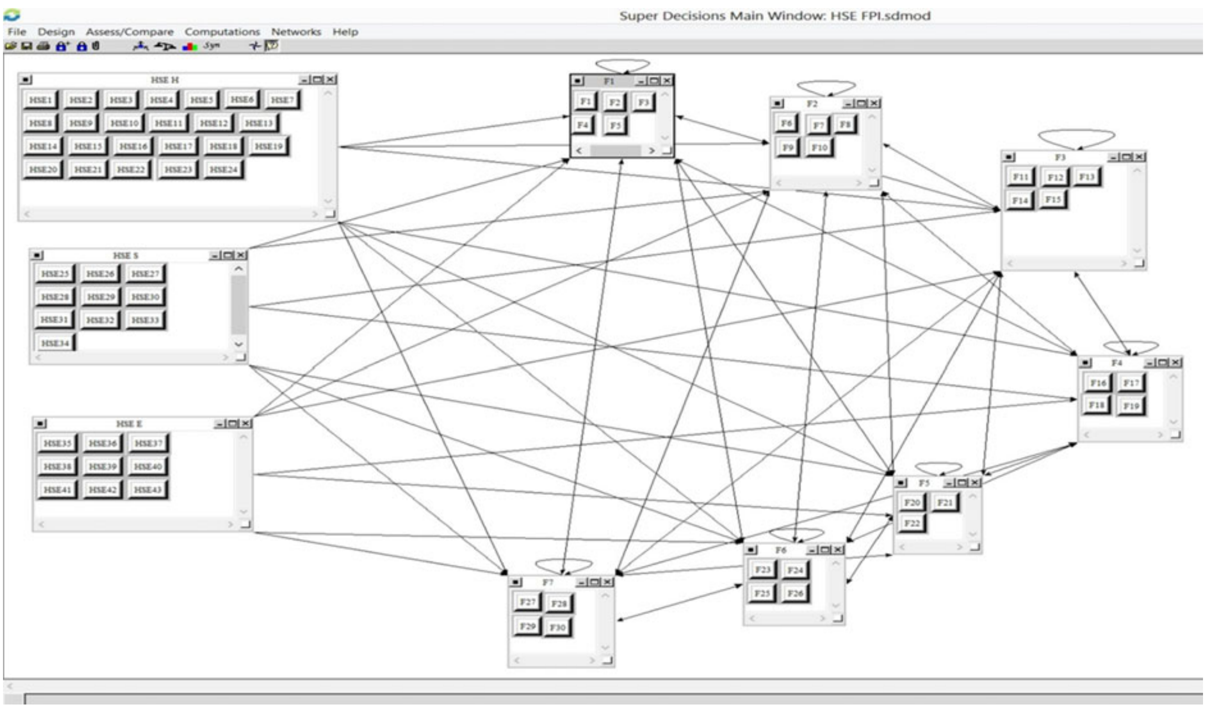
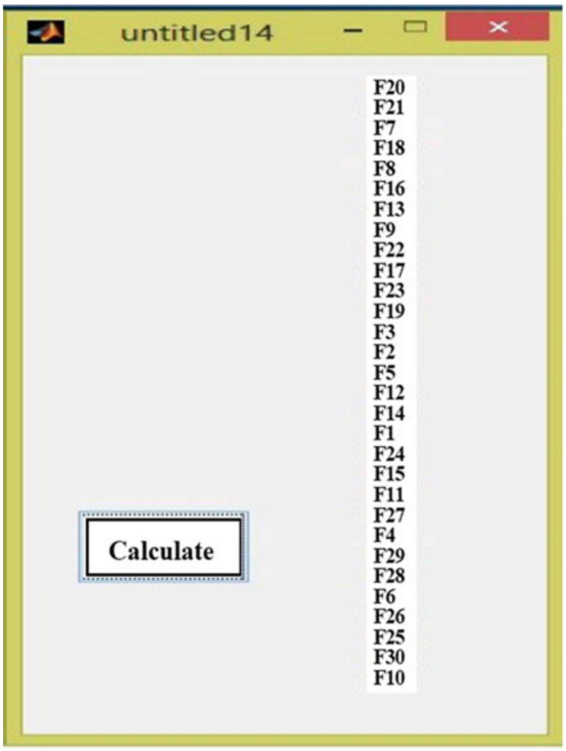


Figure 3
Software graphical interface



graphical interface. The graphical interface of the software is depicted below for easy visualization. The appearance of the graphical interface of the software is as follows (Figure 3).

Table 3
Prioritizing groups of financial indicators based on groups of HSE indicators

Priority	Health	Safety	Environment
First	Profitability	Profitability	Profitability
Second	General financial indicators	General financial indicators	General financial indicators
Third	Return ratios	Return ratios	Return ratios
Fourth	Financial leverage ratios	Financial leverage ratios	Financial leverage ratios
Fifth	Liquidity ratios	Liquidity ratios	Liquidity ratios
Sixth	Investors ratios	Investors ratios	Investors ratios
Seventh	Government sector ratios	Government sector ratios	Government sector ratios

In the graphical interface, upon clicking the calculate button, the system reads the weights from the Excel file and subsequently displays the ranking of financial indicators on the software's graphical interface. The user enters the weights in the Excel software, as demonstrated in the example below (Figure 4):

This software's calculations are based on the user entering weights and a matrix to establish the relative status of financial indicators compared to HSE indicators. The matrix can be modified to accommodate new values, allowing for a different prioritization based on the type of decision-making software used to generate the matrix and its updated values. Below are the sample codes written in Matlab for this system.

```
function varargout = untitled14(varargin)
    gui_Singleton = 1;
    gui_State = struct('gui_Name', mfilename, ...
```

Figure 4
Weight entry sheet

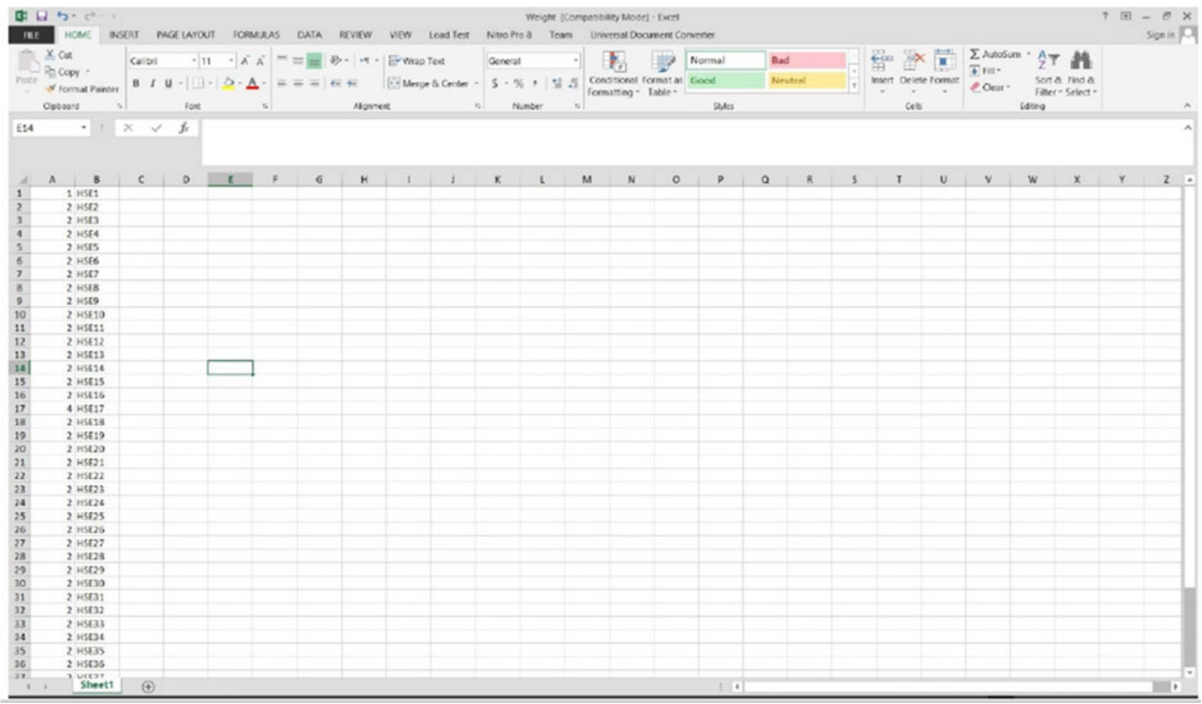


Table 4
The Comparison of ranking of ANP and Promethee technique and final ranking

Rank	Prioritization of financial performance indicators based on ANP technique		Prioritization of financial performance indicators based on Promethee technique		Final combined ranking		
							Total score
1	F23	Total sales	ROA	F20	ROA	F20	58
2	F25	Average annual sales growth	ROI	F21	ROI	F21	58
3	F20	ROA	Total sales	F23	Total sales	F23	58
4	F21	ROI	EVA	F18	EVA	F18	50
5	F24	Total assets	ROE	F22	ROE	F22	48
6	F26	Average annual profit	Net profit margin	F3	Total financial debts	F27	43
7	F27	Total financial debts	Gross profit margin	F2	Average annual profit	F26	43
8	F18	EVA	Profit coverage	F12	Average annual sales growth	F25	43
9	F22	ROE	Debt ratio	F14	Financial leverage	F11	41
10	F11	Financial leverage	Interest cost coverage ratio	F15	Debt ratio	F14	40
11	F29	Costs of repair, renovation, or replacement of assets	Financial leverage	F11	Gross profit margin	F2	38
12	F1	ROCE	Total financial debts	F27	Net profit margin	F3	36
13	F14	Debt ratio	Average annual profit	F26	Interest cost coverage ratio	F15	36
14	F6	Current ratio	Net borrowing and loans given	F30	Total assets	F24	35
15	F30	Net borrowing and loans given	Debt payment period	F10	Net borrowing and loans given	F30	33
16	F15	Interest cost coverage ratio	Current ratio	F6	Dividend coverage	F16	32
17	F2	Gross profit margin	Average annual sales growth	F25	Current ratio	F6	32
18	F8	Inventory holding period	ROCE	F1	ROCE	F1	32
19	F16	Dividend coverage	Costs of repair, renovation, or replacement of assets	F29	Costs of repair, renovation, or replacement of assets	F29	32
20	F3	Net profit margin	Operational cash surplus or deficit	F28	Debt payment period	F1510	22
21	F9	Debt collection period	EBITDA	F4	Inventory holding period	F8	20
22	F12	Profit coverage	Total assets	F24	Assets turnover	F5	16
23	F5	Assets turnover	Assets turnover	F5	Dividend coverage	F16	16
24	F17	Dividend yield	Inventory holding period	F8	Operational cash surplus or deficit	F28	15
25	F10	Debt payment period	EPS	F13	Debt collection period	F9	13
26	F19	Earnings yield	Earnings yield	F19	EBITDA	F4	12
28	F28	Operational cash surplus or deficit	Dividend coverage	F16	Earnings yield	F19	10
28	F13	EPS	Debt collection period	F9	EPS	F13	9
29	F4	EBITDA	Dividend yield	F17	Dividend yield	F17	9
30	F7	Acid ratio	Acid ratio	F7	Acid ratio	F7	2

```
'gui_Singleton', gui_Singleton, ...
'gui_OpeningFcn', @untitled14_OpeningFcn, ...
'gui_OutputFcn', @untitled14_OutputFcn, ...
'gui_LayoutFcn', [], ...
'gui_Callback', []);
if nargin && ischar(varargin{1})
gui_State.gui_Callback = str2func(varargin{1});
end
if nargout
[varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
gui_mainfcn(gui_State, varargin{:});
end
function untitled14_OpeningFcn(hObject, eventdata, handles, varargin)
handles.output = hObject;
guidata(hObject, handles);
function varargout = untitled14_OutputFcn(hObject, eventdata, handles)
varargout{1} = handles.output;
function pushbutton1_Callback(hObject, eventdata, handles)
[NUMERIC,TXT]=xlsread('asa.xls','asa','b3:AR32');
A=NUMERIC;
%B=get(handles.edit1,'string');
%B=str2num(B);
B=xlsread('Weight.xls');
output=A*B;
[sorted,index]=sort(output,'descend');
index=num2str(index);
f=[];
for i=1:30
f=[f ; 'F'];
end
f_texts=strcat(f,index);
```

```
set(handles.text6,'string',f_texts);
function edit1_Callback(hObject, eventdata, handles)
function edit1_CreateFcn(hObject, eventdata, handles)
if ispc && isequal(get(hObject,'BackgroundColor'), get(0,'defaultUicontrolBackgroundColor'))
set(hObject,'BackgroundColor','white');
end
```

5. Conclusion

The overarching objective for numerous economies and organizations today is to cultivate a sustainable, environmentally friendly, and low-carbon economy. To achieve this goal, entities are employing a spectrum of innovative methods, techniques, technologies, and systems. These encompass practices like GSCM, the implementation of smart home systems, and the adoption of rigorous HSE protocols. Given that financial objectives stand at the forefront of priorities for economic entities, it becomes imperative to subject the expenses associated with green and low-carbon activities to a thorough cost-effectiveness analysis or financial evaluation. This evaluation is essential because the response of stakeholders and the capital market to such expenditures, as demonstrated in the research conducted by Liu et al. (2023b), are not always positive.

Financial performance plays a critical role in sustaining operations amid competitive conditions and environmental pressures. These pressures can expose companies to vulnerabilities, making continuous performance monitoring, especially in financial aspects, vital to mitigate risks. HSE, as an area, can impose significant financial and non-financial burdens on companies. Therefore, monitoring and evaluating the impact of HSE on financial performance can enable better management of this domain.

This research investigates the impact of the HSE systems on the firms' financial performance using ANP and Promethee techniques and develops an expert system based on decision matrices to provide suitable financial indicators derived from HSE data. The current expert system was designed with the objective of assessing financial performance in the presence of HSE. It relies on the ranking of financial indicators that best represent the institution's financial performance under the influence of the HSE system.

The system incorporated 43 HSE indicators and 30 conclusive financial performance indicators, derived from the input of 97 experts from the various companies listed on the Iranian Stock Exchange. To determine the importance of financial indicators in displaying the effectiveness of the HSE system, expert opinions and two techniques, ANP and Promethee, were employed.

For determining the most crucial financial indicators based on the firm's specific situation, an expert system was developed using Matlab software. In this system, the user inputs weights through Excel software, and the output offers the new prioritization of financial indicators within the system's environment. This approach ensures a comprehensive evaluation of financial performance in the context of HSE, aiding companies in making informed decisions for improved management and performance outcomes.

The majority of Iranian Stock Exchange-listed manufacturing and industrial firms possess HSE systems. These systems reflect their commitment to environmental sustainability, a low-carbon economy, employee safety, and health. If the expenses incurred by these systems are offset by enhancements in financial performance indicators, the potential for both environmental well-being and alignment with a carbon-neutral economy becomes promising. Then, integrating HSE practices with financial performance not only boosts overall effectiveness and sustainability but also provides businesses with informed decision-making tools that prioritize growth, success, environmental concerns, and the transition to a low-carbon economy.

The research underscores the role of HSE on firms' financial performance and contributes to creating a more informed and responsible environment, aligning with social expectations.

6. Limitations

The implementation of the current research encountered several limitations, and the most significant ones are outlined below:

- Diverse and numerous financial performance indicators: The research faced challenges due to the vast array of financial performance indicators available, making it difficult to encompass all relevant metrics comprehensively.
- Diverse HSE standards: The existence of numerous HSE standards, rules, and instructions varying across different countries and industries posed difficulties in establishing a uniform framework for analysis.
- Limited expertise in both financial and HSE fields: A scarcity of individuals well versed in both financial and HSE domains made it challenging to collect extensive data and expert opinions.
- Limited availability of HSE-related financial information: The absence of comprehensive registration and financial data pertaining to HSE activities restricted the depth of analysis and assessment.
- Focus on general HSE indicators: The research concentrated on general HSE indicators, overlooking industry-specific metrics that could provide more nuanced insights into performance.

Acknowledging these limitations helps to provide context for the research findings and points to areas for potential improvement and further investigation in future studies.

7. Scope for Future Work

While significant progress has been made in the realm of green and low-carbon economies, there remains a pressing need for ongoing research. Given the relatively recent emergence of this crucial global issue, the existing literature and research infrastructure suffer from inadequate resources to adequately support policymakers, managers, and researchers.

In practical terms, the development of innovative systems, such as GSCM systems, smart supply chain management systems, smart home systems, sustainable and clean energy systems, and HSE systems, plays a pivotal role in expediting the attainment of green and low-carbon economies.

In the realm of theory and research, the following subjects are proposed for future works:

- Designing generic framework and system for the global and relative evaluation of firms based on their alignment with green and low-carbon economy objectives.
- Developing a framework cost-effective system for the evaluation of the green-oriented plans, programs, and projects.
- Exploration of emerging domains in the field.
- A best practice network for digitalization of logistics and supply chain management and de-carbonization of operations to nurture a climate-neutral business.
- Strategies for the de-carbonization of operations to cultivate climate-neutral businesses.

- Tackling transportation challenges within the context of sustainable green logistics and supply chains.
- An investigation into how investors and capital markets respond to sustainability-related costs and expenditures, particularly those linked to green and low-carbon performance.
- Evaluating the significance of intellectual capital in the establishment of green and low-carbon organizations.
- Examining the role of social capital in the achievement of green and low-carbon economy.
- How international organization and non-governmental organizations (NGOs) can promote to have a green and low-carbon economy.
- Analyzing the ways in which international organizations and NGOs can contribute to the advancement of green and low-carbon economies.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

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