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Identifying and Prioritizing Factors Affecting Supply Chain Financing in the Energy Sector

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Abstract

The energy sector, due to its complex and evolving nature, requires innovative financing methods. The aim of this study is to identify and prioritize factors influencing supply chain financing in the energy sector. This research is applied in orientation and quantitative in methodology. The theoretical population of the study consisted of experts active in the energy sector with a solid background in financing and supply chain financing. Judgment sampling was employed in this study. The methods used in this research included Fuzzy Delphi and CoCoSo. The Fuzzy Delphi method was utilized to screen the research factors, while CoCoSo was applied for final prioritization of the factors. The primary data collection tools were an expert assessment questionnaire and a prioritization questionnaire. This study was conducted in three stages. In the first step, 21 factors were identified through literature review and interviews with experts. In the next step, these factors were screened using expert assessment questionnaires and the Fuzzy Delphi method. Ten factors, which achieved a favorable defuzzified value, were selected for final prioritization. The selected factors were ranked using the CoCoSo method. The prioritized factors included: the degree of integration of information systems within supply chain components, the penetration rate of data-driven technologies in the energy supply chain, and the level of banks' control over the country's financing sector. Practical recommendations were developed based on the key factors identified in the study. Some of these recommendations included: focusing on the compatibility and adaptability of technologies with existing systems during technology transfer, using fourth-generation technologies to integrate the supply chain, and enhancing the diversity of financing methods in the country through the development of fintechs and financial startups.

Keywords: *Financing, Supply Chain Financing, Supply Chain, Energy Sector*.

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1. Introduction

One of the topics that has drawn the attention of economists since the inception of economic science is economic growth and the financing of development projects. In this regard, the financial industry, through its intermediary role in allocating financial resources to various sub-sectors of the economy, can, while maintaining existing conditions, pave the way for long-term economic growth. Financing refers to the process of providing financial resources for creating or expanding business activities, investments, or purchases. The use of financial instruments in any economic system is essential. Companies and businesses need financial resources to generate revenue and create wealth. Since the 2008 financial crisis, supply chain financing (SCF) has been recognized as a preferred approach to enhancing the management of financial flows across the entire supply chain [1]. SCF encompasses a set of approaches, techniques, and financial tools aimed at optimizing transactions, working capital, and costs across the supply chain, covering stages from product design and after-sales service management to all phases of planning, sourcing, procurement, inventory management, and distribution. The global supply chain finance market was valued at six billion USD in 2021 and is projected to reach 13.4 billion USD by 2031, growing at a compound annual growth rate of approximately nine percent from 2022 to 2031 [2, 3]. SCF, by improving working capital through the control of inventory, accounts payable, and accounts receivable, reduces liquidity constraints and releases a significant amount of working capital, thereby fostering network profitability and efficiency, improving bank balance sheets, and ultimately contributing to sustainable economic growth through non-inflationary measures, and efficient use of credits and facilities [4]. This method aims to resolve issues for parties within a supply chain loop by providing credit instruments such as electronic drafts, production credit certificates (GAM), deferred internal letters of credit, and other permitted financial and commercial instruments [5].

With the increasing complexity of supply chains, efficient working capital management has become a highly challenging issue. SCF can bridge the gap between payment terms and actual goods flow, helping buyers and suppliers improve their cash flow. For suppliers, it accelerates receivables, while for buyers, it extends payables, thus enhancing liquidity. Supply chain financing is an innovative approach to working capital financing for companies that, by efficiently allocating financial resources, can lead to financial stability. The main distinction between supply chain financing methods and traditional methods lies in the continuous coverage of the entire supply chain under financial and risk management tools. In this new ecosystem, financing and risk management models are continuously implemented for multiple supply chain loops. The supply chain finance management platform includes five main components: (1) fintech startups (e.g., banking, insurance, and cryptocurrency fintechs), (2) technology developers (e.g., big data analysts, cloud computing, cryptography, and social media developers), (3) government (e.g., regtech), (4) traditional financial institutions (e.g., banks and insurers), and (5) financial customers (e.g., organizations and anonymous individuals) [6].

Fintechs and the development of new financial technologies play a significant role in the advancement of innovative financing tools [7]. Diversifying financing methods aids various businesses and supply chains. Previously, banks were the primary source of financing, but with increasing economic complexity and the need for sustainability, alternative methods have developed, one of which is the supply chain approach [8, 9]. This approach is influenced by factors such as supply chain integration and technological infrastructure, particularly data-driven technologies [3, 6, 10]. Understanding these factors greatly contributes to the development of SCF applications across various economic sectors.

The 2007-2008 global financial crisis, initiated by the U.S. housing market collapse, laid the groundwork for the evolution of supply chain finance (SCF) as businesses sought financial resources through negotiations with financial institutions [11]. As key financial institutions failed to release funds, governments intervened to prevent potential economic collapse, causing widespread distrust in the financial market. This led to uncertainty and triggered liquidity and credit shocks, which transferred through financial channels into the real economy, severely limiting available funds. In response, supply chains looked for alternative ways to finance business goals, especially working capital needs. Supply chain financing emerged as an innovative approach for organizations to optimize financial flows within the supply chain, aiming to improve liquidity, enhance profitability, and reduce costs by streamlining payment options [2, 12]. Unlike factoring, which is initiated by the seller, SCF is often driven by the buyer, creating a collaborative financial structure with third-party investors or financial institutions [13, 14].

SCF typically involves a third party, such as a financial institution, facilitating transactions between buyers and sellers by paying the seller promptly while extending the buyer's payment terms, thus balancing cash flow for both parties without added financial stress [14]. This method enhances collaboration and credit, allowing buyers greater cash flow control and faster payments for sellers, optimizing liquidity across the network [15]. Unlike traditional financing methods that primarily address the seller's needs, SCF considers both buyer and seller needs, and the buyer's credit rating is pivotal in determining SCF success. Poor creditworthiness may deter financial institutions from upfront payments to suppliers [16, 17]. SCF models optimize working capital by managing accounts payable, receivable, and inventory, ultimately enhancing firm performance, lowering liquidity requirements, and freeing up substantial working capital, maximizing investment returns and shareholder profits [18, 19].

Several studies have examined SCF's growing role and potential. Kaur et al. (2024) explored the challenges of implementing blockchain technology in India's small- and medium-sized enterprises (SMEs) for SCF, identifying barriers like information asymmetry, high transaction costs, and limited access to credit, and found that blockchain adoption could address these issues [20]. Similarly, Gong et al. (2024) identified factors that facilitate blockchain in SCF, highlighting regulatory support and stakeholder motivation as key enablers [21]. In contrast, Choi (2023) assessed blockchain's role in SCF for fashion products, noting that blockchain-backed supply chains experience lower operational risk and higher profitability than traditional bank-centric models [22]. Vu et al. (2022) investigated SCF's impact on SMEs in Vietnam, emphasizing that credit quality, supply chain integration, and information sharing significantly impact SCF, which in turn enhances firm performance [23].

The energy sector is one area that, due to the requirements of sustainable development, a strong emphasis on clean and renewable energies, and the need to smarten many devices to reduce energy consumption, requires diverse and varied financing methods [24-27]. Many projects in this field cannot be financed using conventional bank-centered methods. SCF in the energy sector has recently attracted attention, with most studies focusing on identifying and explaining its applications in general terms. Given the above, the research questions of this study are:

What are the factors influencing SCF in the energy sector?

What is the priority ranking of the factors affecting SCF in the energy sector?

2. Methodology

The objective of the present study is to identify and analyze factors affecting supply chain finance in the energy sector. To this end, Fuzzy Delphi and CoCoSo methods were employed. Both Fuzzy Delphi and CoCoSo are quantitative techniques, utilizing quantitative data for assessment and analysis. The Fuzzy Delphi technique was used for screening factors, while the CoCoSo technique was employed to identify the most significant factors influencing supply chain finance. Given the quantitative nature of the techniques used, this research follows a multi-method quantitative methodology. Additionally, due to the practical benefits of the study's results for the energy sector, the study has an applied orientation.

For data collection, two tools were used: expert interviews and questionnaires. The research factors were derived from a review of articles related to finance and supply chain finance, as well as interviews with energy experts. Subsequently, two questionnaires—an expert assessment questionnaire and a prioritization questionnaire—were distributed among the experts for data analysis. The expert assessment questionnaires were analyzed using the Fuzzy Delphi method, while the prioritization questionnaires were analyzed using the CoCoSo method. As the content of the questionnaires was obtained from reviewing credible articles and interviews with supply chain finance and energy experts, both the expert assessment and impact assessment questionnaires are valid. Furthermore, due to the selection of an optimal sample size (10 participants) and the notable reduction and screening of factors, the prioritization questionnaire exhibited adequate reliability.

The experts in this study consisted of senior managers, consultants, and finance experts in the energy sector. Due to the expert-based nature of the techniques used in the research, judgment sampling was employed, with experts selected based on their expertise in finance and supply chain finance. The sample size in this study was 10 participants, which is an appropriate number for expert-centered techniques with a judgment-based nature.

The current research was carried out in three stages. In the first step, factors affecting supply chain finance in the energy sector were identified through a literature review and interviews with experts. In the next stage, these factors were screened using the Fuzzy Delphi method. In the third stage, the research factors were prioritized using the CoCoSo method.

The Fuzzy Delphi technique was used to screen the research factors. The steps in implementing the Fuzzy Delphi algorithm for screening include the following:

- Determining the appropriate spectrum for fuzzifying verbal expressions;
- Aggregating the fuzzy values;
- Defuzzifying the values;
- Setting a threshold intensity and screening the criteria.

Step 1: Gathering and fuzzifying expert opinions. In the Fuzzy Delphi screening method, the first step is to develop an optimal fuzzy scale for fuzzifying the experts' verbal expressions, often using conventional fuzzy scales. In this study, a five-point Likert scale, shown in Table 1, was used.

Table 1. Fuzzy Delphi Method Scale

Verbal Variable	Fuzzy Value	Triangular Fuzzy Number
Very Low	$\tilde{1}$	(0, 0, 0.25)
Low	$\tilde{2}$	(0, 0.25, 0.5)
Medium	$\tilde{3}$	(0.25, 0.5, 0.75)
High	$\tilde{4}$	(0.5, 0.75, 1)
Very High	$\tilde{5}$	(0.75, 1, 1)

Step 2: Aggregating the fuzzy values. After selecting the appropriate fuzzy scale, experts' opinions are collected and fuzzified. Several procedures exist for aggregating experts' fuzzy opinions. If each expert's opinion is represented as triangular fuzzy numbers (l, m, u), the simplest approach is to calculate the fuzzy mean of the experts' opinions:

$$F_{AVE} = \frac{\sum l}{n}, \frac{\sum m}{n}, \frac{\sum u}{n}$$

Step 3: Defuzzifying the values. In techniques involving a fuzzy approach, researchers eventually convert the final fuzzy values into a definitive number, a process known as defuzzification. A simple technique for defuzzification is to average the triangular fuzzy numbers:

$$if\ \widetilde{F} = (l, m, u)\ then\ F = \frac{l + m + u}{3}$$

Step 4: After selecting the appropriate method and defuzzifying the values, a threshold must be set. This threshold varies by study and is typically determined by the researcher. If the defuzzified value of aggregated expert opinions exceeds the threshold, the factor is retained; otherwise, it is excluded.

After screening the factors influencing supply chain finance, the next step is their analysis and prioritization. In the current study, the CoCoSo method was used to prioritize the factors. This method, leveraging data from both the Fuzzy Best-Worst and Fuzzy WASPAS methods, ranks factors with considerable accuracy and is considered one of the most recent and reliable ranking methods. The steps in the CoCoSo method are as follows:

Step 1: Experts' opinions on the importance of each factor are collected on a 10-point scale.

Step 2: The values of the decision matrix are normalized using the fuzzy approach.

Step 3: Using the formulas below, the weighted sum (S) and weighted product (P) values for each option are calculated. In these formulas, W_j represents the weight of the criteria, inputted into the CoCoSo method. S_i values are obtained using the SAW method, while P_i values are derived from the WASPAS method.

$$S_i = \sum_{j=1}^{n} (w_j r_{ij}),$$

$$P_i = \sum_{j=1}^{n} (r_{ij})^{w_j},$$

Step 4: Each option's score is calculated based on the following three strategies. The first equation describes the arithmetic mean of WSM and WPM scores, while the second equation represents their relative scores compared to the best scores. The third equation is a compromise between the WSM and WPM models, with λ set by the decision-maker, usually 0.5 for flexibility.

$$k_{ia} = \frac{P_i + S_i}{\sum_{i=1}^{m} (P_i + S_i)},$$

$$k_{ib} = \frac{S_i}{\min_i S_i} + \frac{P_i}{\min_i P_i},$$

$$k_{ic} = \frac{\lambda(S_i) + (1-\lambda)(P_i)}{\left(\lambda \max_i S_i + (1-\lambda)\max_i P_i\right)}, \quad 0 \le \lambda \le 1 .$$

Step 5: The final score is calculated using the formula below, which represents the combined arithmetic and geometric mean of the three previous scores. The higher the k score for an option, the more preferred that option is.

$$k_i = (k_{ia}k_{ib}k_{ic})^{\frac{1}{3}} + \frac{1}{3}(k_{ia} + k_{ib} + k_{ic}).$$

3. Findings and Results

The factors influencing supply chain finance in Iran were identified through an analytical review of the literature and expert interviews. These factors are listed in Table 2. To derive the research factors, articles related to supply chain finance from 2010 to 2024 available in reputable scientific databases (Elsevier, Emerald, and Magiran) were reviewed. Seventeen factors were identified through the literature review, and four additional factors were added by the experts consulted for this study.

The validity of the factors was calculated using the Lawshe Content Validity Index (CVI). The CVI for all elements of the questionnaire was above 0.79, indicating adequate validity for the study's questionnaires.

Table 2. Factors Influencing Supply Chain Finance

Research Factors	Research Sources
Supply chain coordination	[3, 6, 10]
Integration level of supply chain information systems	[23]
Penetration rate of data-driven technologies in the energy supply chain	[20]
Development level of fintech in the country	[2, 7]
Energy regulation in the country	[21]
Financial technology regulatory policies in the country	[28, 29]
Support of senior managers for supply chain approaches	Interview
Skills of staff and managers in energy companies regarding modern financing methods	Interview
R&D policies in the energy supply chain	[27, 30]
Innovation policies in energy supply chains	[24, 31]
Decision-making style of managers in energy companies	[8, 32, 33]
Agility level of company structures in the energy sector	[34, 35]
Bank dominance over the country's financial sector	[22, 36]
Diversity of financial instruments in the capital market	[37]
Focus of supply chains on sustainability	[25, 26]
Governance nature in the country's energy supply chains	Interview
Level of international cooperation in energy supply chains	Interview
Share of clean energy in the national energy market	[24, 26]
Religious and legal policies and restrictions related to financing	Interview
Increasing economic and supply chain complexity	[8]
Development of green startups in finance and energy sectors	Interview

Twenty-one factors identified through the literature review and expert interviews were screened using the Fuzzy Delphi technique. At this stage, 11 factors were excluded, and 10 were selected for final prioritization. Factors with a defuzzified value above 0.7 were chosen for prioritization with the CoCoSo method. In this study, 10 factors had a defuzzified value above 0.7, which served as the threshold for factor screening. Generally, the threshold in quantitative research ranges from 0.5 to 0.7; here, a threshold of 0.7 was set. Table 3 lists the final screened factors along with their defuzzified values.

Table 3. Fuzzy Delphi Output for Factors Influencing Supply Chain Finance

Drivers	Lower Limit	Median	Upper Limit	Defuzzified Value
Integration level of supply chain information systems (C1)	0.76	0.88	0.95	0.86
Penetration rate of data-driven technologies in the energy supply chain (C2)	0.74	0.82	0.90	0.82
Energy regulation in the country (C3)	0.71	0.78	0.85	0.78
Financial technology regulatory policies in the country (C4)	0.70	0.77	0.83	0.77

Bank dominance over the country's financial sector (C5)	0.74	0.85	0.93	0.84
Diversity of financial instruments in the capital market (C6)	0.71	0.79	0.85	0.78
Level of international cooperation in energy supply chains (C7)	0.72	0.78	0.84	0.78
Share of clean energy in the national energy market (C8)	0.69	0.78	0.85	0.77
Religious and legal policies and restrictions related to financing (C9)	0.73	0.80	0.89	0.81
Increasing economic and supply chain complexity (C10)	0.67	0.77	0.85	0.76

The screened factors were then analyzed using the CoCoSo method, where the experts rated the significance of each factor influencing supply chain finance on a 10-point scale. A decision matrix was created based on the ratings from 10 experts. The values in this matrix were normalized using the fuzzy approach per the second step of the CoCoSo method. Table 4 shows the normalized decision matrix for the research factors.

Table 4. Normalized Matrix of Factors Influencing Supply Chain Finance

Research Factors	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9	Expert 10
C1	1	0.857	1	1	1	1	1	1	1	1
C2	1	1	1	0.833	0.857	0.8	0.667	0.571	0.833	0.8
C3	0	0.286	0.286	0	0.286	0.2	0.333	0.429	0.333	0
C4	0.286	0.143	0.286	0	0.286	0.6	0.167	0.143	0	0
C5	0.857	0.571	0.429	0.667	0.857	0.6	0.5	0.571	0.333	0.6
C6	0.143	0.286	0.429	0	0.286	0.2	0.167	0	0.167	0
C7	0.143	0	0.286	0.333	0	0	0	0.429	0	0
C8	0.429	0.571	0.286	0.333	0.571	0.8	0.5	0.286	0.667	0.8
C9	0.286	0.429	0.143	0.167	0.429	0.6	0.5	0.429	0.333	0
C10	0	0.143	0	0.167	0.286	0.4	0	0.429	0.333	0

Based on the normalized matrix values, the data for the weighted sum matrix (S) and weighted product matrix (P) are obtained following the formulas in step three of the CoCoSo method. Table 5 shows the weighted sum matrix values for the factors influencing supply chain finance. The weighted sum values are calculated by multiplying the normalized matrix data by the weights of the experts' ratings, all set equally at 0.1. This weight was derived by dividing one by ten. Finally, the values in this matrix are combined using the S index, which is the row sum of the weighted sum matrix and represents the desirability of each option in the weighted average method.

Table 5. Weighted Sum Matrix (S) of Factors Influencing Supply Chain Finance

Research Factors	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9	Expert 10	S Index
C1 - Integration level of supply chain information systems	0.1	0.086	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.986
C2 - Penetration rate of data-driven technologies in the energy supply chain	0.1	0.1	0.1	0.083	0.086	0.08	0.067	0.057	0.083	0.08	0.836
C3 - Energy regulation in the country	0	0.029	0.029	0	0.029	0.02	0.033	0.043	0.033	0	0.216
C4 - Financial technology regulatory policies in the country	0.029	0.014	0.029	0	0.029	0.06	0.017	0.014	0	0	0.192
C5 - Bank dominance over the country's financial sector	0.086	0.057	0.043	0.067	0.086	0.06	0.05	0.057	0.033	0.06	0.599
C6 - Diversity of financial instruments in the capital market	0.014	0.029	0.043	0	0.029	0.02	0.017	0	0.017	0	0.169
C7 - Level of international cooperation in energy supply chains	0.014	0	0.029	0.033	0	0	0	0.043	0	0	0.119
C8 - Share of clean energy in the national energy market	0.043	0.057	0.029	0.033	0.057	0.08	0.05	0.029	0.067	0.08	0.525
C9 - Religious and legal policies and restrictions related to financing	0.029	0.043	0.014	0.017	0.043	0.06	0.05	0.043	0.033	0	0.332

C10 - Increasing economic and supply chain complexity	0	0.014	0	0.017	0.029	0.04	0	0.043	0.033	0	0.176

In addition to calculating the weighted sum matrix, the weighted product matrix (P) also needs to be determined. The calculation formula for this matrix and the P index follows the steps of the WASPAS method. To calculate the weighted product matrix, each value in the normalized matrix is raised to the power of the experts' weight (set to 0.1). The weighted product matrix data are shown in Table 6.

Table 6. Weighted Product Matrix (P) of Factors Influencing Supply Chain Finance

Research Factors	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9	Expert 10	P Index
C1 - Integration level of supply chain information systems	1	0.985	1	1	1	1	1	1	1	1	9.985
C2 - Penetration rate of data-driven technologies in the energy supply chain	1	1	1	0.982	0.985	0.978	0.96	0.946	0.982	0.978	9.811
C3 - Energy regulation in the country	0	0.882	0.882	0	0.882	0.851	0.896	0.919	0.896	0	6.208
C4 - Financial technology regulatory policies in the country	0.882	0.823	0.882	0	0.882	0.95	0.836	0.823	0	0	6.078
C5 - Bank dominance over the country's financial sector	0.985	0.946	0.919	0.96	0.985	0.95	0.933	0.946	0.896	0.95	9.47
C6 - Diversity of financial instruments in the capital market	0.823	0.882	0.919	0	0.882	0.851	0.836	0	0.836	0	6.029
C7 - Level of international cooperation in energy supply chains	0.823	0	0.882	0.896	0	0	0	0.919	0	0	3.52
C8 - Share of clean energy in the national energy market	0.919	0.946	0.882	0.896	0.946	0.978	0.933	0.882	0.96	0.978	9.32
C9 - Religious and legal policies and restrictions related to financing	0.882	0.919	0.823	0.836	0.919	0.95	0.933	0.919	0.896	0	8.077
C10 - Increasing economic and supply chain complexity	0	0.823	0	0.836	0.882	0.912	0	0.919	0.896	0	5.268

The final ranking of the factors influencing supply chain finance in the energy sector using the CoCoSo method is derived from the K index. Calculating the K index requires determining three sub-indices, K_a, K_b, and K_c, with K_c being a combination of K_a and K_b. The value of λ in this study was set to 0.5, a commonly used parameter in previous research. Finally, the K index is obtained by taking the arithmetic and geometric mean of K_a, K_b, and K_c. Table 7 presents the four indices for evaluating the factors in the CoCoSo method, along with the final ranking for each factor.

Table 7. Four Indices for Evaluating Research Factors in CoCoSo

Research Factors	Ka	Kb	Kc	K	Rank
Integration level of supply chain information systems	0.141	11.122	1	5.24	1
Penetration rate of data-driven technologies in the energy supply chain	0.137	0.812	0.97	4.372	2
Energy regulation in the country	0.082	3.579	0.585	1.971	6
Financial technology regulatory policies in the country	0.08	3.34	0.571	1.865	7
Bank dominance over the country's financial sector	0.129	7.724	0.917	3.894	3
Diversity of financial instruments in the capital market	0.08	3.133	0.564	1.78	8
Level of international cooperation in energy supply chains	0.047	2	0.331	1.107	10
Share of clean energy in the national energy market	0.126	7.059	0.897	3.621	4
Religious and legal policies and restrictions related to financing	0.108	5.085	0.766	2.735	5
Increasing economic and supply chain complexity	0.07	2.976	0.496	1.65	9

Based on the K index, the factors "integration level of supply chain information systems," "penetration rate of data-driven technologies in the energy supply chain," and "bank dominance over the country's financial sector" ranked as the highest in priority and significance. The higher this index for a factor, the more significant that factor is considered.

Practical recommendations were developed based on the key factors influencing supply chain finance in the energy sector.

4. Discussion and Conclusion

The energy sector is experiencing significant shifts, including the emergence of new technologies and an increasing share of clean energy in national energy portfolios. These changes have amplified the importance of adopting innovative financing methods. Supply chain finance (SCF) has recently gained attention from industries and businesses, particularly in the energy sector. This study aimed to identify and prioritize the factors influencing SCF in the energy sector.

The research was conducted in three stages. Initially, 21 factors were identified through a literature review and expert interviews. These factors were then screened using expert assessment questionnaires and the Fuzzy Delphi method. Ten factors with favorable defuzzified values were selected for final prioritization with the CoCoSo method. The prioritization questionnaires, rated on a 10-point scale, were distributed among experts who provided their insights on each factor. Based on the CoCoSo results, the top-priority factors included the integration level of supply chain information systems, the penetration rate of data-driven technologies in the energy supply chain, and the level of bank dominance over the national financial sector. Practical recommendations were developed based on the most critical factors identified.

One significant factor influencing SCF is the integration of information systems within supply chain components. Integration growth is driven by two primary factors. First, fourth-generation technologies, such as the Internet of Things (IoT), blockchain, and big data, play a crucial role in supply chain integration. These technologies enable data-driven analyses across various areas, such as forecasting and risk analysis. Blockchain can be utilized to develop smart contracts, while IoT has a substantial role in enhancing the intelligence of the energy supply chain. The second consideration is the compatibility of new technologies with existing systems. A lack of compatibility can reduce integration and disrupt the effective use of SCF.

ing models and tools that clearly demonstrate these technologies' benefits can increase acceptance. Managers are more likely to support technology adoption when they perceive tangible improvements within their organizations and processes. Third, successful deployment of these technologies requires coordination among compaRegarding the penetration rate of data-driven technologies in the energy supply chain, three main points warrant attention. First, organizational culture within the energy supply chain is critical; data-driven technologies are effective only if the prevailing decision-making approach within organizations is data-driven. Currently, managers often rely on limited personal experience and intuition. Changing this culture requires support from senior management. Second, the perceived benefits of fourth-generation technologies by managers and influential organizational figures are essential. Designnies and supply chain components for technology transfer and R&D projects, which often entail substantial costs.

Financing in Iran is largely bank-centered, with banks primarily providing loans to large, traditional industries and projects. However, banks' resources are limited and cannot fully meet the diverse and extensive needs of the industry. Banks also have limited expertise and often reject innovative projects. Collaboration with fintechs, especially financing fintechs, could enhance banks' capacity to evaluate innovative projects. This collaboration requires a positive outlook from banks towards fintechs and investment in fintech development. Additionally, reducing the dominance of banks in the financial sector necessitates expanding and diversifying fintech options in the country. Most Iranian fintechs are focused on payments and have a peripheral role in the financial industry. Developing fintechs requires balanced regulation and support from major financial institutions. Regulatory frameworks in the energy and financial sectors heavily favor large institutions, often overlooking the interests of smaller players, such as green and financial startups.

Future research suggestions include studying the future of SCF in the energy sector and identifying and prioritizing factors influencing SCF in other sectors, such as the automotive industry.

Authors' Contributions

Authors equally contributed to this article.

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Declaration of Interest

The authors report no conflict of interest.

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All procedures performed in this study were under the ethical standards.

References

[1] L. C. Yuan, "Research on the Development of Supply Chain Finance Innovation Assisted by Fintech," in *Advances in Economics, Business and Management Research*, vol. 126, 2020.

[2] Z. Lou, Q. Xie, J. H. Shen, and C. C. Lee, "Does supply chain finance (SCF) alleviate funding constraints of SMEs? Evidence from China," *Research in International Business and Finance*, vol. 67, p. 102157, 2024, doi: 10.1016/j.ribaf.2023.102157.

[3] Z. Cao, S. X. Chen, T. Dong, and E. Lee, "Climate Change Uncertainty and Supply Chain Financing," *The British Accounting Review*, p. 101423, 2024, doi: 10.1016/j.bar.2024.101423.

[4] M. Fathallah and M. Najafi, "Developing a model for supply chain financial management and chain-based financing," *Industrial Engineering Research in Production Systems*, vol. 4, no. 9, pp. 257-269, 2016, doi: 10.22084/ier.2017.11472.1562.

[5] M. Ahmadi, R. Mosaee, A. Zamani, and A. Salehnia, "Supply chain financing (chain-based financing)," Strategic Studies Office, Imam Sadiq University, 2021. [Online]. Available: https://ipmss.ir/committees/c-financing/c-fin-strategic-reports/supply-chain-financing/

[6] H. H. Lee, S. A. Yang, and K. Kim, "The role of fintech in mitigating information friction in supply chain finance," 2019.

[7] C. H. Tsai and P. Kuan-Jung, "The FinTech revolution and financial regulation: The case of online supply-chain financing," *Asian Journal of Law and Society*, vol. 4, no. 1, pp. 109-132, 2017, doi: 10.1017/als.2016.65.

[8] H. Song, S. Han, W. Liu, and A. Ganguly, "What role do FinTech companies play in supply chain finance? A signaling intermediary perspective," *Journal of Business & Industrial Marketing*, vol. 38, no. 6, pp. 1279-1294, 2023, doi: 10.1108/JBIM-12-2021-0587.

[9] H. Song, M. Li, and K. Yu, "Big data analytics in digital platforms: how do financial service providers customise supply chain finance?," *International Journal of Operations & Production Management*, vol. 41, no. 4, pp. 410-435, 2021, doi: 10.1108/IJOPM-07-2020-0485.

[10] J. Li, Z. He, and S. Wang, "A survey of supply chain operation and finance with Fintech: Research framework and managerial insights," *International Journal of Production Economics*, vol. 247, p. 108431, 2022, doi: 10.1016/j.ijpe.2022.108431.

[11] L. Klapper and D. Randall, "Financial crisis and supply-chain financing," in *Trade finance during the great trade collapse*, 2011, pp. 73-86.

[12] X. Xu, X. Chen, F. Jia, S. Brown, Y. Gong, and Y. Xu, "Supply chain finance: A systematic literature review and bibliometric analysis," *International Journal of Production Economics*, vol. 204, pp. 160-173, 2018, doi: 10.1016/j.ijpe.2018.08.003.

[13] H. S. Obaid and H. Nozari, "Examining dimensions and components and application of supply chain financing (in chain stores)," *International Journal of Innovation in Management, Economics and Social Sciences*, vol. 2, no. 4, pp. 81-88, 2022, doi: 10.52547/ijimes.2.4.81.

[14] Z. Lai, G. Lou, H. Ma, S. H. Chung, X. Wen, and T. Fan, "Optimal green supply chain financing strategy: Internal collaborative financing and external investments," *International Journal of Production Economics*, vol. 253, p. 108598, 2022, doi: 10.1016/j.ijpe.2022.108598.

[15] Z. R. Marak and D. Pillai, "Factors, outcome, and the solutions of supply chain finance: review and the future directions," *Journal of Risk and Financial Management*, vol. 12, no. 1, p. 3, 2018, doi: 10.3390/jrfm12010003.

[16] N. Amberg, T. Jacobson, and Y. Qi, "Supply-Chain Finance: An Empirical Evaluation of Supplier Outcomes," SSRN, 2024.

[17] J. Jansen, "Supply Chain Finance Perspectives," 2024.

[18] H. Bai, L. Huang, and Z. Wang, "Supply chain financing, digital financial inclusion and enterprise innovation: Evidence from China," *International Review of Financial Analysis*, vol. 91, p. 103044, 2024, doi: 10.1016/j.irfa.2023.103044.

[19] J. Huang, H. Huang, Y. Si, Y. Xu, S. Liu, and X. Yang, "Green supply chain finance strategies with market competition and financial constraints," *Heliyon*, vol. 10, no. 8, 2024, doi: 10.1016/j.heliyon.2024.e29511.

[20] J. Kaur, S. Kumar, B. E. Narkhede, M. Dabić, A. P. S. Rathore, and R. Joshi, "Barriers to blockchain adoption for supply chain finance: the case of Indian SMEs," *Electronic Commerce Research*, vol. 24, no. 1, pp. 303-340, 2024, doi: 10.1007/s10660-022-09566-4.

[21] Y. Gong, T. Zhang, P. Dong, X. Chen, and Y. Shi, "Innovation adoption of blockchain technology in supply chain finance," *Production Planning & Control*, vol. 35, no. 9, pp. 992-1008, 2024, doi: 10.1080/09537287.2022.2155564.

[22] T. M. Choi, "Supply chain financing using blockchain: Impacts on supply chains selling fashionable products," *Annals of Operations Research*, vol. 331, no. 1, pp. 393-415, 2023, doi: 10.1007/s10479-020-03615-7.

[23] T. Vu, D. Nguyen, T. Luong, T. Nguyen, and T. Doan, "The impact of supply chain financing on SMEs performance in Global supply chain," *Uncertain Supply Chain Management*, vol. 10, no. 1, pp. 255-270, 2022, doi: 10.5267/j.uscm.2021.9.003.

[24] D. Wang, D. Zhao, and F. Chen, "Research on financing strategy of green energy-efficient supply chain based on blockchain technology," *Energies*, vol. 16, no. 7, p. 2985, 2023, doi: 10.3390/en16072985.

[25] Q. Wang, S. Yuan, D. Ostic, and L. Pan, "Supply chain finance and innovation efficiency: An empirical analysis based on manufacturing SMEs," *PLOS ONE*, vol. 18, no. 7, p. e0286068, 2023, doi: 10.1371/journal.pone.0286068.

[26] T. Xia, Y. Wang, L. Lv, L. Shen, and T. C. E. Cheng, "Financing decisions of low-carbon supply chain under chain-to-chain competition," *International Journal of Production Research*, vol. 61, no. 18, pp. 6153-6176, 2023, doi: 10.1080/00207543.2021.2023833.

[27] Y. Xia, Q. Guo, H. Sun, K. Li, and Z. Mu, "Green R&D financing strategy in platform supply chain with data-driven marketing," *Sustainability*, vol. 14, no. 15, p. 9172, 2022, doi: 10.3390/su14159172.

[28] M. H. Maleki, S. M. Mortezavi, S. Shirouyehpour, and M. J. Zare Behnamiri, "The role of big data in the future of the

banking industry with a scenario planning approach," *Journal of Intelligent Business Management Studies,* vol. 12, no. 47, pp. 271-313, 2023.

[29] M. Ahmadi, A. Roosta, M. H. Maleki, and F. Asayesh, "A framework for identifying drivers impacting the future of innovative marketing in the banking industry with a focus on blockchain technology," *Journal of Innovation and Creativity in Humanities,* vol. 12, no. 48, pp. 177-202, 2023.

[30] X. Pan, S. Guo, and J. Chu, "P2P supply chain financing, R&D investment and companies' innovation efficiency," *Journal of Enterprise Information Management,* vol. 34, no. 1, pp. 578-597, 2021, doi: 10.1108/JEIM-07-2020-0258.

[31] Q. Gong, M. Ban, and Y. Zhang, "Blockchain, enterprise digitalization, and supply chain finance innovation," *China Economic Transition= Dangdai Zhongguo Jingji Zhuanxing Yanjiu,* vol. 5, no. 2, pp. 131-158, 2022.

[32] M. J. Haddadpour Jahromi, D. Andalib Ardekani, M. H. Maleki, and A. Nasser Sadrabadi, "Identifying and analyzing drivers affecting the future of distributed energy production based on blockchain technology," *Journal of Energy Policy and Planning Studies,* vol. 9, no. 3, pp. 86-124, 2023.

[33] W. Yu, C. Y. Wong, R. Chavez, and M. A. Jacobs, "Integrating big data analytics into supply chain finance: The roles of information processing and data-driven culture," *International Journal of Production Economics,* vol. 236, p. 108135, 2021, doi: 10.1016/j.ijpe.2021.108135.

[34] D. Eckstein, M. Goellner, C. Blome, and M. Henke, "The performance impact of supply chain agility and supply chain adaptability: the moderating effect of product complexity," *International Journal of Production Research,* vol. 53, no. 10, pp. 3028-3046, 2015, doi: 10.1080/00207543.2014.970707.

[35] N. Sharma, B. S. Sahay, R. Shankar, and P. R. S. Sarma, "Supply chain agility: review, classification and synthesis," *International Journal of Logistics Research and Applications,* vol. 20, no. 6, pp. 532-559, 2017, doi: 10.1080/13675567.2017.1335296.

[36] H. Nozari and J. Ghahremani-Nahr, "Assessing key performance indicators in blockchain-based supply chain financing: Case study of chain stores," *International Journal of Innovation in Engineering,* vol. 2, no. 3, pp. 42-58, 2022, doi: 10.59615/ijie.2.3.42.

[37] S. Han, J. P. Ulhøi, and H. Song, "Digital trust in supply chain finance: the role of innovative fintech service provision," *Journal of Enterprise Information Management,* 2024, doi: 10.1108/JEIM-07-2022-0238.