Original Research

Application of Fuzzy TODIM Aligned with the SCOR Model to Identify and Rank Green Supply Chain Strategies

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Abstract

The present study developed and prioritized green supply chain strategies with uncertainty over time under fuzzy conditions in Mobarakeh Steel Company. First, the internal strengths, weaknesses, opportunities, and threats were identified based on theoretical foundations and experts' opinion. Then, the green supply chain strategies of Mobarakeh Steel Company were developed using the SWOT method. Fuzzy ANP method was used for weighing the dimensions of sustainability while the TOPSIS and TODIM methods were used for weighing the strategies. The results indicated that among the indicators of sustainability, "economic" indicator had the first rank, "environmental" indicator had the second rank, and "social" indicator had the third rank. In addition, SO strategies had the first rank, ST strategies had the second rank, WO strategies had the third rank, WT strategies had the fourth rank. By calculating total performance according to SCOR DEA model, in SCOR supply chain network, the Mobarake steel of Isfahan have the highest performance and Arin Folad of Isfahan have the lowest performance. A big difference was observed between the performance level calculated by the DDEA method and the performance calculated by DEA, in some cases, the performance calculated by the DEA method is lower than that calculated by the DDEA method. The average calculated performance in the DEA method is equal to 0.78 and the mean for the DDEA method is 0.83.

Keywords: Green supply chain, Strategic planning, SWOT, Fuzzy MCDM, SCOR Model.

INTRODUCTION

In today's competitive landscape, organizational growth and long-term sustainability depend heavily on well-designed strategies aimed at enhancing productivity [1]. Productivity, a fundamental driver of both development and survival, is therefore of paramount importance [2]. Given rapidly evolving customer needs, organizational environments are subject to constant change. Furthermore, resource scarcity presents a major constraint and challenge to organizations [3]. In the context of intensifying economic competition, improving productivity and maximizing the effective use of available resources and capacities have become essential. Indeed, without optimized productivity, achieving organizational objectives is unlikely [4].

A previous study developed a Supply Chain Operations Reference (SCOR) model to evaluate the performance of Iran's natural gas supply chain network. The model was parameterized using monthly data over a five‑year planning horizon and analyzed across three sequential stages: production, transmission, and distribution. It accounted for exogenous and unfavorable inputs and outputs, as well as intermediate products. Overall efficiency was calculated as the composite of the relative efficiencies of all supply chain components over the five‑year period, combined with actual monthly operational data. The efficiency metrics for each stage could be adapted for similar analyses in other energy supply chains, such as water, oil, electricity, and wind [5].

Maclean and Wilson (2011) emphasized that environmental degradation—particularly global warming—poses a critical threat [6]. Environmental advocacy groups argue that protecting the environment is an urgent priority. Evidence shows that changes in atmospheric patterns are largely driven by human activities, making anthropogenic behavior the leading cause of environmental damage. To mitigate such impacts, governments must enforce laws and regulations that limit environmentally harmful actions by organizations [7].

Unlike previous studies that mainly relied on the integration of SWOT, ANP, and TOPSIS in a static framework, this research proposes a multi-layered and dynamic decision-making approach. First, sustainability dimensions were weighted through SWOT and Fuzzy ANP. Then, the primary strategies were prioritized using Fuzzy TOPSIS, and the secondary strategies were ranked with Fuzzy TODIM in order to incorporate profit–loss relationships, interdependencies, and both positive and negative criteria. Another novelty of this work is the simultaneous evaluation of the performance of Iranian steel supply chain companies using the SCOR model under fuzzy conditions, revealing the differences between dynamic and static performance. This comprehensive framework provides richer decision-making insights compared to conventional SWOT–ANP–TOPSIS applications.

The notion of the green supply chain (GSC) emerged in response to the significance of environmentally responsible benchmarks and supply chains [8]. This study focuses on developing and prioritizing GSC strategies while accounting for uncertainty over time under fuzzy conditions. A general overview of the research is also provided.

Review of Literature

Green supply chain management (GSCM) merges environmental responsibility with operational efficiency. Zaeri and Ramezani (2011) selected suppliers in a GSC framework using Analytic Hierarchy Process (AHP) to weight criteria including quality, delivery, price, and environmental standards such as environmental management systems, green design, recycling, and eco-friendly procurement [9].

Taleshi et al. (2015) developed green management strategies for energy, wastewater, and air pollution control in Yazd teaching hospitals, using SWOT with internal and external factor evaluation. SO strategies emphasized advanced technologies for optimizing resource use, wastewater treatment, and compliance with pollution laws [10].

Khodashenas et al. (2016) applied SWOT with Fuzzy TOPSIS to rank environmental, economic, and social strategies, identifying the ST (selective growth) strategy as optimal. The approach highlighted the value of fuzzy logic in handling qualitative judgment under uncertainty [11].

Dehghan-Dehnavi and Delshad (2017) examined determinants of GSCM strategies, stressing environmental protection amid global competition, market shifts, and industrial challenges such as pollution and energy crises. They positioned GSC as a proactive solution to enhance environmental performance and productivity [12].

Dynamic models have enriched GSC strategy research. Sepahi Chavoshlou et al. (2019) used game theory in a three-player model—government, manufacturer, consumer—formulating payoff functions and solving for Nash equilibrium. Their findings showed that multi-actor optimization can yield more efficient outcomes than static approaches [13].

Ahmadinejad et al. (2020) ranked GSCM strategies in Yazd Wire and Cable Company with Analytic Network Process (ANP), placing efficiency-based strategies highest and green design as the top criterion [14]. SCM in general impacts the natural environment, motivating adoption of GSCM to reduce pollution, cut costs, and gain competitive advantage through reputation, customer satisfaction, and access to eco-conscious markets [15, 16].

Davari et al. (2014) identified gaps between green consumers' environmental beliefs and behaviors, recommending integrated short- and long-term green marketing strategies to improve consumer-based brand equity [17].

Gopal and Thakkar (2016) investigated critical success factors for sustainable supply chain practices in India's automotive industry, including organizational complexity, structure, regulatory frameworks, technological innovation, ISO standards, stakeholder relationships, and recycling [18].

Malviya et al. (2018) proposed a sustainable strategy selection model using ANP in an Indian automotive case, ranking the resource-based strategy highest and recommending formal green management systems [19].

Rodriguez-Aguilar (2020) designed a composite environmental performance index integrating operational, financial, and environmental metrics for comprehensive GSC performance assessment [20].

Introducing green products poses market challenges. Tahmasebi Zadeh and Boyer (2021) proposed a mathematical model integrating green product development with supply chain configuration, considering market share loss and supplier selection. They advised gradual greening for SMEs and full innovation for firms with larger market share [21, 22].

In manufacturing sustainability, Malek and Desai (2021) identified financial and strategic barriers and advocated strong governmental regulation as the most effective enabler for green production adoption [23, 24].

Panpatil et al. (2023) evaluated green supply chain practices (GSCPs) using a hybrid fuzzy model, ranking environmental regulations, organizational practices, supplier/customer relationships, green product and production, and green logistics practices in order of importance [25].

Dzikriansyah (2023) studied SMEs in Indonesia, finding that internal factors like strategic orientation had no significant effect on GSCM adoption, while external drivers—especially governmental regulation—were decisive [26].

The literature shows methodological diversity: SWOT, AHP, TOPSIS, ANP, fuzzy logic, and game theory; sectoral applications from healthcare to heavy industry; and marketing and operational innovation studies. Yet, most employ static, single-layer prioritization (e.g., SWOT with direct MCDM ranking), without a secondary stage to capture interdependencies or decision-maker risk attitudes. Moreover, SCOR-based dynamic performance assessment is scarcely integrated into GSC strategy planning, particularly in heavy industries.

The present study addresses these gaps by combining Fuzzy ANP and TOPSIS for initial strategy weighting with Fuzzy TODIM for secondary prioritization, reflecting gain-loss considerations and interdependencies, and aligning with SCOR to assess both dynamic and static supply chain performance in the Iranian steel industry.

RESEARCH METHODOLOGY

I. Method

The method used in this study was analytical-survey. A combination of library and field research methods was used for data collection. Library method was used for collecting the data about research literature and research background while field method was used for collecting the data to answer the research questions.

II. Statistical population and sample

The statistical population of this study included all managers, experts, and stakeholders of Mobarakeh Steel Company. In order to determine the sample size based on the limited statistical population, the following formula is used:

$$\boldsymbol{n} = \frac{N \times Z_{\alpha/2}^{2} p(1-p)}{d^{2}(N-1) + Z_{\alpha/2}^{2} P(1-P)} \tag{1}$$

Where:
n: sample size
N: population size
Z: the value of standard normal variable as 1.96 at 95% confidence level.
P: The value of the attribute ratio in the population. It can be considered as 0.5 if it is not available. In this case, the variance value will reach its maximum value.
q: The percent of members without the attribute in the population. (q = 1-p).
d: Allowed error value equal which is considered as 0.05.

In the present study, the number of subjects in the statistical population was reported as 200. Based on N = 200, the sample size was calculated as 131.755 using the Cochran formula which was equal to 132.

$$\frac{200\times1.96^2\times0.5\times0.5}{0.05^2\times199+1.96^2\times0.5\times0.5}=131.755$$

III. Data collection method and tools

In this study, library and field methods were used for data collection. Library method was used for collecting the data about research literature and research background while field method was used for collecting the data to answer the research questions. In reviewing the theoretical foundation and literature, the Internet, scientific articles, and similar theses were used. In the field phase, which is the most significant phase of data collection, a questionnaire was used in order to collect data.

IV. Data analysis method

In the present study, first the internal and external strategic factors were investigated for developing green supply chain strategy in Mobarakeh Steel Company. The SWOT matrix analysis was used to develop the strategies. After developing the green supply chain strategies, hybrid multi-criteria decision-making methods were used to prioritize and provide the final model. The fuzzy ANP method was used for determining the weight of sustainability indicators and then TOPSIS and Fuzzy TODIM methods were used to prioritize green supply chain strategies.

RESULTS

I. Results of the SWOT Method

TABLE I
INITIAL LIST OF STRENGTHS

Factor Code	Description of Strengths
S_1	Management's attention to improving energy consumption patterns
S_2	Management's attention to developing an urgent plan to minimize workplace injuries
S_3	Adequate expertise
S_4	Managerial accountability
S_5	Possession of verifiable documentation
S_6	Attention to waste reduction
S_7	Use of modern technologies
S_8	Attention to suppliers' ISO 14001 certification
S_9	Company planning meetings to predict and solve environmental problems
S_{10}	Development of sustainable consumption paradigms for renewable resources
S_{11}	Attention to measuring pollutant emissions
S_{12}	Resolution of community-level complaints regarding environmental issues
S_{13}	Participation in regional recycling initiatives
S_{14}	Application of comprehensive environmental quality management
S_{15}	Proper use of natural resources (minerals)
S_{16}	Management commitment to GSCM processes
S_{17}	Presence of information systems
S_{18}	Implementation of green sourcing, procurement, packaging, distribution, and sales methodologies
S_{19}	Deployment of effective production waste disposal strategies
S_{20}	Optimal planning of transportation fleet to minimize emissions of polluting gases
S_{21}	Implementation of energy-efficient lighting and heating

A preliminary list of 21 strengths was developed, as detailed in Table I. This list was subjected to expert review, leading to the exclusion of six items based on consensus. The finalized set of organizational strengths is presented in Table II. The rationale for exclusion was twofold: either the strengths were non-existent or overlapped with other organizational strengths.

TABLE II
THE FINAL LIST OF STRENGTHS

Factor Code	Description of Strengths
S_1	Management's attention to improving energy consumption patterns
S_2	Management's attention to developing an urgent plan to minimize workplace injuries
S_3	Adequate expertise
S_4	Attention to waste reduction
S_5	Use of modern technologies
S_6	Attention to suppliers' ISO 14001 certification
S_7	Company planning meetings to predict and solve environmental problems
S_8	Development of sustainable consumption paradigms for renewable resources
S_9	Attention to measuring pollutant emissions
S_{10}	Resolution of community-level complaints regarding environmental issues
S_{11}	Application of comprehensive environmental quality management
S_{12}	Management commitment to GSCM processes
S_{13}	Presence of information systems
S_{14}	Deployment of effective production waste disposal strategies
S_{15}	Optimal planning of transportation fleet to minimize emissions of polluting gases

TABLE III
THE INITIAL LIST OF WEAKNESSES

Factor Code	Description of Weaknesses
W_1	Poor performance in proper landscape (green space) design
W_2	Poor performance in preventing environmental degradation
W_3	Inattention to occupational safety and ergonomic design standards
W_4	Absence of routine pollutant concentration monitoring
W_5	Weak and sporadic supervision of production
W_6	Lack of collaborative employee involvement in issues such as energy, water, and pollution prevention
W_7	Insufficient planning and a systematic approach to renovating company buildings to conform with sustainable architecture and construction practices
W_8	Failure to seek expert advice on energy conservation ideas
W_9	Absence of chemical and microbial monitoring of all materials discharged into the urban sewage network
W_{10}	Disregard for occupational safety protocols in workspace configuration

A preliminary set of ten weaknesses was developed, as described in Table III. Expert consultation led to the removal of two weaknesses, resulting in the finalized set presented in Table IV. The experts justified these exclusions by stating that the removed weaknesses either lacked relevance to the organization under study or exhibited overlap with other identified weaknesses.

TABLE IV
FINAL WEAKNESSES

Factor Code	Description of Weaknesses
W_1	Poor performance in preventing environmental degradation
W_2	Inattention to occupational safety and ergonomic design standards
W_3	Absence of routine pollutant concentration monitoring
W_4	Weak and sporadic supervision of production
W_5	Lack of collaborative employee involvement in issues such as energy, water, and pollution prevention
W_6	Insufficient planning and a systematic approach to renovating company buildings to conform with sustainable architecture and construction practices
W_7	Failure to seek expert advice on energy conservation ideas
W_8	Absence of chemical and microbial monitoring of all materials discharged into the urban sewage network

TABLE V
INITIAL LIST OF OPPORTUNITIES

Factor Code	Description of Opportunities
O_1	Familiarization of private sector companies and contractors with energy consumption optimization and related policies and regulations
O_2	Presence of new technologies to optimize extraction and production
O_3	Provision of national directives for carbon dioxide emission management
O_4	Presence of regulations regarding green management
O_5	The existence of regulations, exemplified by Article 190 of the Fifth Five-Year Plan Law of the Islamic Republic of Iran, regarding the green management program
O_6	The existence of the Air Pollution Prevention Law, approved in 1995, regarding commercial sources of pollutants
O_7	Government attention to environmental pollutants and budget allocation in this regard
O_8	Government attention to environmental management standards
O_9	Allocation of funds by the government to implement green management
O_{10}	Enhancement of community culture for environmental preservation in recent years

Ten potential opportunities were initially defined, as detailed in Table V. The list was subsequently subjected to expert review, resulting in the exclusion of three opportunities. The revised list is presented in Table VI. The removed opportunities were either non-applicable to the studied organization or overlapped with other opportunities.

TABLE VI
FINAL LIST OF OPPORTUNITIES

Factor Code	Description of Opportunities
O_1	Familiarization of private sector companies and contractors with energy consumption optimization and related policies and regulations
O_2	Presence of new technologies to optimize extraction and production
O_3	Provision of national directives for carbon dioxide emission management
O_4	Presence of regulations regarding green management
O_5	Government attention to environmental management standards
O_6	Allocation of funds by the government to implement green management
O_7	Enhancement of community culture for environmental preservation in recent years

TABLE VII
INITIAL LIST OF THREATS

Factor Code	Description of Threats
T_1	Absence of dedicated annual environmental goals
T_2	Failure to provide practical guidelines for the identification and mitigation of environmental incidents and contingencies
T_3	Insufficient attention to investigating morbidity induced by industrial pollution
T_4	Lack of cooperation between governmental and non-governmental institutions in environmental protection and maintenance
T_5	Inadequate awareness among the community regarding GSC implementation
T_6	Technological deficit and restricted access to ergonomic work environments
T_7	Failure to forecast the prerequisites in the energy conveyance sector
T_8	Economic sanctions impeding access to modern technologies
T_9	Insufficient funding to implement waste separation and disposal plans

Initially, nine threats were identified, outlined in Table VII. Subsequently, this list was consulted with a panel of experts who favored eliminating three items, resulting in the final list presented in Table VIII. The rationale for removing these threats was twofold: they were irrelevant to the enterprise under study or overlapped with other threats.

TABLE VIII
THE FINAL LIST OF THREATS

Factor Code	Description of Threats
T_1	Absence of dedicated annual environmental goals
T_2	Failure to provide practical guidelines for the identification and mitigation of environmental incidents and contingencies
T_3	Insufficient attention to investigating morbidity induced by industrial pollution
T_4	Technological deficit and restricted access to ergonomic work environments
T_5	Economic sanctions impeding access to modern technologies
T_6	Insufficient funding to implement waste separation and disposal plans

This study employed a survey instrument designed as an evaluation matrix that included internal and external strategic factors to collect data. A SWOT analysis was conducted, and the GSC strategies were formulated. Subsequently, pairwise comparison facilitated the weighting of sustainability (social, economic, and environmental) indicators. Next, a secondary survey was implemented to assess the strategies relative to these sustainability indicators. The study was built on fuzzy TOPSIS and TODIM methodologies for analysis.

II. Data Analysis Methods

Fuzzy TOPSIS and TODIM methodologies were used to prioritize primary and secondary strategies in the GSC, with an emphasis on the interdependent relationships among component factors (sustainability dimensions) influencing the primary chain strategies. Given the significance of green supply, TOPSIS was employed to rank primary strategies, as it can incorporate both positive and negative parameters. Moreover, it benefits from a rigorous mathematical framework. The method works within a spatial framework, determining the optimal alternative as the one that maximizes divergence from the nadir option while minimizing convergence to the ideal. This characteristic, along with its mathematical foundation, renders it superior to other Multiple Attribute Decision-Making approaches. Given the presence of both positive and negative criteria, this technique was selected as the solution. TODIM was used to prioritize secondary strategies and assess the relative importance of their associations with sustainability criteria. Option evaluation and ranking follow iterative criterion and reference criterion determination. This method calculates a global value to measure each option's dominance, which is then examined relative to the various performance dimensions of the index. This global value is calculated using a gain-loss formula, making the method suitable for ranking secondary strategies based on both positive and negative criteria and their interdependence. The synergistic application of these methodologies may mitigate some of the inherent vagueness and uncertainty associated with Mobarakeh Steel Company's strategic decision-making processes regarding the GSC.

II.I. Fuzzy TOPSIS

Hwang and Yoon introduced TOPSIS in 1981 [27]. This technique predicates that the chosen option has the shortest distance to the positive ideal solution (the best state) and the longest distance to the negative ideal solution (the worst state). The utility of each indicator changes in a regular manner.

II.II. Fuzzy TODIM

Various methods exist for ranking search options in MCDMs, each possessing distinct characteristics and features. First introduced by Gomez and Lima in 1992, TODIM represents one of these methods. This method's primary concept involves assessing each option's dominance relative to others through the total value, followed by the evaluation and ranking of the options based on various dimensions of the performance indicators. The total value is calculated using both losses and profits. TODIM is classified as a compensatory approach, indicating that the shortcomings of one criterion can be offset by the strengths of other criteria. Furthermore, as with similar methods, the criteria must be independent of one another. In addition, qualitative indicators are quantified using this method.

II.III.I. TODIM Steps

A) Formulation of the decision matrix

The first phase in all MCDM methodologies aimed at ranking research alternatives involves the generation of a decision matrix. This matrix includes a set of indicators and options defined by the decision-makers. Moreover, techniques such as the Delphi method, which facilitates the identification of key indicators through iterative surveys, may be used during this phase. The decision matrix is as follows: within this matrix, x11 can, for example, denote the evaluation of option A1 relative to criterion C1. This evaluation can be a real number or a value within a defined range.

TABLE IX
THE DECISION MATRIX

	w_1	w_2	…	w_j		w_n
	c_1	c_2	…	c_j	…	c_n
A_1	x_{11}	x_{12}	…	x_{1j}	…	x_{1n}
…	…	…	…	…	…	…
A_i	x_{i1}	x_{i2}	…	x_{ij}	…	x_{in}
…	…	…	…	…	…	…
A_{m1}	x_{m1}	x_{m2}	…	x_{mj}	…	x_{mj}

Furthermore, at this point, the weight of the criteria needs to be established. The weights may be established directly by the participants or through methods such as AHP or entropy techniques.

B) Normalization of the decision matrix

The decision matrix is normalized using the following equations. The first equation applies to positive criteria, while the second is applied to negative criteria with negative polarity. This process converts all criteria to positive ones.

For positive criteria:

$$x_{ij} = \frac{y_{ij} - \min(y_{ij})}{\max(y_{ij}) - \min(y_{ij})} \tag{2}$$

For negative criteria:

$$x_{ij} = \frac{\max(y_{ij}) - y_{ij}}{\max(y_{ij}) - \min(y_{ij})} \tag{3}$$

C) Determination of relative weights

This stage involves determining relative weights. Relative weights are computed through a division of the weights of the criteria by the largest weight. As a result, at least one criterion will have a weight of 1.

D) Quantification of the dominance degree

The dominance degree of option Ai over option Aj, representing the dominance degree of each option, is computed by the following equation:

$$\delta(A_i, A_j) = \sum_{c=1}^{m} \varphi_c(A_i, A_j), \forall(i, j) \tag{4}$$

In the above equation, the preference index value is calculated as follows:

$$\varphi_c(A_i, A_j) = \begin{cases} \sqrt{\frac{w_{rc}(p_{ic} - p_{jc})}{\sum_{c=1}^{m} w_{rc}}}, \text{if } (p_{ic} - p_{jc}) > 0 \\ 0 \text{ if } (p_{ic} - p_{jc}) = 0 \\ -\frac{1}{\theta}\sqrt{\frac{\sum_{c=1}^{m} w_{rc}(p_{jc} - p_{ic})}{w_{rc}}}, \text{if } (p_{ic} - p_{jc}) > 0 \end{cases} \tag{5}$$

In this equation, θ represents the deficiency factor. A θ<1 selection reflects that the decision-maker seeks to choose an option with minimal loss that is valid for all criteria. On the other hand, θ>1 indicates a preference for maximizing gains, even at the expense of substantial losses in certain criteria. The convention in most studies is to set θ=1.

E) Determining the total value

This phase involves computing the total value of each option using the specified formula. Options are then ranked based on these values, with higher total values indicating better rankings.

$$\varepsilon_i = \frac{\sum_{j=1}^{n} \delta(A_i,A_j) - \min \sum_{j=1}^{n} \delta(A_i,A_j)}{\max \sum_{j=1}^{n} \delta(A_i,A_j) - \min \sum_{j=1}^{n} \delta(A_i,A_j)} \tag{6}$$

II.II. II. TODIM Results

The Fuzzy TODIM method, similar to the Fuzzy TOPSIS method, initiates with formulating a fuzzy decision matrix that includes alternatives (strategies) and criteria (economic, social, and environmental) and is subsequently normalized. Positive and negative criteria are applied to normalize the decision matrix, following the relationships outlined in Section 3.

Relative weights are determined once the normalized fuzzy decision matrix has been established. In order to determine the relative weights, the weight of each criterion is divided by the largest weight. This guarantees that at least one criterion carries a weight of 1.

The next step involves determining the degree of dominance, the extent to which option Ai dominates option Aj, and the overall dominance of each option. The final step determines the overall value of each option based on its ability to be ranked.

TABLE X
NORMAL DECISION-MAKING MATRIX

Name	Component/Dimension	Economic	Environmental	Social
Strategy WO	Procuring and deploying new technologies	(0,0,1)	(1,1,1)	(0,1,1)
	Familiarization and institutionalization of culture based on green management regulations	(1,1,1)	(0.5,0.58,0.7)	(0,0,1)

Name	Component/Dimension	Economic	Environmental	Social
	Creating a documented plan to renovate Mobarakeh Steel Company buildings based on architecture and construction green principles and Green Management By-law	(0.25,0.44,0.44)	(0,1,1)	(1,1,1)
Strategy (SO)	Leveraging information systems to increase public awareness regarding the significance of the environment and sustainable development	(0,0,0.65)	(0,0.14,0.33)	(1,1,1)
	Developing a strategic directive to design waste discharge and disposal systems that address environmental concerns in accordance with national green management guidelines	(0.18,0.24,0.57)	(0,0,1)	(1,1,1)
	Modifying energy consumption patterns using new technologies and experienced consultants	(0,0.67,1)	(1,1,1)	(0.7,1,1)
	Setting increased community satisfaction as a goal and providing a strategy to address community complaints regarding environmental issues	(1,1,1)	(0,1,1)	(1,1,1)
Strategy (ST)	Responding to community member complaints and providing a manual to educate people about environmental protection	(0,0,1)	(0,1,1)	(1,1,1)
	Employing various educational tools to familiarize people with the consequences and harms of environmental pollution	(0.21,0.39,0.58)	(1,1,1)	(0,0,1)
	Promoting a culture of responsibility in communities to encourage collective action in preventing litter and managing waste in public areas, parks, and green spaces	(0.6,0.8,1)	(0,1,1)	(1,1,1)
Strategy (WT)	Collaboration with relevant organizations to identify and address incidents and emergencies (e.g., fire incidents)	(0,0.5,0.6)	(0,0.3,0.4)	(1,1,1)
	Applying scientific research findings (production planning, workforce allocation, job rotation)	(1,1,1)	(0,1,1)	(0.4,1,1)
	Collaboration with relevant organizations to identify and address incidents and emergencies so as to prevent and mitigate environmental consequences (fire incidents in Mobarakeh Steel Company buildings)	(0.11,0.45,1)	(1,1,1)	(0.5,1,1)

The degree of dominance was then calculated, with θ set to 1 for these iterations. Subsequently, the total value was computed, and the final weighting was established.

TABLE XI
RESULTS OF THE OVERALL FUZZY TODIM VALUE AND FINAL WEIGHTING.

Name	Description	Weight	Rank
Strategy (WO)	Employing expert contracting firms to optimize energy use and apply innovative efficiency solutions.	0.163	4
	Procuring and deploying new technologies	0.177	1
	Infusing strategic thinking into the workforce through expert consultants and contractors to enhance production using new technologies.	0.160	5
	Familiarization and institutionalization of culture based on green management regulations	0.172	2
	eveloping a documented renovation plan for Mobarakeh Steel Company buildings aligned with green architecture principles and the Green Management By-law.	0.165	3
	Using state funds to reduce environmental pollutants	0.163	4

Name	Description	Weight	Rank
Strategy (SO)	Leveraging information systems to increase public awareness regarding the significance of the environment and sustainable development	0.148	1
	Leveraging information systems to familiarize the community members with the company's annual environmental goals and to use their opinions	0.141	3
	Developing a strategic plan for designing waste discharge and disposal systems aligned with national green management standards.	0.141	3
	Providing a suitable plan and strategy for designing and leveraging ergonomic work tools	0.140	4
	Modifying energy consumption patterns using new technologies and experienced consultants	0.148	1
	Setting community satisfaction goals and addressing environmental complaints through coordination with relevant authorities and corrective actions.	0.139	5
	Leveraging experienced contracting companies and consultants to implement appropriate and new waste collection systems	0.142	2
Strategy (ST)	Responding to community member complaints and providing a manual to educate people about environmental protection	0.200	3
	Employing various educational tools to familiarize people with the consequences and harms of environmental pollution	0.176	5
	Promoting community responsibility and collective action to prevent littering and manage waste in public spaces and green areas.	0.218	1
	Infusing cultural values among the public and developing strategic approaches to modify energy usage habits	0.208	2
	Infusing awareness among community members through advertising means to use public transportation	0.198	4
Strategy (WT)	Cooperating with organizations to set annual environmental goals, prohibit tree cutting, and promote green principles in urban renovation and construction.	0.194	3
	Applying research-based methods in production planning, workforce allocation, and job rotation to cut costs, reduce ergonomic risks, and improve productivity.	0.199	2
	Collaborating with organizations to prevent and manage environmental incidents and emergencies, such as industrial fires.	0.214	1
	Leveraging the country's educated workforce and their talents to design ergonomic work tools	0.181	4
	Monitoring the company's performance in waste separation and disposal	0.163	5

Table XI indicates the following:

1. Among the WO strategies, "Procuring and deploying new technologies" exhibits the highest priority, with a weight of 0.177.
2. Among the SO strategies, "Leveraging information systems to increase public awareness regarding the significance of the environment and sustainable development "and "Modifying energy consumption patterns using new technologies and experienced consultants" both occupy the foremost rank. Moreover, "Transferring complaints to competent government authorities and providing a solution to reduce complaints" is ranked fifth, with a weight of 0.139."
3. Regarding the ST strategies, the top priority, with a weight of 0.218, was "Promoting a culture of responsibility in communities to encourage collective action in preventing litter and managing waste in public areas, parks, and green spaces." Additionally, "Employing various educational tools to familiarize people with the consequences and harms of environmental pollution" ranked fourth, with a weight of 0.198.
4. In terms of the WT strategies, "Collaboration with relevant organizations to identify and address incidents and emergencies so as to prevent and mitigate environmental consequences (fire incidents in Mobarakeh Steel Company buildings)" was ranked first at 0.214. On the other hand, "Monitoring the company's performance in waste separation and disposal" was in

fifth place, with a weight of 0.163.

SCOR METHOD

It is critical to present the scoring model within a multi-tiered system framework when implementing the SCOR methodology for network data. The multi-tiered system is defined as follows: The SCOR system consists of five stages that are distinguished by functional input and output variables. If the performance metrics of a supply chain are extracted at each stage, the efficiency of that supply chain can be calculated relative to other supply chains using the SCOR model for network data.

Input and Output Performance Indicators

Techniques such as SCOR serve as tools that cannot be assumed as alternative techniques; instead, their synergistic application within performance evaluation systems appears indispensable. In other words, by establishing a systematic interrelationship between the aforementioned models, one can supplement the other, mitigating the latter's limitations. As a result, the careful implementation and integration of these methodologies represent a potentially effective strategy.

SCOR MODEL RESULTS

Table XII displays the calculated efficiency values at each stage and the overall efficiency of forty decision-making units. Steel companies located in Isfahan and Chaharmahal-and-Bakhtiari are as follows:

Takin Foolad Fardad: DMU_1; Isfahan Mobarakeh Steel Company: DMU_2; Saba Foolad Zagros: DMU_3; Sefiddasht Steel Complex: DMU_4; Behsaz Steel Industrial Group: DMU_5; Rolled Steel Production: DMU_6; Tadbir Steel Company of Isfahan: DMU_7; Natanz Steel Industries: DMU_8; Taraz Steel: DMU_9; Kasra Shear Steel: DMU_{10}; Isfahan Alloy Steel Company: DMU_{11}; Rastak Rod Steel: DMU_{12}; Steel Pipe Industrial Group: DMU_{13}; Benjamin Fajr Mobarakeh Steel Company: DMU_{14}; Naghsh Fulad Arya Naghsh Foolad: DMU_{15}; Irik Paydar Steel Company: DMU_{16}; Isfahan Sazeh Negin Steel Company: DMU_{17}; Datis Sepahan Steel Company: DMU_{18}; Kashan Amirkabir Steel: DMU_{19}; Arian Foolad Isfahan: DMU_{20}; Arya Naghsh Foolad: DMU_{21}; Saba Foolad Manzume Complex: DMU_{22}; Arad Steel: DMU_{23}; Kaveh Steel: DMU_{24}; Qeshm Golden Steel: DMU_{25}; Amirkabir Steel Company: DMU_{26}; Isfahan Iron and Steel Company: DMU_{27}; Rahabran Petro Foolad Company: DMU_{28}; Kavan Steel Company: DMU_{29}; Atiyeh Naqshejahan Steel Company: DMU_{30}; Kavir Steel Complex: DMU_{31}; Shahrekord Steel Factory: DMU_{32}; Vista Steel Company: DMU_{33}; Sepahan Foolad Form Company: DMU_{34}; Kimia Steel Complex: DMU_{35}; Arca Foolad Taj Naqshejahan: DMU_{36}; Sepahan Payam Sanat Steel Company: DMU_{37}; Parsian Atiyeh Foolad Company: DMU_{38}; Mahan Sepahan Steel: DMU_{39}; and Farrokhshahr Steel: DMU_{40}.

TABLE XII
CALCULATING THE SUPPLY CHAIN EFFICIENCIES OF STEEL COMPANIES USING THE SCOR MODEL UNDER FUZZY CONDITIONS.

Decision-making unit	Spring efficiency	Summer efficiency	Autumn efficiency	Winter efficiency	Total efficiency
DMU_1	0.876	0.884	0.897	0.923	0.90
DMU_2	0.836	0.806	0.816	0.79	0.8
DMU_3	0.799	0.805	0.818	0.837	0.84
DMU_4	0.918	0.932	0.943	0.954	0.93
DMU_5	0.817	0.837	0.845	0.857	0.83
DMU_6	0.882	0.90	0.915	0.922	0.90
DMU_7	0.830	0.831	0.84	0.918	0.89
DMU_8	0.878	0.84	0.81	0.787	0.8
DMU_9	0.821	0.794	0.802	0.752	0.79
DMU_{10}	0.859	0.854	0.859	0.865	0.84
DMU_{11}	0.876	0.844	0.831	0.83	0.8
DMU_{12}	0.804	0.829	0.847	0.864	0.81
DMU_{13}	0.889	0.891	0.901	0.919	0.89
DMU_{14}	0.841	0.842	0.803	0.81	0.8
DMU_{15}	0.874	0.877	0.884	0.892	0.88
DMU_{16}	0.817	0.803	0.797	0.734	0.8
DMU_{17}	0.811	0.832	0.802	0.784	0.79
DMU_{18}	0.878	0.881	0.892	0.908	0.87
DMU_{19}	0.827	0.811	0.769	0.746	0.79
DMU_{20}	0.801	0.825	0.83	0.856	0.82
DMU_{21}	0.895	0.909	0.914	0.926	0.93

Decision-making unit	Spring efficiency	Summer efficiency	Autumn efficiency	Winter efficiency	Total efficiency
DMU_{22}	0.873	0.813	0.857	0.893	0.86
DMU_{23}	0.835	0.806	0.841	0.817	0.79
DMU_{24}	0.835	0.807	0.776	0.748	0.8
DMU_{25}	0.861	0.851	0.837	0.794	0.8
DMU_{26}	0.877	0.834	0.817	0.781	0.82
DMU_{27}	0.891	0.895	0.90	0.917	0.92
DMU_{28}	0.869	0.83	0.825	0.899	0.85
DMU_{29}	0.857	0.84	0.878	0.888	0.86
DMU_{30}	0.898	0.858	0.804	0.805	0.8
DMU_{31}	0.838	0.832	0.821	0.797	0.79
DMU_{32}	0.815	0.818	0.81	0.818	0.82
DMU_{33}	0.865	0.826	0.82	0.794	0.81
DMU_{34}	0.802	0.818	0.829	0.863	0.83
DMU_{35}	0.833	0.799	0.781	0.754	0.79
DMU_{36}	0.766	0.785	0.827	0.858	0.80
DMU_{37}	0.852	0.827	0.799	0.763	0.8
DMU_{38}	0.832	0.804	0.783	0.792	0.78
DMU_{39}	0.837	0.804	0.788	0.749	0.81
DMU_{40}	0.859	0.802	0.801	0.808	0.81

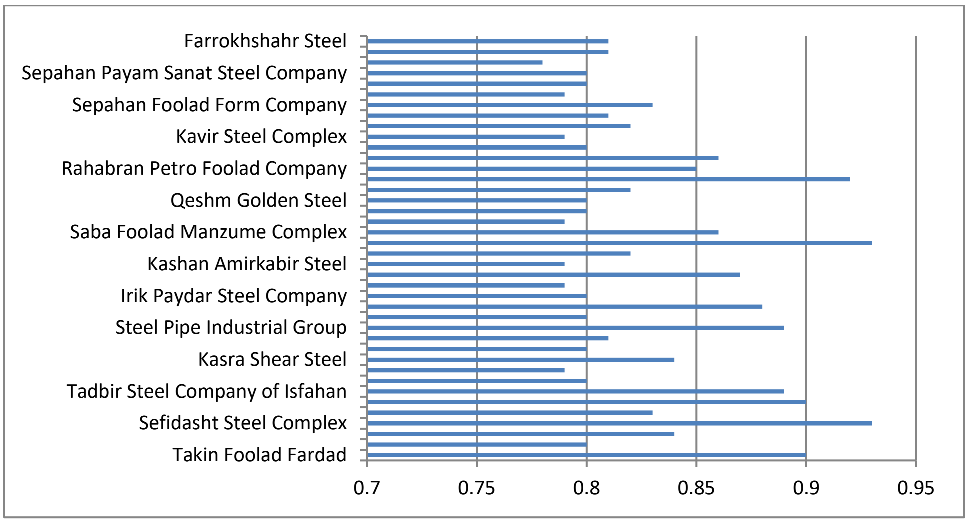

FIGURE 1

TOTAL PERFORMANCE AS DETERMINED BY THE SCOR MODEL UNDER FUZZY LOGIC CONDITIONS.

The dynamic performance evaluation of the total supply chain, as shown in Table XII and Figure 1, reveals that Sefiddasht Steel Complex, Isfahan Mobarakeh Steel Company, and Kasra Shear Steel had the highest efficiency. In contrast, Arka Foolad Taj Naghshjahan and Arian Foolad had the lowest efficiency among the 40 steel companies. Importantly, all firms exhibited higher efficiency indices relative to the static baseline.

CONCLUSION

This study began by identifying internal factors (strengths and weaknesses) and external factors (opportunities and threats). Based on the SWOT methodology, Mobarakeh Steel Company's green supply chain (GSC) strategies were classified into four categories: competitive-offensive (SO) strategies, contingency or diversification (ST) strategies, revision or adaptation (WO) strategies, and defensive (WT) strategies. Multi-criteria decision-making methods, namely TOPSIS and TODIM, were then applied to rank and assign weights to the SO strategies identified as most critical. Among the four categories, WO strategies ranked third and WT strategies ranked fourth.

Partial strategic analyses revealed that within the WO category, *procuring and deploying new technologies* held the highest priority. The top-ranked SO strategies included leveraging information systems to increase public awareness of environmental and sustainable development issues and modifying energy consumption patterns using new technologies and experienced consultants. The most important ST strategy was promoting a culture of responsibility in communities to encourage collective action in preventing litter and managing waste in public areas, parks, and green spaces. Within the WT group, the highest-priority strategies were collaboration with relevant organizations to identify and address environmental emergencies and preventing and mitigating the consequences of incidents such as fires at Mobarakeh Steel Company buildings.

Subsequently, the study evaluated the performance of several steel companies at the second GSC tier. Overall efficiency was calculated using the DEA-SCOR model within the SCOR supply chain framework. Results showed that the Mobarakeh Steel Complex achieved the highest performance, whereas Arian Foolad recorded the lowest. The DDEA method produced the same ranking, identifying Mobarakeh Steel Company (Isfahan) as the top performer and Arian Foolad as the lowest. Efficiency scores obtained using the SFA method were closely aligned with the DEA results. Notably, the DEA method yielded lower average efficiency scores (0.78) compared to the DDEA method (0.83), indicating improved performance under dynamic modeling.

The primary contribution of this study lies in integrating a hybrid multi-criteria decision-making framework (SWOT – Fuzzy ANP – Fuzzy TOPSIS – Fuzzy TODIM) with the SCOR-based performance evaluation under uncertainty. This approach not only prioritizes both primary and secondary green supply chain strategies but also measures the real operational efficiency of companies in both static and dynamic modes. The use of Fuzzy TODIM allows considering profit–loss relationships and criterion interdependencies, while its connection with the SCOR model enables a more agile alignment between green strategies and operational performance. This combined methodology goes beyond existing SWOT–ANP–TOPSIS approaches, offering deeper managerial insights for sustainable decision-making in the steel industry.

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