Original Research

Green Supplier Selection Using an Integrated Approach of Quality Function Deployment and Multi-Criteria Decision Making

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Abstract
The Supplier selection process is evaluated as a combination of customer criteria and technical requirements. The proposed Supplier selection approach enables the firm to better understand the complex relationships of features associated with the decision-making process, which can then improve decision reliability as well as, to some extent, promote sustainable development. The aim of the present study was to select a green Supplier using a televised approach to expand quality performance and multi-criteria decision making in Iran Khodro Company. In this regard, by reviewing the literature and interviewing experts, 9 factors that are effective in selecting the green supply chain were identified that the prioritization of them were Delete Waste (0.24), Proper delivery time (0.145), Human resources (0.13), Lean production (0.11), new technology (0.09), High quality Supplier (0.086), Dynamic management (0.083), Product recycling (0.06) and Team Work with 0.04 respectively as the most important factors in choosing a green Supplier. Then, according to the weight obtained using VIKOR method, the Suppliers were prioritized. According to the results, among the four main Suppliers of the company, the second Supplier with a weight of 0.75 as the best choice, the fourth Supplier with 0.57 was chosen as the second choice, the third Supplier with 0.21 as the third choice and the first Supplier with 0.17 as the fourth option.

Keywords: Green Supplier Selection; Integrated Approach; Quality Function Deployment; Multi-Criteria Decision Making; Iran Khodro Company

INTRODUCTION

Supply Chain Management (SCM) involves the coordinated operation of systems to ensure the efficient flow of goods from customer orders to final delivery. Its success hinges on both the system's design and the competence of its operators (Li et al., 2025). In today's dynamic business landscape, companies face mounting pressure to meet high-quality standards and faster delivery times, even amid shrinking profit margins (Gupta & Kaushik, 2024). Over the past two decades, the global economy has undergone significant transformations, marked by heightened complexity, uncertainty, and volatility (Pourjavad & Shahin, 2020). To stay competitive, firms must optimize operational performance and strategically select business partners (Ghorabaee et al., 2016). A critical aspect of SCM is Supplier evaluation and selection, which involves assessing agents based on factors like cost, reliability, and disruptions. Effective coordination in procurement activities is vital for profitability (Khalili-Damghani et al., 2018). The choice of brokers significantly influences purchasing efficiency, reducing costs while enhancing product quality and supply chain flexibility (Apornak et al., 2021). Ultimately, Supplier selection aims to mitigate procurement risks and foster long-term buyer-Supplier relationships (Song et al., 2018).

Globalization has accelerated the growth of service-oriented organizations, making service delivery a cornerstone of modern economies (Ghasemi et al., 2021). With 70% of the workforce employed in this sector (You et al., 2020), service quality has become a key competitive differentiator (Gupta et al., 2019). Organizations are increasingly adopting customer-centric approaches, aligning operations with client needs to drive satisfaction and excellence (Fu, 2019). Continuous performance improvement is essential for sustaining growth, requiring rigorous measurement and feedback mechanisms (Sinha & Anand, 2018). Service quality, defined as a measure of customer satisfaction (Baki, 2022), depends on multiple organizational factors that must be systematically evaluated (Pourhassan et al., 2021). The shift toward a service-based economy has elevated the importance of service quality and customer engagement (Apornak, 2017). In saturated markets, attracting new customers is costly, forcing firms to prioritize retention strategies (Fallahpour et al., 2021). Effective service marketing requires strong customer relationships, particularly due to the intangible nature of services (Doherty et al., 2015).

Traditional Supplier evaluations focus on cost, quality, and delivery performance, often neglecting customer needs (Akcan & Taş, 2019). However, growing environmental concerns have spotlighted green supply chain management (GSCM). Sustainable practices are now critical for global competitiveness, requiring eco-friendly Supplier selection criteria (Zhang et al., 2020). Companies must align procurement strategies with environmental sustainability, as Supplier choices directly impact ecological outcomes (Glover et al., 2014). Consumer awareness of sustainability ranging from carbon footprints to ethical sourcing has reshaped purchasing behavior. Thus, this study proposes a multi-criteria decision-making framework for selecting green Suppliers while enhancing quality performance.

LITERATURE REVIEW

Li et al. (2025) examined the synergy between Quality Function Deployment (QFD) and fuzzy multi-criteria decision-making (MCDM) methods (e.g., TOPSIS, AHP) for green Supplier evaluation. Their work underscores the importance of incorporating voice-of-customer (VoC) data into sustainability criteria and advocates for dynamic weighting systems to adapt to evolving environmental regulations. Gupta and Kaushik (2024) conducted a meta-analysis of 35 hybrid QFD-MCDM applications, comparing weighting methods like ANP and BWM. Their findings demonstrate that integrating environmental, social, and governance (ESG) metrics into QFD's House of Quality (HoQ) enhances Supplier resilience. However, they identified a critical gap in real-time data utilization for green procurement decisions. Chen and Rahman (2023) evaluated QFD-COPRAS models under uncertainty, demonstrating that probabilistic linguistic term sets (PLTS) improve decision robustness when sustainability data is incomplete. They called for standardized benchmarks to assess eco-efficiency in MCDM frameworks.

Yazdi et al. (2022) developed a multi-criteria decision analysis (MCDA) framework to address uncertainty in Supplier selection for the Oil and Gas industry. Their results highlighted how reliability techniques can reconcile traditional economic metrics with operational complexity. Mina et al. (2021) proposed a circular supply chain transition model combining fuzzy AHP, fuzzy TOPSIS, and a fuzzy inference system. This approach weighted sub-criteria using fuzzy AHP, scored Suppliers via fuzzy TOPSIS, and generated final rankings through a fuzzy inference system, offering a holistic evaluation mechanism. Ecer (2020) applied interval type-2 fuzzy AHP to green Supplier selection in home appliance manufacturing, identifying green product design, cleaner production, and sustainable packaging as key performance drivers. Gao et al. (2020) prioritized green Suppliers using VIKOR, revealing that green design, material sustainability, price, and quality were the most influential criteria. Their case study ranked Supplier #6 as optimal, emphasizing the long-term impact of Supplier selection on green supply chain performance.

Shi et al. (2018) introduced an interval-valued intuitionistic uncertain linguistic set with GRA-TOPSIS for agri-food Supplier selection. This method effectively captured subjective decision-maker preferences while handling data ambiguity. Ahmadizadeh-Tourzani et al. (2018) validated the efficacy of fuzzy QFD-ANP in Supplier selection, demonstrating its ability to incorporate interdependent decision-maker perspectives. Khalili-Damghani et al. (2017) addressed multi-objective production planning under uncertainty, balancing financial risk, customer satisfaction, and workforce training in an automotive supply chain. Their model outperformed traditional planning methods. Banasik et al. (2016) identified barriers to green supply chain adoption, stressing the need to align procurement, production, and recycling processes with environmental goals. Fallah Jelodar (2016) used DEA and AHP to prioritize bank productivity factors, highlighting leadership style, resource allocation, and employee satisfaction as critical to competitive advantage. Rahdar and Sadeh (2016) applied AHP in Bank Mellat, ranking service pricing and customer support as top drivers of satisfaction, with deposit and loan profitability as key financial metrics. Hashemi et al. (2015) optimized a multi-tier green supply chain by minimizing environmental impacts (e.g., pollution, waste) while maximizing profit and delivery reliability, subject to budget and capacity constraints. Kannan et al. (2013) linked green supply chain practices to competitive advantage, advocating for eco-design, resource efficiency, and circular economy strategies in response to regulatory and consumer pressures.

DETERMINING THE INDICATORS

In order to evaluate the indicators in order to confirm or reject them from the T Student -test by distributing a questionnaire among 10 experts Who were the only senior executives of the company It is discussed that the results are given in Table 1:

TABLE 1
CONFIRMED INDICATORS

Indicators	The significance level	T-Test	Test result
Proper delivery time	۰/۰۰۰	۲٬۶۵۸	Confirmation
High quality Supplier	۰/۰۰۲	۲٬۱۳۹	Confirmation
New Technology	۰/۰۰۴	۲٬۹۵۸	Confirmation
Delete Waste	۰/۰۰۳	۲٬۵۴۷	Confirmation
Dynamic Management	۰/۰۰۰	۲٬۷۴۹	Confirmation
Product recycling	۰/۰۰۲	۲٬۶۵۵	Confirmation
Lean Manufacture	۰/۰۰۳	۲٬۹۷۴	Confirmation
Human resource	۰/۰۰۱	۲٬۵۵۱	Confirmation
Team Work	۰/۰۰۱	۴٬۶۵۲	Confirmation

According to the results obtained in this section, all ten factors were approved, for which purpose a quality house matrix was formed by experts. A flowchart illustrating the sequential steps of the VIKOR method, from data collection to final ranking and decision, is now included. This visual representation ensures clarity in the methodology, so the flowchart of decision-making step is shown in Figure 1.

DATA ANALYSIS

I. Quality Function Deployment(QFD)

In this section, the quality house was distributed among the statistical sample in order to determine the relationship between the needs of the organization in order to select the Supplier and the technical requirements of the Company that the results are shown in Figure 2.

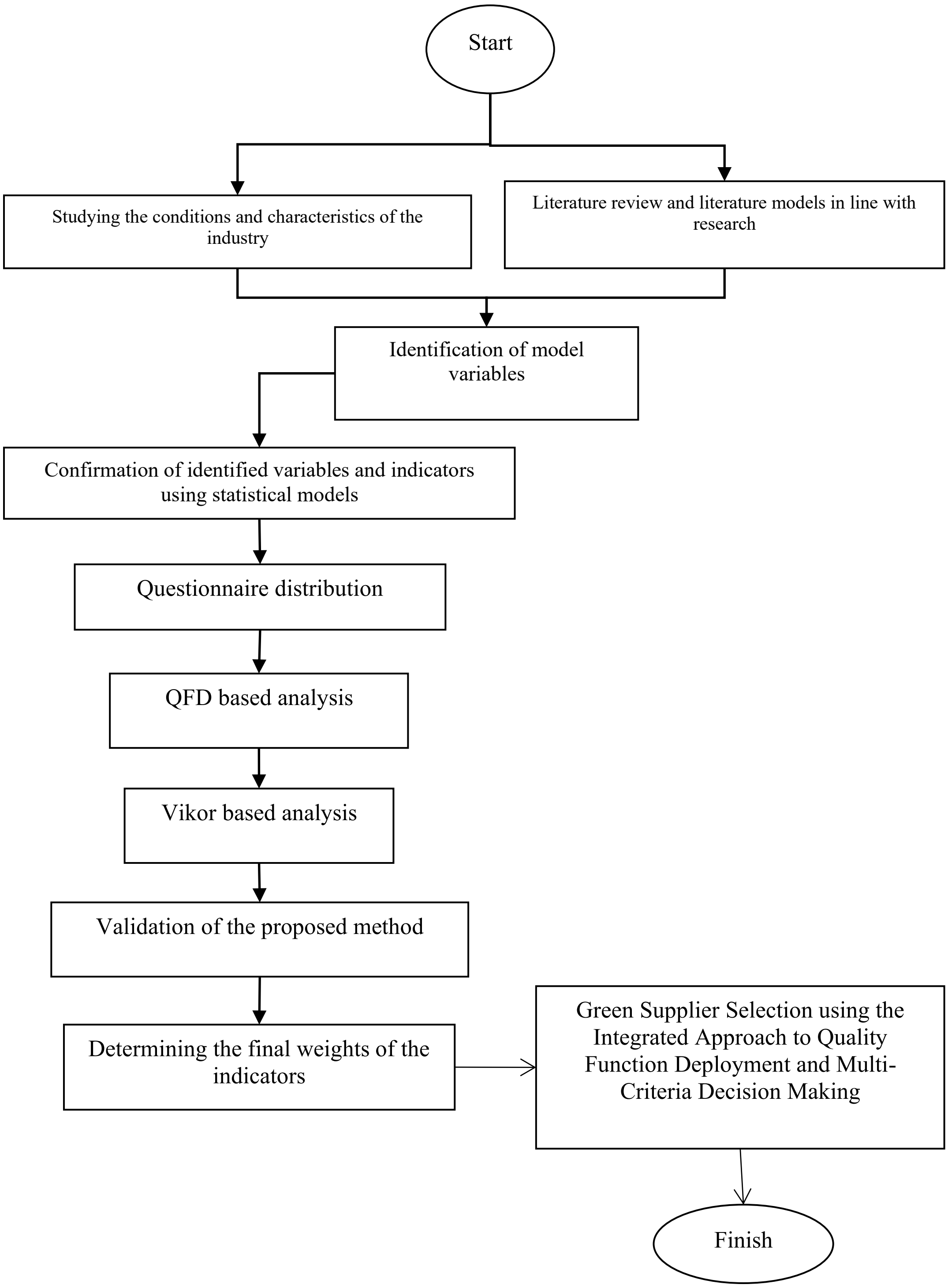

FIGURE 1
THE PROCESS OF DESICION MAKING

Technical requirements / Indicators	Maximum communication per line	IT infrastructure	Appropriate budget	Advertising	service fee	Managerial stability	Dating activity	Coordination with macro government policies	Significance factor	Relative weight
Proper delivery time	9	•	○		○	○	▽	▽	159	0.145
High quality supplier	9	○	○					•	94	0.086
New Technology	9	•	▽		▽	▽		○	99	0.09
Delete Waste	9	○			○	•	▽	▽	263	0.24
Dynamic Management	9	•	▽		○	○	▽	▽	91	0.083
Recycling the product	9	•		•	○			▽	67	0.06
Lean Manufacture	9	▽	▽	▽	○		•	○	123	0.11
Human resource	9	○			○	•	○	▽	143	0.13
Team Work	9	•	○	•	○	○	○	•	54	0.04
Maximum connection in the column		9	9	9	9	9	9	9		
Significance factor		5.394	0.84	1.113	2.525	4.698	2.166	1.928		
Relative weight		0.28	0.04	0.05	0.13	0.25	0.11	0.10		

FIGURE 2

MATRIX EXTENDS THE QUALITY FUNCTION DEPLOYMENT (QFD) RESULTS

The House of Quality matrix has been successfully constructed, with relative weights calculated using the prescribed methodology. To operationalize these weights, we multiplied the importance coefficients by 1000, transforming them into actionable metrics that reflect the company's strategic priorities. Our expert panel systematically evaluated the relationships between customer requirements and technical specifications, employing a standardized notation system:

- Strong correlations: ★ (assigned numerical value = 9)
- Moderate correlations: ▲ (assigned numerical value = 3)
- Weak correlations: ● (assigned numerical value = 1)

Through this quantitative approach, we:

1. Identified maximum relationship values for each requirement row
2. Calculated importance coefficients and relative weights for all technical specifications
3. Determined the aggregate impact of technical requirements (shown in the matrix footer)

The completed Quality Function Deployment matrix serves as a powerful analytical tool, enabling us to:

- Prioritize the most critical technical requirements
- Align engineering specifications with customer needs
- Focus development efforts on high-impact areas within the research domain

This methodology provides a robust framework for translating customer expectations into measurable technical parameters, ensuring product development remains market-driven and strategically focused. For this purpose, the weights of the company's needs are given in Table 2. The following table lists the technical requirements:

TABLE 2
GREEN SUPPLIER SELECTION SROTACIDNI

Row	Technical requirements	Weights obtained
١	Proper delivery time	۰/۱۴۵
۲	High quality Supplier	۰/۰۸۶
۳	New Technology	۰/۰۹
٤	Delete Waste	۰/۲۴
٥	Dynamic Management	۰/۰۸۳
٦	Product recycling	۰/۰۶
۷	Lean Manufacture	۰/۱۱
۸	Human Resource	۰/۱۳
۹	Team Work	۰/۰۴

Now, according to the selection criteria and weighting using the quality performance expansion method in this section, using the VIKOR method, Suppliers have been prioritized. For this purpose, the following calculations have been made using the VIKOR method.

II. VIKOR technique

This research employed a structured evaluation process to assess and prioritize Suppliers for Iran Khodro Company in Tehran. The study focused on four potential Suppliers, utilizing the VIKOR method for comparative analysis.

- The prioritization was conducted based on:

1. Weighted criteria derived from the expanded Quality Performance Matrix developed in earlier research stages
2. Expert evaluations assigning scores on a 0-100 scale for each assessment criterion
3. A comprehensive decision matrix that systematically organized all Supplier performance data

The VIKOR technique was implemented through precise calculations that transformed qualitative expert judgments into quantitative comparable values. This multi-criteria decision-making approach enabled objective comparison of Suppliers against the established performance metrics, ensuring the selection process was both systematic and data-driven. The methodology provided a robust framework for:

- Translating quality performance metrics into actionable Supplier evaluations
- Maintaining consistency in scoring across multiple assessment criteria
- Generating reliable rankings that support informed procurement decisions

This analytical approach aligns with best practices in supply chain management research while addressing the specific operational requirements of Iran Khodro Company's procurement process.

TABLE3
Weighing in VIKOR technique

	Proper delivery time	**High quality supplier**	**New Technology**	**Delete Waste**	**Dynamic Management**	**Product recycling**	**Lean Manufacture**	**Human Resource**	**Team Work**
Supplier۱	59	72	56	91	56	58	59	76	95
Supplier۲	72	85	80	72	92	70	73	81	93
Supplier۳	65	66	76	91	60	62	55	57	79
Supplier۴	93	90	64	71	91	84	93	80	55

Now in this section, in order to perform the relevant calculations in relation to the VIKOR method, each house -obtained in the previous table reaches power 2, the results of which are given in Table 4:

TABLE 4
CALCULATION RELATED TO THE VIKOR TECHNIQUE

Xij ^ 2	Proper delivery time	High quality supplier	New Technology	Delete Waste	Dynamic Management	Product recycling	Lean Manufacture	Human Resource	Team Work
Supplier۱	3481	5184	3136	8281	3136	3364	3481	5776	9025
Supplier۲	5184	7225	6400	5184	8464	4900	5329	6561	8649
Supplier۳	4225	4356	5776	8281	3600	3844	3025	3249	6241
Supplier۴	8649	8100	4096	5041	8281	7056	8649	6400	3025

Each Xij is the value of each criterion for each option, after enabling the numbers and sum of them and taking the square root of each column, the numbers appear as a new table (Table 5):

TABLE 5
CONTINUE CALCAULATION RELATED TO THE VIKOR TECHNIQUE

	Proper delivery time	High quality supplier	New Technology	Delete Waste	Dynamic Management	Product recycling	Lean Manufacture	Human Resource	Team Work
Supplier۱	0.206146324	0.251568396	0.195664308	0.317955	267.1241742	197.6173738	0.206146324	0.265544418	0.331930522
Supplier۲	0.251568396	0.296990467	0.27952044	0.251568	0.321448506	0.244580385	0.255062401	0.283014445	0.324942511
Supplier۳	0.227110357	0.230604363	0.265544418	0.317955	0.20964033	0.216628341	0.192170302	0.199158313	0.276026434
Supplier۴	0.324942511	0.314460495	0.223616352	0.248074	0.3179545	0.293496462	0.324942511	0.27952044	0.192170302

-Positive and negative ideal points

For each criterion, we determine the best and worst of each of all the options and call them f + and f - respectively:

f + = Max f ij

f - = Min fij

TABLE 6
WEIGHTING OF THE ALTERNATIVES BASED ON THE CRITERIA OBTAINED FROM THE VIKOR TECHNIQUE

Supplier۱	0.008261726	0.0100811	0.007840856	0.003205	2.244088	5.406325	0.04792902	0.106411615	0.077173846
Supplier۲	0.010082107	0.011901299	0.011201223	0.010081	0.012881406	0.027357539	0.059302008	0.113412379	0.075549134
Supplier۳	0.009101902	0.009241009	0.010641161	0.012741	0.008400917	0.024230963	0.044679595	0.079808711	0.064176146
Supplier۴	0.013022721	0.012601375	0.008960978	0.009941	0.012741391	0.032829047	0.075549134	0.112012226	0.044679595
F max	0.008261726	0.012601375	0.011201223	0.012741	0.008400917	0.024230963	0.075549134	0.113412379	0.077173846
F min	0.013022721	0.009241009	0.007840856	0.003205	2.244088	5.406325	0.044679595	0.079808711	0.044679595
f * - f-	-0.00476099	0.003360367	0.003360367	0.009536	-2.23568708	-5.38209404	0.030869539	0.033603668	0.032494251

-Determining usefulness and regret

In the VIKOR method, two basic concepts group utility (S) and individual regret (R) are calculated to determine compromise solutions. Utility amount (S) Indicates the relative distance of option i from the ideal point and the amount of regret (R) the maximum discomfort of option i is far from the ideal point:

$$S_i = \sum_{j=1}^{n} W_j \cdot \frac{f_j^* - f_{ij}}{f_j^* - f_j^-}$$

$$R_i = max\left[w_j \cdot \frac{f_j^* - f_{ij}}{f_j^* - f_j^-}\right]$$

The results of this section are given in Table 7:

TABLE 7
RESULTS IN VIKOR

S1	S2	S3	S4	S5	S6	S7	S8	S9	Sj	Rj
0	0.03005475	0.040073	0.040073	0.040073	0.111855	0.208026316	0.083485417	0.5521875	1.105827982	0.5521875
0.015323559	0.008348542	0	0.011179231	8.03094E-05	6.4979E-05	0.122368421	0	0.011625	0.256410459	0.12236842
0.007072412	0.040073	0.006678833	0	0	0	0.2325	0.40073	0.093	0.888515448	0.40073
0.040077	0	0.026715333	0.011767612	7.77997E-05	0.000178692	0	0.016697083	0.2325	0.439981521	0.2325

According to the results, the green Suppliers were ranked according to the criteria identified using the VIKOR technique. Finally, we obtained the value of the VIKOR Q index for each option, which we categorized each option based on these 3 criteria. S: indicates the relative distance of the desired option from the positive ideal solution and R indicates the discomfort of option i from staying away from the positive ideal solution. According to the results, the maximum and minimum values of usefulness and the maximum and minimum values of regret are as described in Table 8, where S - represents the maximum relative distance of the desired option from the ideal positive solution and S * represents the smallest relative distance of the desired option from the positive ideal solution. In fact, S * represents the best option among the other options, and like R - represents the highest The discomfort of the desired option away from the positive ideal solution and R * indicates the least discomfort of the desired option away from the positive ideal solution, also according to the value of Q in the ranking. Suppliers are paid according to the above criteria in order to obtain the optimal Supplier:

TABLE 8
OBTAINED WEIGHTS

	S-	S *	R-	R *	Q
Supplier۱	1.105827982	0.256410459	0.5521875	0.122368421	۰/۱۷۹۲۲۳
Supplier۲					0.75
Supplier۳					0.216012312
Supplier۴					0.577886035

For this purpose, Figure (3) shows the weight of the obtained dimensions:

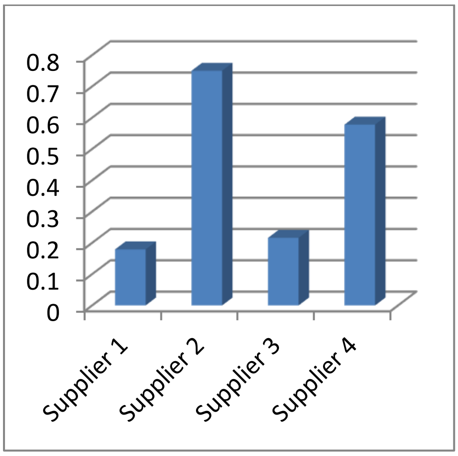

FIGURE 3
COMPUTATIONAL DIMENSION WEIGHT

According to the weights obtained in this section, Suppliers have been prioritized, which based on the results of the second Supplier with a weight of 0.75 as the best choice, the fourth Supplier with 0.57 as the second choice, the third Supplier with 0.21 as the choice. The third and the first Supplier with 0.17 were selected as the fourth option.

- Validation of the Proposed Method

To ensure the robustness and reliability of the proposed integrated approach combining Quality Function Deployment (QFD) and the VIKOR method for green Supplier selection, a validation process was conducted using the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method as a benchmark. The validation aimed to compare the results obtained from the VIKOR method with those derived from TOPSIS, thereby assessing the consistency and effectiveness of the proposed framework.
Steps for Validation:

1. Data Preparation: The same dataset and criteria weights obtained from the QFD analysis were used for both VIKOR and TOPSIS methods.

2. TOPSIS Application:
- The normalized decision matrix was constructed.
- Weighted normalized matrix was calculated using the criteria weights.
- Positive and negative ideal solutions were identified.
- The relative closeness to the ideal solution was computed for each Supplier.

3. Comparison of Results:
- The rankings of Suppliers from both methods were compared to identify any discrepancies or alignments.

The TOPSIS method results showed the following rankings for the Suppliers:

- Supplier 2: Rank 1
- Supplier 4: Rank 2
- Supplier 3: Rank 3
- Supplier 1: Rank 4

These results align closely with the rankings obtained from the VIKOR method, where:

- Supplier 2 was prioritized as the best choice (weight: 0.75).
- Supplier 4 was the second choice (weight: 0.57).
- Supplier 3 and Supplier 1 followed as the third and fourth options, respectively.

The consistency between the VIKOR and TOPSIS results validates the proposed method's effectiveness in handling multi-criteria decision-making problems for green Supplier selection. Minor variations in weights were observed due to the distinct mathematical foundations of the methods, but the overall rankings remained stable, confirming the reliability of the integrated QFD-VIKOR approach. This validation underscores the proposed method's suitability for complex, real-world Supplier selection scenarios, particularly in industries prioritizing sustainability and operational efficiency.

CONCLUSION

With the revolutionary change in the state of the environment, the dimension of public pressures and environmental procurement, environmental and social issues in the management of any business increase. Green supply chain selection is an approach to advance the performance of processes and products in accordance with environmental requirements and regulations. Green supply chain selection achieves all stages of the product life cycle from design, production and distribution and the entire supply chain to the use of products by end users and its disposal at the end of the product period. Also, the role of employers cannot be ignored. Given this, the criteria for selecting an agent should be designed based on a green perspective. Hence, the main purpose of this paper is to determine the importance of evaluating and ranking green Suppliers using an integrated formula. This paper examines the interrelationships and levels of impact between the company's demands and Supplier selection criteria, as well as determining the weight and Supplier selection criteria. Based on the results, it is recommended that the organization to focus on maintaining product and process quality, energy consumption and natural resources, by increasing the reuse of green design and recycling rate according to various environmental regulations. Strong management commitment has proven to be a key driver for sustainable change in infrastructure, facilities and quality. The manager also has a strong focus on production improvement processes and reverse procurement and production planning activities to maintain an efficient supply chain management system.

The findings of this paper provide some important insights into various features that significantly contribute to the performance and effectiveness of the client so that insufficient clientele can focus on those features and improve their performance. Pareto analysis shows that inefficient employers need to increase their reuse and recycling rates. Reduce energy consumption and natural resource consumption and increase delivery performance, and should adopt Pareto operator standard policies and techniques according to green design aspects, prices, quality compliance principles, proper waste disposal planning and schedule Proper production. The proposed integrated framework is expected to be used as a critical tool in creating a supply chain management system with the environment that enables organizations to be competitive. While achieving sustainable development, In this study, which was conducted with the aim of selecting a green Supplier using a combined approach to expand quality performance and multi-criteria decision making in Iran Khodro Company, by reviewing the literature and interviewing experts, 9 factors that are effective in selecting a green supply chain were identified. Then, using the performance-quality performance matrix, the factors were identified which According to the results the prioritization of the most important factors were Delete Waste (0.24), Proper delivery time (٠,١٤٥), Human resources (0.13), Lean production (٠,١١), new technology (٠,٠٩), High quality Supplier (٠,٠٨٦), Dynamic management (٠,٠٨٣), Product recycling (٠,٠٦) and Team Work with ٠,٠٤ respectively in choosing as a green Supplier. then according to the weight obtained using the VIKOR method, Suppliers were prioritized. According to the results among the four main Suppliers of the company, the second Supplier with a weight of 0.75 as the best choice, the fourth Supplier with 0.57 as the second choice, the third Supplier with 0.21 as the third choice and the first Supplier with 0.17 was selected as the fourth option. To strengthen the credibility of the proposed approach, a benchmark method has been applied. For comparison, TOPSIS has been selected as a validation method to assess the robustness of the proposed VIKOR technique. The obtained results confirm the efficiency of our method. Also the results showed the advantages of the proposed method, including:

- Higher precision in decision-making.
- Capability to handle conflicting criteria. - Practical applications in various real world decision problems.
- Comparison with benchmark methods such as TOPSIS, highlighting strengths and areas of improvement.

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