Designing a Model to Identify and Rank the Factors Influencing the Selection of Suppliers of the Iran Steel National Industrial Group

Abstract

The aim of the current research was to design a model for identification and ranking of factors influencing the selection of suppliers of Iran's National Steel Industrial Group. In terms of the method, the current research is part of the descriptive research and based on its main purpose, it is an exploratory and confirmatory study, and in terms of the applied purpose. The framework used is a combination based on multi-criteria methods. In this regard, based on the research literature and experts' opinion, evaluation criteria and the selection of the appropriate supplier are determined using the Delphi method. After filtering the criteria, based on the DEMATEL technique, the desired criteria affecting the evaluation and selection of suppliers will be determined and the relationship between them and the modeling of these relationships will be done. In the third step, the ANP method is used to weight the criteria. Finally, in the fourth stage, the questionnaire to determine structural modeling relationships is completed by the experts of the organization and using the data obtained from the questionnaires, the method of structural equations is used to confirm the exploratory model. The technique used in the current research was an in-depth interview-Delphi method, a statistical population of 10 knowledgeable experts on the subject of the research, and a non-probability chain sampling method. The results of the research showed that the factor of product authenticity and compliance with the standards and requested analysis of the product are in the first rank and the factors of authentic or exclusive representative of goods and after-sales services (guarantee and warranty) are in the second and third ranks, respectively.

Keywords: MCDM, DEMATEL, Supply chain, Steel industry, Network analysis process.

1. Introduction

Today's companies are facing intense competition. Competition makes companies increasingly use new applications to improve quality and reduce costs and production time. Therefore, producers must be coordinated with the dynamic conditions of the market and be receptive to change (Klein, 2023). In today's business world, companies cannot compete without close cooperation with external partners. The concept of supply chain management emerged in this direction and seeks to optimally manage the physical and informational flows that are exchanged between actors of the supply chain (Kumar & Shankar, 2024). Supply chain management is a complex concept and a system that includes three key parts: the supply focus on obtaining raw materials for the manufacturer, the manufacturer's focus on converting the obtained raw materials into the final product, and the distribution focus on delivering products to customers through distributors, warehouses and retailers (Liu et al., 2024).

An important point that should be noted is that, basically, in order to maintain competition in the market, the producer should first focus on reducing production costs and production time cycle. Therefore, companies must outsource many parts of their products to suppliers (Rossi et al., 2023). Suppliers are significantly important for the company due to their role and overall impact on the competitiveness of supply chains. Therefore, the evaluation and selection of suppliers is considered a critical issue from the management and operational point of view, and achieving the competitive advantage of the companies, the goals of the entire supply chain, reducing the purchase costs and supply risk and increasing the product quality (Wu et al., 2024; Silvestri et al., 2024; Mollashahi et al., 2024). In the process of choosing the right suppliers, the buyer can provide the required parts and services with the right quality, the right price, the right amount and the right time. For this reason, in order to choose the right suppliers, their performance must be evaluated. The evaluation includes categorizing the supplier's performance based on a set of positive, negative or neutral criteria is possible (Torabi & Heidari, 2023). Therefore, evaluating suppliers and selecting the best ones is a basic and complex decision-making problem with the aim of reducing the initial number of potential suppliers to the final options (Kiani et al., 2023; Amini et al., 2023).

Since the process of evaluating and deciding on the selection of suppliers is based on multiple quantitative and qualitative criteria, the process of selecting a supplier is a multi-criteria issue that is based on subjective criteria, based on individual opinions and experiences, available information. And sometimes it is solved based on techniques and algorithms supporting the decision process (Amini et al., 2023). On the other hand, since decision-making is a very complex process based on several indicators, criteria and goals, it is inherently a difficult issue, especially since the information that is the basis for decision-making is often vague and incomplete. To overcome this difficulty, logic and fuzzy method are used in multi-criteria decision making process. Despite the large volume of studies in the field of supplier evaluation and selection, there is a great void and lack of comprehensive studies of the supply chain in the steel industry, especially in Iran's steel industries.

The steel industry is one of the leading industries in the world and one of the basic and strategic industries of the world. It is one of the important and influential goods in the industrial growth and development of countries, it is called the mother industry. After oil and gas, steel is the second largest commodity in global trade, and a large number of industries such as transportation, construction, machinery manufacturing, mining and other industries related to energy production and transmission are dependent on the steel industry. Therefore, the improvement and development of steel is of special importance in the economic development of countries. In terms of steel production conditions, Iran has many relative advantages, which ranks 15th in the world with an annual production of 16 million tons of steel (Morshedi & Nezafati, 2021). National Steel Industrial Group of Iran is also considered one of the largest steel producers in Iran, which was established in Ahvaz city in 1342 as the country's first steel rolling mill to produce all types of plain, ribbed and corner rebars. Now this huge complex is one of the important exporters of steel products, while providing a major part of the country's needs (Shahpouri et al., 2024).

As can be seen, the role of the supply chain in the steel industry is very significant, and on the other hand, National Steel Group has a special role in Iran's economy. However, in the field of comprehensive investigation of the supply chain in the National Steel Group, no comprehensive, scientific and preparatory study has been conducted and this company still lacks a model for selecting suppliers. Therefore, in this research, an attempt is made to design and present a model to identify and rank the factors influencing the selection of suppliers of Iran's National Steel Industrial Group.

2. Literature Review

1-2- Supply chain

Supply chain is a network of processes aimed at supplying goods and services. This chain includes suppliers, manufacturers, distributors and sellers who cooperate in a coherent manner in order to increase the level of customer satisfaction (Sadri etal., 2024). Supply chain is a dynamic entity that contains information, product and financial flows. The term supply chain refers to the flow of materials and products, information and money that flows from customers to retailers, then to distributors/wholesalers, then to the final product manufacturer and finally to suppliers and vice versa (Chaudhuri et al., 2023). The important point in this regard is to check the performance of the supply chain. In this regard, it should be acknowledged that the proper functioning of the supply chain plays a key role in the success of an organization and the sustainable achievement of its goals and especially its profitability (Jahangiri et al., 2023). Supply chain performance refers to the broad activities of the supply chain to meet customer requirements, which include the ability to access products and services, timely delivery and timely performance of services, inventory and capacity in the supply chain for proper performance to meet the needs of the final customer (De Moor et al., 2024). Supply chain performance transcends company boundaries; Because it includes the main materials, parts, subassemblies and final products and services and their distribution through different channels to the final customer (Mahmoodi et al., 2023). In the same way, the performance of the supply chain cuts the functional boundaries of the organization, such as procurement, production, distribution, marketing and sales, and research and development. In this regard, a big challenge is how to evaluate the performance of business chain activities in front of companies and organizations (Helli et al., 2024).

2-2- Making a decision in the field of supplier selection

Decision-making issues in the field of supplier selection have attracted a lot of attention due to the increase in competition between companies, and companies are forced to choose suitable suppliers and maintain and continue the relationship with them. are Basically, the theories and discussions raised in the field of supplier selection are mainly focused on two important issues: first; Identification of evaluation criteria and decision-making methods (Ahmadpour et al., 2023). In the field of criteria selection, decision-makers must carefully select the criteria that reflect their competitive priorities, ideals, and goals due to the fact that they are faced with multiple and sometimes conflicting criteria (Keyhanizadeh, 2024). In this context, Burgess et al. (2023) believe that important criteria such as past performance, production facilities and ability, price, technical ability, financial situation, communication system, reputation and position in the industry, interest in business, organization and management, Operational controls, agreement or compatibility, history of working relationships, amount of past transactions, training facilities, reciprocal arrangements are effective. They believe that the nature of purchase is effective in determining the type and importance of factors in selecting and providing suppliers (Burgess et al., 2023). Some other theoreticians have also come to the conclusion that among these criteria, the quality, price and delivery performance of suppliers are the most important promotional and patronage criteria in industrial markets (De Meyer et al., 2024; Romano et al., 2023).

In the following, new standards were introduced and discussed in this regard. For example, Ersahin et al. (2024) criteria such as supplier's support for the product, supplier's reputation, product quality, increase in credit by the supplier, personality of sellers, friendly relations with suppliers, closeness of suppliers, improvement of the organization By the supplier, reciprocal transactions, the behavioral image with the supplier were evaluated as very important in this regard (Ersahin et al., 2024). Also, Xu et al. (2023) have also introduced five criteria as the main supplier evaluation criteria, which are: stability of the supplier, basic economic criteria, geographic proximity, and product-related services (Xu et al., 2023). From the point of view of Chaudhuri et al. (2023), evaluation and supplier selection criteria are classified into four groups, which are: technology issues, financial criteria, organizational culture and strategy, and financial criteria. Finally, based on the view of Junaid et al. (2023), a supplier selection and evaluation system based on four indicators of quality, timely delivery, price, and services will be able to be reviewed and evaluated (Junaid et al., 2023). In relation to decision-making methods, some researchers used classical methods such as Analytical Hierarchy Process (AHP), Network Analysis Process and TOPSIS to solve supplier selection problems with clear numerical evaluation information. In this regard, Maretto et al. (2022) using the application of AHP in the selection of suppliers in the communication system showed that hierarchical analysis can help improve group decision-making in the selection of suppliers that improves the customer's situation. slow down On the other hand, due to the systematicity of the purchase decision process, using the proposed AHP model reduces the time required for supplier selection. It should also be acknowledged that due to the complexity of decision-making issues, decision-making information is more ambiguous than before. In this regard, da Silva and colleagues believe that linguistic variables such as reputation are suitable for describing quantitative evaluation information. Many fuzzy decision-making methods have been proposed to convert linguistic variables into triangular fuzzy numbers (Da Silva et al., 2023).

-Wulandari et al., (2024) in an article titled: “Hybrid MCDM Career Recommendation System for Information System Student Using AHP, VIKOR and Weighted Euclidean Distance” showed that the approaches used in this research are AHP, VIKOR, and weighted Euclidean distance. Subsequently, the TOPSIS method is used as a comparison to VIKOR. The consistent weights from AHP are used to calculate the course ideal mark and the weighted Euclidean distance score. By using AHP weight for VIKOR and TOPSIS calculation, there are differences in the results of the top alums, which their course mark used as the benchmark for the ideal score. AHP-VIKOR method gives higher ideal course mark compared to AHP-TOPSIS in some of the courses. Suggestions to students are given based on calculating the closeness of student marks to ideal marks on each specialization track.

-Acar et al., (2024) in an article titled: “Sustainable stationary hydrogen storage application selection with interval-valued intuitionistic fuzzy AHP” showed that the evaluation criteria are derived from four dimensions of sustainability: economic, environmental, social, and technical performance, each further decomposed into sub-criteria. The study's novelty lies in using a novel intuitionistic fuzzy AHP, offering a more nuanced and robust understanding of the trade-offs between the various options and effectively capturing the vagueness and subjectivity inherent in human decision-making. Through this methodology, CHG emerged as the most promising option with a preference score of 0.487, closely followed by UH with a score of 0.453. The lowest preference score was accorded to MH, with a score of 0.301. These quantitative insights underscore the relative sustainability performance of each technology under the defined criteria. The findings contribute to the growing body of literature on sustainable hydrogen storage, providing policymakers and practitioners with a multicriteria decision-making tool that captures the complexity of sustainability considerations. This study underlines the critical role of holistic, multicriteria evaluations in advancing sustainable hydrogen storage.

-Muerza et al., (2024) in an article titled: “Selection of an international distribution center location: A comparison between stand-alone ANP and DEMATEL-ANP applications” showed that the both approaches rank the alternatives similarly, although they assign varying degrees of importance to decision criteria. The research was constrained by a limited number of alternatives and respondents, as well as imprecision in human judgments. Future research will explore additional sustainability and social criteria, more alternative locations, and incorporate fuzziness for a more comprehensive selection of the optimal International Distribution Center (IDC) location.

-Mizrak et al., (2024) in an article titled: “Prioritizing cybersecurity initiatives in aviation: A dematel-QSFS methodology” showed that “Regulatory Compliance” and “Threat Detection Systems” are the most influential factors, emphasizing the need for strict adherence to standards and advanced threat detection capabilities. Additionally, the significance of “User Training” and “Data Encryption Protocols” underscores the importance of comprehensive training programs and strong encryption measures. By incorporating strategic management theories such as the Resource-Based View (RBV), Contingency Theory, and Risk Management Theory, this study presents a strategic framework to assist aviation organizations, policymakers, and researchers in developing effective cybersecurity strategies, ensuring the safety and security of global air travel.

-Shanta et al., (2024) in an article titled: “Municipal solid waste management: Identification and analysis of technology selection criteria using Fuzzy Delphi and Fuzzy DEMATEL technique” showed that 14 criteria were categorized as causal elements that have the most significant influence on the MSWM technology selection process and 7 criteria were categorized as effect. The selection of MSWM technology demands greater consideration of the top three ranked criteria, namely T4-Access to Technology (AT), T8- Feasibility (F), and the Ec6-Infrastructure requirements (IR). By identifying the pertinent criteria, structures and interrelationships, the outcome of the study can facilitate a better understanding of causal relationships among the criteria that require specific consideration from the decision-makers and allow them to select appropriate MSW management technology.

-Pang et al., (2024) in an article titled: “Key Factors Influencing Sustainable Population Growth: A DEMATEL-ANP Combined Approach” showed that with a data volume of 4000, the optimized model achieves an accuracy of 0.973, precision of 0.981, recall of 0.969, and an F1 score of 0.89, demonstrating the model's superior performance. The DEMATEL method analyzes the direct relationships among the factors. The results show that economic development and technological advancement have impact scores of 3.91 and 3.43, respectively, indicating their strong influence on other factors and their role in promoting sustainable demographic growth. Education and gender equality, health services, and technological advancement each have impact scores of 3.39, meaning they are significantly affected by other factors and are sensitive in the growth process. Finally, the ANP method is used to calculate the weights of each factor, determining their relative importance in sustainable social demographic growth. The results highlight that economic development level

and technological advancement and innovation are core factors influencing sustainable social demographic growth, with significant direct and indirect impacts on other factors and a crucial role in the overall system.
-Taebi et al., (2024) in an article titled: “Identification and prioritization of suitable supplier selection criteria based on the four dimensions of sustainability with a multi-criteria decision-making approach” showed that the price and economic benefit have the most value for the organization, and then the control of water consumption, energy and resources, research and development and green innovation, transparency of information and preservation of work values and ethical principles are more important than other criteria. Managers can use the results of this research to evaluate and select a sustainable supplier.
-Gholamian (2024) in an article titled: “A multi-objective model based on group decision-making and interval-valued Pythagorean fuzzy sets for the supplier selection and order allocation problem” showed that the new decision support system uses three steps in order to evaluate and select suppliers of the problem, which are: In the first step, indicators and decision-making options were extracted through research background checks, interviews with experts, and documents available in the organization. In the second step, by implementing the data coverage analysis model, the decision-making options were ranked and the effective units were identified. Finally, in the third step, with the implementation of UTASTAR, the efficiency of Sapco's efficient units was determined in order to select the most favorable supplier.
-Keshavarz-Ghorabaee (2024) in an article titled: “Evaluation and selection of a sustainable supplier by providing a decision support system based on a new data envelopment analysis model and cumulative star utility” showed that the performance of the proposed approach in solving the supplier selection and order allocation problem.
-Nasri et al., (2023) in an article titled: “Defining and prioritizing criteria for sustainable supplier selection in the oil and petrochemical industry (case study: National Iranian Oil Company)” showed that the weights of each criterion related to sustainable supplier selection are extracted by the ANP method. It has been concluded in this study that when selecting suppliers for the oil industry, decision-makers should pay attention to both financial indicators and environmental indicators.
-Sayyari et al., (2023) in an article titled: “Strategic International Business Innovation:A New Approach in Development of Iran's Pharmaceutical Industry)” showed that causal conditions with (0.39), contextual conditions with (0.55), and intervening conditions with (0.34) have an effect on strategies, and strategies have an effect on outcomes with (0.85).
The investigation of the background of the research shows that, firstly, in the important and influential steel industry, the dimensions of identification and ranking of factors affecting the selection of suppliers have not been done, and secondly, most of the issues raised are general and may not meet the specialized needs of the steel industry. In this regard, it seems that other important dimensions can also play a role in identifying and ranking the factors influencing the selection of suppliers of Iran's National Steel Group Company, which is evident in previous researches, and this indicates the existence of a theoretical gap in this field.

3. Methodology

This study is an exploratory and confirmatory study with the aim of designing and evaluating the structural model of the factors influencing the selection of suppliers of Iran's National Steel Industrial Group, therefore, in terms of practical purpose and in terms of method, it is included in the category of descriptive-superior research. The framework used in this research is a combined method based on multi-criteria methods. Because there is a degree of uncertainty in decision-making, which is caused by the subjective evaluation of qualitative or quantitative criteria by several decision-makers, it is preferred to use fuzzy logic to resolve the ambiguity, because despite the ambiguity and uncertainty, traditional approaches are ineffective. Basically, fuzzy logic and theory in the supplier selection process enables researchers to model the multi-criteria decision making process using incomplete or ambiguous information of the decision makers (Bazargan, 2024). Therefore, based on research literature and experts' opinion, evaluation criteria and selection of suitable supplier are determined by Delphi method. After filtering the criteria, based on the DEMATEL technique, the desired criteria affecting the evaluation and selection of suppliers will be determined and the relationship between them and the modeling of these relationships will be done. In the third step, the ANP method is used to weight the criteria. Finally, in the fourth stage, the questionnaire for determining structural modeling relationships is completed by the experts of the organization and using the data obtained from the questionnaires, the method of structural equations is used to confirm the exploratory model (Mason , 2023).

The technique used in this studyis an in-depth interview-Delphi method. In this regard, we should briefly mention that the Delphi technique is used in cases where, due to the existence of conflicting and insufficient facts and information about a particular subject, there is a need for separate ideas and judgments of people about a subject. The structured process should be turned into a single result agreed upon by them. The Delphi method can be done with the cooperation of people who have knowledge and expertise in the research topic and provide valuable ideas. These people are known as the Delphi panel. The most important difference between the Delphi method and other joint decision-making methods is the expertise of experts who do not directly communicate with each other. The selection of experts for the Delphi panel is one of the most important steps of this method. Unlike quantitative surveys, these people are not selected based on probability sampling. Because the Delphi technique is a qualitative approach, not a quantitative one. This technique is a simple and practical method for group decision-making and requires experts who have a deep understanding and knowledge of the research topic and are committed to completing the questionnaire in successive rounds. In this case, people are selected in order to use their knowledge in a specific problem and based on indicators that originate from the nature of the subject and research problem (Gall, 2023). When the researcher does not know all the necessary people to be a member of the panel, the chain sampling method is used, which is one of the non-probability methods. In this method, the researcher first identifies a person or a group of knowledgeable people and through them reaches other suitable people. This work continues until the opinions are close to each other and the answers are almost similar. As a result, 10 people were identified as experts from Iran's National Steel Group using the Delphi method, and interviews were conducted with them, and in these interviews, they were asked to give their opinions about the factors influencing the evaluation and selection process. The suppliers of the organization should state in detail. Finally, 10 factors resulted as the most effective factors, which are: price and cost of transportation, delivery time, product authenticity and compliance with the required standards and analysis of the product, product quality, supplier's resume, sending samples or the possibility of testing specialty products. and ordering before the full delivery of the order, after-sales services (guarantee, warranty), supplier's responsiveness (at the stage of returning, inquiry and placing an order or tracking the shipment of goods), product packaging, having a valid or exclusive representative. In Table 1, the demographic characteristics of the interviewees are given:

Table 1.

Demographic characteristics of the interviewees

Indicator	Type	Qty	percentage
Gender	Female	2	20
	Male	8	80
Age	Between 35 and 45 years	3	30
	From 46 to 55 years	5	50
	More than 56 years	2	20
Education	MA	3	30
	Ph.D	7	70
Experience	From 15 to 20 years	3	30
	From 21 to 29 years	5	50
	More than 30 years	2	20

The reason for the combination of DEMATEL and ANP

To choose the right framework, several actions and scenarios are necessary. Many multi-criteria decision-making approaches have been proposed in the supplier evaluation and selection literature, each of them has its advantages and disadvantages. It is difficult to choose the best method for evaluating and selecting a labor provider, that's why companies use a variety of different methods. Therefore, the most important issue in the supplier selection process is to design a suitable model for selecting the most suitable supplier. Among the multi-criteria decision-making methods, hierarchical analysis process and network analysis process, which consider qualitative aspects, are widely used. These methods are used to evaluate the weight of the indicators using the pairwise comparison matrix and expert judgment (Delavar, 2021). Due to the fact that the decision-makers' inclinations are not the same regarding related criteria, each of the criteria may be given a certain weight. Also, in the real world, standards are rarely independent. Therefore, if the evaluation factors of suppliers influence each other and there is an internal relationship between the criteria, the NP method is a suitable multi-criteria decision making method. Now, the main reason for the combination of DIMATEL and ANP is that in order to calculate the relationships between the model parameters, ANP forms a pairwise comparison matrix and calculates the eigenvectors corresponding to each of the pairwise comparison matrices and puts it in It places a suitable position in the hypermatrix; Therefore, the use of this technique in calculating the internal and external relationship between elements will require a large number of pairwise comparison matrices. This leads to complexity and spending a lot of time to solve the problem. Dimatel technique can be used to deal with this limitation. However, DEMATEL is not able to form hypermatrix and on the other hand, ANP has such ability. In fact, DEMATEL alone is not able to determine the weight and importance of indicators and it is considered a subset of the large NP system (Bazargan, 2024).

2-3- DEMATEL

In recent years, the combination of DIMATEL and INP has many uses, because this method has been used as a powerful tool capable of describing and evaluating complex systems by identifying and modeling cause and effect relationships between criteria. (Delavar, 2021). DEMATEL steps are explained as follows in Table 2:

Table 2.
Verbal variables and corresponding fuzzy numbers

Fuzzy values of fuzzy scales	
Very high impact	(0.75,1.0,1.)
High impact	(0.5,0.75,)
Low impact	(0.25,0.5,0.7)
Very low impact	(0,0.25,0)
No impact	(0,0,0.25)

4. Findings

1-4- Calculating the average matrix

At first, based on fuzzy verbal scales that indicate the limit of no influence to high influence (Table 2), all the experts were asked to determine the degree of direct influence of each factor on the other factor through pairwise comparison. As a result, one matrix was created for each expert. n×n (n number of criteria) has fuzzy coefficients defined. After completing H (the number of respondents), the mean matrix (the fuzzy initial direct correlation matrix) is calculated using equation (1):

$$a_{\mathrm{ij}} = \frac{1}{\mathrm{H}} \sum_{\mathrm{K}=1}^{\mathrm{H}} c_{ij}^{k} \qquad (1)$$

It is the degree of influence of factor i on factor j.

1. Calculation of the initial normalized direct correlation matrix

After the mean matrix, the obtained matrix is converted into a normalized direct matrix according to the following relations (2 and 3).

$$\mathrm{S}_1 = \max_{1 \le i \le n}\left[\sum_{j=1}^{n} \mathrm{a}_{\mathrm{ij}}\right] \qquad (2)$$

$$\boxed{D} = \frac{A}{S_1} = \mathrm{a}_{\mathrm{ij}} = \frac{\mathrm{a}_{\mathrm{ij}}}{\mathrm{s}} = \left[\frac{\mathrm{l}_{\mathrm{ij}}}{\mathrm{s}}, \frac{\mathrm{m}_{\mathrm{ij}}}{\mathrm{s}}, \frac{\mathrm{u}_{\mathrm{ij}}}{\mathrm{s}}\right] = (\mathrm{l}'', \mathrm{m}'', \mathrm{u}'') \qquad (3)$$

The above mathematical relationship indicates that the value of S1 is equal to the largest number of the sum of the limits of the row elements of the average matrix, which after dividing the elements of the average matrix one by one by the value of S, the normalized primary direct correlation matrix can be obtained. Table (3) shows the normalized matrix or the primary direct correlation matrix.

Table 3.
Primary direct correlation matrix

W			V			S			M			L			I			H			D			B			A			M
0.05	0.02	0.01	0.07	0.05	0.02	0.03	0	0	0.01	0.07	0.05	0.3	0.01	0	0.7	0.04	0.07	0.11	0.09	0.06	0.1	0.07	0.04	0.9	0.06	0.03	0.03	0	0	A
0.07	0.05	0.03	0.03	0	0	0.07	0.04	0.02	0.04	0.01	0	0.1	0.08	0.05	0.1	0.08	0.051	0.5	0.02	0.01	0.03	0	0	0.03	0	0	0.11	0.08	0.06	B
0.11	0.09	0.07	0.05	0.03	0.02	0.03	0	0	0.08	0.06	0.04	0.1	0.08	0.05	0.1	0.09	0.071	0.1	0.01	0.08	0.03	0	0	0.03	0	0	0.01	0.09	0.07	D
0.11	0.08	0.05	0.03	0	0	0.03	0	0	0.07	0.04	0.02	0.09	0.06	0.04	0.11	0.09	0.062	0.03	0	0	0.1	0.01	0.08	0.05	0	0	0.11	0.01	0.08	H
0.09	0.07	0.04	0.03	0	0	0.08	0.05	0.03	0.09	0.06	0.04	0.07	0.05	0.02	0.09	0	0	0.1	0.08	0.05	0.7	0.04	0.07	0.07	0.04	0.02	0.09	0.07	0.04	I
0.08	0.05	0.03	0.03	0	0	0.03	0	0	0.03	0	0	0.03	0	0	0.08	0.05	0.025	0.1	0.08	0.05	0.7	0.05	0.03	0.03	0	0	0.03	0.01	0	L
0.11	0.08	0.06	0.04	0.01	0	0.09	0.06	0.04	0.03	0	0	0.03	0	0	0.11	0.08	0.051	0.1	0.08	0.06	0.8	0.06	0.03	0.03	0.01	0	0.11	0.08	0.06	M
0.11	0.08	0.06	0.03	0	0	0.03	0	0	0.14	0.06	0.03	0.03	0	0	0.11	0.08	0.054	0.04	0.01	0	0.0	0.00	0.11	0.11	0.09	0.06	0.03	0.01	0	S
0.07	0.04	0.02	0.03	0	0	0.03	0	0	0.03	0	0	0.03	0	0	0.09	0.06	0.036	0.09	0.06	0.03	0.8	0.05	0.03	0.03	0	0	0.08	0.05	0.03	V
0.03	0	0	0.09	0.07	0.04	0.07	0.05	0.03	0.01	0.08	0.05	0.07	0.05	0.02	0.11	0.08	0.057	0.02	0.19	0.16	0.9	0.07	0.01	0.01	0.08	0.05	0.11	0.08	0.06	W

2. Calculation of the effect matrix of total relations (T)

The total relationship matrix shows the intensity of the relative influence of the ruler on the direct and indirect relationships in the system is calculated from the following relations (4) to (7).

$$T = \lim_{H\to\infty} (D^1 \oplus D^2 \oplus \ldots\ldots \oplus D^H) \tag{4}$$

Each portion is $t_{ij} = \left(l^t{}_{ij}, m^t{}_{ij}, u^t{}_{ij}\right)$ and is calculated as follows:

$$L_{IJ} = D_L \times (I - D_L)^{-1} \tag{5}$$

$$m_{IJ} = D_m \times (I - D_m)^{-1} \tag{6}$$

$$u_{IJ} = D_u \times (I - D_u)^{-1} \tag{7}$$

In this matrix, I is the singular matrix, and H_l, H_m, and H_u are each nxn matrix, whose elements form the lower, middle, and upper numbers of the triangular fuzzy numbers of the matrix M, as shown in table (4).

Table 4.
Total relationship matrix

W			V			S			M			L			I			H			D			B			A			T
0.25	0.1	0.02	0.18	0.54	0.02	0.15	0.02	0	0.27	0.12	0.05	0.19	0.05	0.01	0.28	0.14	0.036	0.33	0.19	0.08	0.29	0.17	0.05	0.22	0.08	0.03	0.23	0.1	0.02	A
0.25	0.09	0.03	0.13	0.11	0	0.18	0.06	0.03	0.2	0.04	0.01	0.24	0.1	0.05	0.29	0.12	0.06	0.26	0.08	0.03	0.21	0.05	0.01	0.16	0.03	0.01	0.29	0.12	0.06	B
0.32	0.18	0.09	0.17	0.43	0.02	0.16	0.03	0.01	0.28	0.12	0.05	0.26	0.12	0.06	0.34	0.19	0.093	0.36	0.22	0.12	0.25	0.12	0.03	0.18	0.04	0.01	0.33	0.18	0.09	D
0.32	0.14	0.07	0.15	0.2	0.01	0.16	0.02	0.01	0.26	0.09	0.03	0.25	0.1	0.05	0.34	0.16	0.081	0.28	0.1	0.03	0.32	0.18	0.1	0.2	0.05	0.01	0.32	0.17	0.1	H
0.31	0.13	0.06	0.15	0.17	0	0.21	0.07	0.03	0.29	0.11	0.05	0.24	0.08	0.03	0.27	0.08	0.02	0.35	0.16	0.07	0.31	0.14	0.06	0.22	0.07	0.02	0.32	0.13	0.05	I
0.24	0.09	0.04	0.11	0.1	0	0.12	0.01	0	0.17	0.03	0.01	0.15	0.03	0.01	0.25	0.09	0.037	0.28	0.13	0.06	0.26	0.11	0.06	0.14	0.02	0	0.2	0.05	0.02	L
0.34	0.16	0.07	0.16	0.27	0.01	0.23	0.08	0.04	0.24	0.06	0.02	0.2	0.04	0.01	0.35	0.16	0.072	0.36	0.19	0.09	0.32	0.17	0.08	0.2	0.04	0.01	0.34	0.17	0.08	M
0.31	0.13	0.07	0.14	0.11	0	0.16	0.02	0.01	0.32	0.09	0.04	0.18	0.03	0.01	0.33	0.13	0.066	0.27	0.07	0.02	0.23	0.05	0.01	0.25	0.11	0.07	0.25	0.06	0.02	S
0.24	0.08	0.03	0.12	0.12	0	0.13	0.01	0	0.18	0.03	0.01	0.16	0.03	0.01	0.27	0.11	0.045	0.28	0.12	0.05	0.27	0.12	0.06	0.15	0.02	0	0.25	0.1	0.04	V
0.32	0.14	0.03	0.24	0.82	0.04	0.24	0.08	0.04	0.35	0.15	0.07	0.29	0.12	0.04	0.42	0.24	0.09	0.51	0.36	0.19	0.39	0.26	0.1	0.3	0.13	0.06	0.41	0.24	0.09	W

3. De-fuzzing

In order to reach the relationship structure between the criteria through the relationship network map, first de-fuzzification should be done. In this step, we de-fuzzify the fuzzy numbers obtained from the previous step according to formula (8).

$$T = M + \frac{(U-L)}{4} = \begin{bmatrix} T_{11} & \cdots & T_{1n} \\ \vdots & \ddots & \vdots \\ T_{m1} & \cdots & T_{mn} \end{bmatrix} \tag{8}$$

The modified matrix of the total relationship is according to table (5).

Table 5.

De-fuzzing matrix of total communication

	A	B	D	H	I	L	M	S	V	W
A	0.33	0.29	0.44	0.50	0.41	0.23	0.37	0.17	0.71	0.34
B	0.40	0.18	0.26	0.33	0.40	0.32	0.24	0.23	0.24	0.33
D	0.49	0.22	0.36	0.55	0.50	0.37	0.38	0.19	0.60	0.48
H	0.47	0.25	0.47	0.37	0.48	0.34	0.33	0.18	0.34	0.44
I	0.44	0.28	0.44	0.49	0.34	0.31	0.38	0.28	0.31	0.43
L	0.25	0.15	0.36	0.39	0.33	0.18	0.20	0.13	0.21	0.32
M	0.49	0.24	0.47	0.53	0.50	0.24	0.29	0.03	0.43	0.48
S	0.30	0.35	0.27	0.34	0.44	0.21	0.39	0.18	0.25	0.42
V	0.34	0.17	0.38	0.39	0.37	0.19	0.21	0.14	0.24	0.32
W	0.62	0.41	0.62	0.82	0.64	0.49	0.49	0.32	1.05	0.45

4. Preparing a relationship network map

After de-fuzzifying and creating the matrix of total relations, by transferring the information from the matrix T to the directed graph map, the structure and the way of communication between the criteria can be investigated. For this purpose, a threshold value (α) of the level of effects using formula (9). It is necessary to make a decision. After determining the threshold value, only the values of the rows and columns of the T matrix that are greater than α are transferred to the directed graph map.

$$\alpha = \frac{\sum_{i=1}^{n}\sum_{j=1}^{m} T_{ij}}{m\times n} \qquad \begin{cases} T_{ij} \geq \alpha & T_{ij} = u_{ij} \\ & u_{ij} = 0 \end{cases} \tag{9}$$

5. Reaching the causal diagram structure (cause and effect ranking)

Causal diagram contains the cause and effect relationship between factors and determines the degree of influence and susceptibility of factors. For this purpose, by calculating the sum of the rows and columns of the matrix, the total T parameters (s_i and r_j) are obtained. s_i indicates the total amount of direct and indirect influence of factor i on other factors of the system, and r_i or the sum of i columns of matrix T indicates the total effect that factor i receives from other factors. By calculating the values (s_i and r_j), you can calculate the causal diagram and the cause and effect ranking of the criteria.

(s_i+r_j) defines the set of influence and influence of the desired factor in the system. In other words, the larger (s_i+r_j) a criterion is, the more interaction the desired factor has with other factors. The final value of the effect of each factor on the set of other factors of the system is also obtained from the difference (s_i-r_j). If it is positive, factor i will affect other factors, and if it is negative, factor i will be affected by other factors. according to relations (10) and (11).

S_i-R_j>0 Effective criteria (S_i+R_j) The importance of these indicators (10)

S_i-R_j>0 Effective measure (S_i-R_j) The relationship of these indicators (11)

By entering the values of (s_i+r_j) and (s_i-r_j) in a Cartesian machine, you can show the causal diagram of the factors involved in the problem, in the structure of the causal diagram, the factors below are strongly influenced by their upstream factors. As shown in table (6).

Table 6.

Importance and influence of indicators

W	V	S	M	L	I	H	D	B	A	
9.8065	7.1308	5.2696	7.242	5.3062	8.1108	8.39	8.1931	5.4598	7.9204	R+S
1.8166	-1.643	1.0291	0.6579	-0.257	-0.704	-1.051	0.0716	0.3936	-0.314	R-S
Effective	Receptive	Effective	Effective	Receptive	Effective	Receptive	Effective	Effective	Receptive	Relationships

2-4- Rating of factors with ANP

In order to rank and prioritize factors, fuzzy network analysis will be used, a new theory developed from the hierarchical analysis process, proposed by Saaty to overcome the problem of mutual dependence and feedback between criteria and options. ANP controls the dependency within criteria (internal dependency) and between different criteria (external dependency). In order to facilitate the implementation of the Super Decision software as well as pairwise comparisons, first the factors are symbolized as in Table (7) and then the network analysis steps have been performed as follows.

Table 7.

Notation of factors

Basic content	**Symbol**
Price	V1
Delivery time	V2
Authenticity of the product and compliance with the standards and requested analysis of the product	V3
Product quality	V4
Resume of the provider	V5
Sending samples or the possibility of testing specialized and manufactured goods before full delivery	V6
After-sales service (guarantee and warranty)	V7
Responsiveness of the supplier (in inquiry and ordering, follow-up, etc.)	V8
Product packaging	V9
Authentic or exclusive representative of goods	V10

Step 1- Making a network diagram of the research: in this step, the problem should be divided into criterion levels and sub-criteria and options, if any, and the relationships between them should be determined. A very important point in this step is the existence of relationships between criteria. These relationships can be determined through two-by-two comparisons by asking experts. The network diagram of this research is shown in Super Decision software in Figure (1).

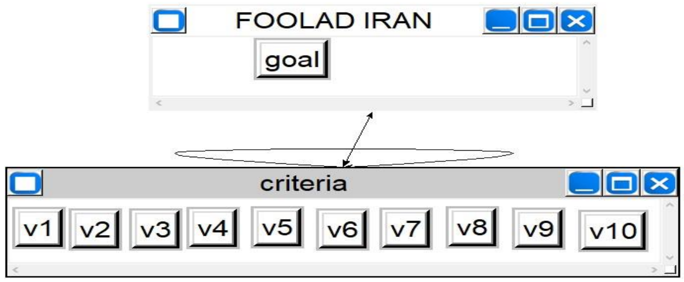

Figure 1.
Research network diagram

Step 2- Formation of pairwise comparisons matrix: In this step, the elements of each level are compared to other related elements at a higher level in a pairwise manner and pairwise comparisons matrices are formed. Also, at the end, a pairwise comparison of internal relationships should be made. These pairwise comparisons are done for all the experts and then collected through the geometric mean in the form of a cumulative matrix and entered into the Super Decision software. Table (8) shows an example of pairwise comparisons.

Table 8.
Examples of fuzzy pairwise comparisons of research factors

	v1	v2	v3	v4	v5	v6	v7	v8	v9	v10
v1		(4,5,6)	(1,1,1)	(1,1,1)	(4,5,6)	(6,7,8)	(3,4,5)	(5,6,7)	(5,6,7)	(7,8,9)
v2			(0.2,0.25,0.333)	(0.166,0.2,0.25)	(6,7,8)	(3,4,5)	(2,3,4)	(1,1,1)	(1,1,1)	(1,2,3)
v3				(1,1,1)	(4,5,6)	(2,3,4)	(1,1,1)	(2,3,4)	(1,1,1)	(4,5,6)
v4					(9,9,9)	(9,9,9)	(7,8,9)	(6,7,8)	(6,7,8)	(6,7,8)
v5						(4,5,6)	(4,5,6)	(1,1,1)	(2,3,4)	(0.25,0.333,0.5)
v6							(0.16,0.2,0.25)	(0.16,0.2,0.25)	(1,1,1)	0.(4,5,6)
v7								(6,7,8)	(3,4,5)	(1,1,1)
v8									(2,3,4)	(0.166,0.2,0.25)
v9										(0.25,0.333,0.5)
v10										

Before the start of the third step, according to the limitations of the Superdesign software, all pairwise comparisons for experts were transformed by using the geometric mean as a cumulative transformation, and after that using the surface center method and relation 1-4 to de-fuzzification.

Relationship 1-4
$$df_{ij} = \frac{[(u_{ij}-l_{ij})+(m_{ij}-l_{ij})]}{3} + l_{ij}$$

Table 9.

Diphased pairwise comparisons

	v1	v2	v3	v4	v5	v6	v7	v8	v9	v10
v1		3.4418	1.0718	1.0000	6.4625	7.0000	2.3097	5.8916	5.8420	6.1059
v2			0.3164	0.2532	5.5241	0.8259	0.3465	1.6141	0.8959	2.6955
v3				1.0000	6.5629	3.5568	1.0000	4.5436	3.9233	5.0610
v4					9.0000	7.7231	1.8661	7.0000	6.6649	6.0419
v5						0.2236	0.2759	0.8959	1.2821	0.2383
v6							0.2349	0.7798	1.0000	0.4189
v7								7.0000	4.5731	1.0000
v8									3.0000	0.2000
v9										0.2123
v10										

Step 3- formation of the initial super matrix: using the weight of the obtained pairwise comparisons, we form the initial super matrix. The primary supermatrix is the same weights that were obtained from pairwise comparisons in the second step. The output of the super matrix in the Super Decision software of this research is reported in Table (10).

Table 10.

Initial supermatrix of factors

	V1	V2	V3	V4	V5	V6	.....	V10	Goal
V1	0	0.149947	0.058014	0.059858	0.124989	0.047115	.....	0.095288	0.210154
V2	0.128191	0	0.043519	0.041036	0.137328	0.192109	.....	0.062869	0.068091
V3	0.196122	0.183366	0	0.107072	0.185341	0.255275	.....	0.226858	0.169276
V4	0.241945	0.11816	0.11147	0	0.144462	0.157128	.....	0.136738	0.22007
V5	0.02011	0.028938	0.035747	0.04081	0	0.037777	.....	0.040549	0.021351
V6	0.055944	0.027968	0.124185	0.240845	0.051303	0	.....	0.043059	0.035569
V7	0.140429	0.204111	0.187924	0.154042	0.08543	0.023515	.....	0.215764	0.138852
V8	0.047006	0.145609	0.055622	0.03334	0.079188	0.071132	.....	0.063914	0.04735
V9	0.050903	0.033789	0.110447	0.093241	0.069495	0.062889	.....	0.114961	0.029633
V10	0.119349	0.108112	0.273072	0.229756	0.122463	0.153061	.....	0	0.059654
Goal	1	1	1	1	1	1	1	1	0

Step 4 - Creating the balanced supermatrix: After creating the initial supermatrix, the balanced supermatrix must be created. This matrix for this research is presented in table (11).

Table 11.

Balanced super matrix

V1	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
V2	0	0.134953	0.052213	0.053872	0.11249	0.042403	0.073807	0.060335	0.088378	0.08576
V3	0.115371	0	0.039167	0.036932	0.123596	0.172898	0.046892	0.149214	0.060704	0.056582
V4	0.17651	0.165029	0	0.096365	0.166807	0.229748	0.164755	0.160016	0.228257	0.204172
V5	0.21775	0.106344	0.100323	0	0.130016	0.141415	0.115317	0.08867	0.144811	0.123064
V6	0.018099	0.026044	0.032173	0.036729	0	0.033999	0.032164	0.022812	0.045935	0.036494
V7	0.05035	0.025171	0.111767	0.216761	0.046173	0	0.032822	0.059683	0.082648	0.038753

V8	0.126386	0.1837	0.169131	0.138638	0.076887	0.021163	0	0.157551	0.07489	0.194187
V9	0.042305	0.131048	0.05006	0.030006	0.071269	0.064019	0.107082	0	0.035172	0.057523
V10	0.045813	0.03041	0.099402	0.083917	0.062546	0.0566	0.086535	0.027153	0	0.103464
	0.107414	0.097301	0.245764	0.20678	0.110217	0.137755	0.240627	0.174566	0.139205	0

Step 5 - creation of the limit supermatrix (limited - limited): the balanced supermatrix must be raised to the infinite power so that each row becomes a convergent number. And that number is the weight of that criterion or subcriterion or option. The output of limited Super Manris for pre-futures and post-futures is specified in table (12).

Table 12.

Limiting super matrix

	V1	**V2**	**V3**	**V4**	**V5**	**V6**	**V7**	**V8**	**V9**	**V10**
V1	0.079738	0.079738	0.079738	0.079738	0.079738	0.079738	0.079738	0.079738	0.079738	0.079738
V2	0.068332	0.068332	0.068332	0.068332	0.068332	0.068332	0.068332	0.068332	0.068332	0.068332
V3	0.147859	0.147859	0.147859	0.147859	0.147859	0.147859	0.147859	0.147859	0.147859	0.147859
V4	0.120154	0.120154	0.120154	0.120154	0.120154	0.120154	0.120154	0.120154	0.120154	0.120154
V5	0.030338	0.030338	0.030338	0.030338	0.030338	0.030338	0.030338	0.030338	0.030338	0.030338
V6	0.071495	0.071495	0.071495	0.071495	0.071495	0.071495	0.071495	0.071495	0.071495	0.071495
V7	0.122838	0.122838	0.122838	0.122838	0.122838	0.122838	0.122838	0.122838	0.122838	0.122838
V8	0.058143	0.058143	0.058143	0.058143	0.058143	0.058143	0.058143	0.058143	0.058143	0.058143
V9	0.066251	0.066251	0.066251	0.066251	0.066251	0.066251	0.066251	0.066251	0.066251	0.066251
V10	0.143944	0.143944	0.143944	0.143944	0.143944	0.143944	0.143944	0.143944	0.143944	0.143944

Finally, after calculating the bounded super matrix, the final weight of each factor can be obtained by normalizing the obtained weights. These weights are reported in table (13) for all the factors of this research.

Table 13.

Weight of factors

Agent title	**Weight**	**Symbol**	**Rank**
Price	0.07974	V1	5
Delivery time	0.06833	V2	7
Authenticity of the product and compliance with the standards and requested analysis of the product	0.14786	V3	1
Product quality	0.12015	V4	4
Resume of the provider	0.03034	V5	10
Sending samples or the possibility of testing specialized and manufactured goods before full delivery	0.07149	V6	6
After-sales service (guarantee and warranty)	0.12284	V7	3
Responsiveness of the supplier (in inquiry and ordering, follow-up, etc.)	0.05814	V8	9
Product packaging	0.06625	V9	8
Authentic or exclusive representative of goods	0.14394	V10	2

As it is clear in the table above, the factor of product authenticity and compliance with the standards and requested analysis of the product with a weight of 0.147 in the first rank and the factors of authentic or exclusive representative of the product and after-sales services (guarantee and warranty) with weights of 0.143 respectively. and 0.122 are in the second and third ranks.

5- Discussion and conclusion

Basically, the supplier selection process is a strategic management activity for the supply of raw materials and services. Choosing the right supplier leads to reducing the purchase risk, increasing customer satisfaction and developing positive relationships between the supplier and the buyer, while choosing the wrong supplier can cause economic problems and subsequently affect the performance of the organization. The supplier evaluation process is a multifaceted process, the first and basic stage of which is the development of performance evaluation indicators and the identification of decision-making panels. In making decisions that involve prioritizing, ranking, or choosing between priorities, researchers use techniques collectively known as multi-criteria decision-making approaches. Their goal is to help decision makers choose preferred options or directly select individual options that best meet their needs. One of the most important problems in many decision-making methods is the accurate evaluation of relevant data. Often in real decision-making applications, the data are ambiguous. Therefore, it is desirable to develop decision-making methods that use fuzzy data.

Steel is one of the important and influential goods in the industrial growth and development of countries. Also, the role of the supply chain in the steel industry is very significant, and on the other hand, the National Steel Group has a special role in Iran's economy. Therefore, due to the lack of an operational model for the evaluation and selection of suppliers in Iran's National Steel Industrial Group Company, the current research aims to identify and rank the factors affecting the selection of suppliers and use the combined FANP/DEMATEL approach to the important issue of the problems of Iran's steel industry. has paid in the selection of suppliers. Therefore, in this research, it has been tried to identify and prioritize the factors influencing the selection of suppliers of Iran National Steel Industrial Group in the form of a model. In order to realize this issue, the authors of the present study took three important steps: in the first step, based on library studies and referring to the literature related to the subject, they extracted a set of factors influencing the selection of suppliers, and in the second step, by conducting interviews In a semi-structured way, 10 experts related to the subject in Iran's National Steel Industrial Group were asked to express their opinions about the factors affecting the evaluation and selection process of the organization's suppliers in detail. Finally, 10 factors were found to be the most effective factors, which are: price and cost of transportation, delivery time, product authenticity and compliance with the required standards and analysis of the product, product quality, supplier's resume, sending samples or the possibility of testing specialized and customized products. Before the complete delivery of the order, after-sales services (guarantee, warranty), supplier's response (at the stage of returning, inquiry and ordering or tracking the shipment of goods), product packaging, having a valid or exclusive representative. Finally, in the third step, using the Fuzzy NP technique, the factors identified in the previous two steps were ranked, and the results indicated that the factor of product authenticity and compliance with the standards and requested analysis of the product ranked first and the factors of authentic or exclusive representative. Goods and after-sales services (guarantee and warranty) are ranked second and third, respectively. The findings of this study were consistent with the findings of Keshavarz-Ghorabaee (2024), Gholamian (2024), Pang et al. (2024) and Acar et al. (2024), but it did not have much alignment with the research findings of Taebi et al. (2024), Mizrak & Akkartal (2024), Muerza (2024) and Nasri et al (2023).

Suggestions

- It is suggested to the future researchers to strengthen and make the model obtained from the current research more practical and to ensure the validity and reliability of the model, to conduct the necessary tests using simulation techniques;
- It is also suggested that the weights and indicators of each criterion be determined more precisely. Also, according to the categories of goods required by steel companies in the categories of standard goods, construction and raw materials, researchers can separate the general model presented in this research into more specialized and detailed models;

- Another suggestion is to conduct research in the fields of evaluation and selection of contractors and projects.

Research Limitations

This study like other researches, has faced limitations and problems, such as:

- ✓ Due to questionnaires and interviews to collect data, some people refused to provide real answers and gave unrealistic answers;
- ✓ The large number of questions in the questionnaires led to the prolongation of its execution time, which did not affect the accuracy of the participants' answers;
- ✓ Considering that the present research was conducted in a situation where the company was in a financial, management crisis, and there was a constant transfer and change of position of employees, this issue may have affected the results.

References

Acar, R., Haktanır, E., Temur, G., & Beskese, A. (2024). Sustainable stationary hydrogen storage application selection with interval-valued intuitionistic fuzzy AHP. *International Journal of Hydrogen Energy*, 49(4), 619-634. https://doi.org/10.1016/j.ijhydene.2023.10.081

Ahmadpour, M., Gholipour Kanaani, Y., & Movahhedi, M.M. (2023). The Structural Model for Evaluating the Performance of the Sustainable Supply Chain of the Service Sector (Case Example: Social Security Organization). *Journal of System Management*, 9(2), 169-181. https://doi.org/10.30495/jsm.2023.1973196.1716

Amini, M. T. A., Esmaeili, M., Hosseini, M. H. H., & Bagheri, S. M. B. (2023). Developing a Model of Value-Creating Defense Supply Chain Management(Approach of Creating a Competitive Advantage in Food Industry). *Military Management Quarterly*, 23(89), 149-172. [In Persian] https://doi.org/10.22034/IAMU.2023.562306.2788

Bazargan, A. (2024). *Research methods in behavioral sciences*. [In Persian]

Burgess, P., Sunmola, S., & Wertheim-Heck, S. (2023). A review of supply chain quality management practices in sustainable food networks. *Journal of Heliyon*, 9(11), 577-592. https://doi.org/10.1016/j.heliyon.2023.e21179

Chaudhuri, R., Chatterjee, S., Gupta., S., & Kamble, S. (2023). Green supply chain technology and organization performance: Moderating role of environmental dynamism and product-service innovation capability. *Technovation*, (128), 694-711. https://doi.org/10.1016/j.technovation.2023.102857

Da Silva, S., Favero, L., Moreira, M., & Dos Santos, M. (2023). Proposal of a diversified investment portfolio in stocks: An approach to AHP-Gaussian method. *Procedia Computer Science*, (221), 418-425. https://doi.org/10.1016/j.procs.2023.07.056

Delavar, D. (2021). *Educational and Psychological research*. Tehran: Virayesh. [In Persian]

De Meyer, A., Verdonck, S., Storms, I., & Muys, B. (2024). Spatio-temporal feedstock availability and techno-economic constraints in the design and optimization of supply chains: The case of domestic woody biomass for biorefining. *Journal of Cleaner Production*, (440), 51-68. https://doi.org/10.1016/j.jclepro.2024.140873

De Moor, D., Wagenaar, J., Poos, R., Den Hertog, D., & Fleuren, H. (2024). A robust approach to food aid supply chains. *European Journal of Operational Research*, 318(1), 269-285. https://doi.org/10.1016/j.ejor.2024.04.034

Ersahin, E., Giannetti, M., & Huang, R. (2024). Trade credit and the stability of supply chains. *Journal of Financial Economics*, (155), 91-110. https://doi.org/10.1016/j.jfineco.2024.103830

Gall, M. (2023). *Quantitative and qualitative research methods*. Translated by Ahmadreza Nasr, Tehran: SAMT. [In Persian]

Gholamian, S. A. (2024). Evaluation and selection of a sustainable supplier by providing a decision support system based on a new data envelopment analysis model and cumulative star utility. *Journal of System*

and Productivity Engineering, 4(1), 1-21. [In Persian] https://doi.org/10.1016/j.measurement.2016.01.032
Helli, S. S., Mokhtari, H., & Dehnavi, S. (2024). Optimizing the Construction Supply Chain Network Considering the Flow of Materials, Equipment, Manpower, Drawings and Technical Documents. *Research in Production and Operations Management*, 15(2), 27-55. [In Persian] https://doi.org/10.22108/pom.2024.141270.1554
Jahangiri, J., Danaei, A., Akbari, M., & Vakil AlRaaya, Y. (2023). Investigating the Role of Social Media in Digital Supply Chain Resilience with a Hybrid Approach. *Journal of System Management*, 9(4), 85-104. https://doi.org/10.30495/jsm.2023.1981402.1784
Junaid, M., Zhang, Q., Cao, M., & Luqman, A. (2023). Nexus between technology enabled supply chain dynamic capabilities, integration, resilience, and sustainable performance: An empirical examination of healthcare organizations. *Technological Forecasting and Social Change*, (196), 443-457. https://doi.org/10.1016/j.techfore.2023.122828
Keshavarz-Ghorabaee, M. (2024). A multi-objective model based on group decision-making and interval-valued Pythagorean fuzzy sets for the supplier selection and order allocation problem. *Industrial Management Studies*, 22(74), 1-25. [In Persian] https://doi.org/10.22054/jims.2024.80903.2926
Keyhanizadeh, A. (2024). Examining the Role of Behavioral Dimensions and Technical Dimensions of Green Supply Chain Management on the Performance of the Organization with Regard to the Mediating Role of Information Technology Capabilities in the Food Industry of Kaveh Industrial City. *New Research Approaches in Management Sciences*, 13(33), 1-12. [In Persian] http://jnraims.ir/article-1-358-en.html
Kiani, M., Andalib Ardakani, D., Mirfakhredini, S. H., & Zare Ahmadabadi, H. (2023). An Analysis of the Barriers to the Implementation of the Circular Economy and Industry 4.0 in the Supply Chain: The Meta-Synthesis Approach and Fuzzy DANP. *Journal of Industrial Management Perspective*, 13(4), 9-45. [In Persian] https://doi.org/10.48308/jimp.13.4.9
Klein, G. (2024). Transformational and transactional leadership, organizational support and environmental competition intensity as antecedents of intrapreneurial behaviors. *European Research on Management and Business Economics*, 29(2), 637-656. https://doi.org/10.1016/j.iedeen.2023.100215
Kumar, U., & Shankar, R. (2024). Smart dairy: Unleashing emerging ICT-enabled lean dairy supply chains through data-driven decision-making. *International Journal of Information Management Data Insights*, 4(2), 174-193. https://doi.org/10.1016/j.jjimei.2024.100297
Liu, Q., Liang, Y., Liu, C., Xue, J., Zhang, H., Tu, R., Zou, X., & Liang, Y. (2024). Developing an integrated and collaborated evaluation index system for crude oil supply chains: A case study from China. *Chemical Engineering Research and Design*, 28(1), 71-88. https://doi.org/10.1016/j.cherd.2024.10.014
Mahmoodi, J., Ehtesham Rasi, R., & Irajpoor, A. (2023). A Mathematical Model to Optimize Cost, Time in The Three echelon Supply Chain in Post COVID 19 pandemic. *Journal of System Management*, 4(9), 255-271. https://doi.org/10.30495/jsm.2023.1985225.1822
Maretto, L., Faccio, M., & Battini, D. (2022). A Multi-Criteria Decision-Making Model Based on Fuzzy Logic and AHP for the Selection of Digital Technologies. *IFAC-PapersOnLine*, 55(2), 319-324. https://doi.org/10.1016/j.ifacol.2022.04.213
Mason, J. (2023). *Qualitative research method*. Translated by Mohammad Heidarpour Kelidsar, Tehran: Shahrab. [In Persian]
Mizrak, F., & Akkartal, G. (2024). Prioritizing cybersecurity initiatives in aviation: A dematel-QSFS methodology. *Journal of Heliyon*, 10(16), 325-339. https://doi.org/10.1016/j.heliyon.2024.e35487
Mollashahi, H., Fakhrzad, M. B., Hoseini Nasab, H., & Khademi Zare, H. (2024). Inter-Chain Competition Based on Sustainability and Resilience Indicators in the Problem of Supply Chain Network Design. *Supply Chain Management*, 26(82), 77-93. [In Persian] https://scmj.ihu.ac.ir/article_208782.html?lang=en
Morshedi, A., & Nezafati, N. (2021). The Interpretation of Knowledge Management Implementation Challenges and the Design of Relevant Solutions in Supply Chains (Case study: Steel Industry). *Strategic*

Management of Organizational Knowledge, 4(3), 175-223. [In Persian] https://jkm.ihu.ac.ir/article_206881.html?lang=en&lang=en&lang=en&lang=en&lang=en

Muerza, A., Milenkovic, M., LarrodE, E., & Bojovic. N. (2024). Selection of an international distribution center location: A comparison between stand-alone ANP and DEMATEL-ANP applications. *Research in Transportation Business & Management*, (56), 74-92. https://doi.org/10.1016/j.rtbm.2024.101135

Nasri, S. A., Sarabi, A., Shabanian, A., Hosseini, S. M., & Nowshadi. R. (2023). Defining and prioritizing criteria for sustainable supplier selection in the oil and petrochemical industry (case study: National Iranian Oil Company). *Quarterly Journal of Energy Policy and Planning Research*, 9(1), 210-235. [In Persian] http://epprjournal.ir/article-1-1095-en.html

Pang, F., Miao, G., Li, Y., & Shi, Y. (2024). Key Factors Influencing Sustainable Population Growth: A DEMATEL-ANP Combined Approach. *Journal of Heliyon*, 10(4), 245-257. https://doi.org/10.1016/j.heliyon.2024.e39404

Romano, A., Ferreira, L., & Caeiro, S. (2023). Why companies adopt supply chain sustainability practices: A study of companies in Brazil. *Journal of Cleaner Production*, (433), 220-238. https://doi.org/10.1016/j.jclepro.2023.139725

Rossi, C., Shen, L., Junginger, M., & Wicke, B. (2023). Sustainability certification of bio-based products: Systematic literature review of socio-economic impacts along the supply chain. *Journal of Cleaner Production*, (468), 503-522. https://doi.org/10.1016/j.jclepro.2024.143079

Sadri, N., Modiri, M., Fathi Hafshjani, K., & Valmohammadi, C. (2024). Supply Chain Risk Management Analysis based on Resilience Capabilities (Comprehensive Structural Interpretive Modeling Approach). *Journal of System Management*, 10(3), 47-73. https://sanad.iau.ir/en/Article/918301

Sayyari, M., CheraghAli, M., & Saeidi, P. (2023). Strategic International Business Innovation:A New Approach in Development of Iran's Pharmaceutical Industry). *Journal of System Management*, 9(4), 73-84. https://doi.org/10.30495/jsm.2023.1980921.1782

Shahpouri, R., Amirshahi, A., & Salehababdi, A. (2024). Ranking of Financing Methods in Iran's Steel Industry through the Statistical Model of Multi-indicator Decision Making. *Journal of Research and Economic Policies*, 31(108), 33-65. [In Persian] http://qjerp.ir/article-1-3454-en.html

Shanta, M., Choudhury, I., & Salman, S. (2024). Municipal solid waste management: Identification and analysis of technology selection criteria using Fuzzy Delphi and Fuzzy DEMATEL technique. *Journal of Heliyon*, 10(1), 507-522. https://doi.org/10.1016/j.heliyon.2023.e23236

Silvestri, R., Carloni, E., Morrone, D., & Santovito, S. (2024). The role of blockchain technology in supply chain relationships: Balancing efficiency and relational dynamics. *Journal of Purchasing and Supply Management*, 48(4), 229-246. https://doi.org/10.1016/j.pursup.2024.100967

Taebi, P., Alavi Sadr, M. H., & Khatami Firouzabadi, S. M. A. (2024). Identification and prioritization of suitable supplier selection criteria based on the four dimensions of sustainability with a multi-criteria decision-making approach. *Iranian Rubber Industry*, 28(112), 46-63. [In Persian] https://doi.org/10.3390/su142416809

Torabi, S., & Heidari, Y. (2023). Integrated production and distribution scheduling in a dental prosthetics supply chain under additive manufacturing environment. *Industrial Management Studies*, 21(69), 43-75. [In Persian] https://doi.org/10.22054/jims.2023.59976.2638

Wu,Y., Wang, J., & Yang, P. (2024). How supply chain digitalization investment affects firm's financial and non-financial performance: Evidence from listed companies in China. *International Review of Financial Analysis*, 32(1), 1-14. https://doi.org/10.1016/j.irfa.2024.103639

Wulandari, C., Astutik, P., Soegito, R., Dharmawan, Y., Munawaroh, H., & Bariyah, T. (2024). Hybrid MCDM Career Recommendation System for Information System Student Using AHP, VIKOR and Weighted Euclidean Distance. *Procedia Computer Science*, (234), 364-372. https://doi.org/10.1016/j.procs.2024.03.016

Xu, J., Yu, Y., & Hu, L. (2023). Political ties and information technology: Untangling their impact on supply chain social responsibility and sustainable performance. *Journal of Purchasing and Supply Management*, 29(5), 1-14. https://doi.org/10.1016/j.pursup.2023.100879